HVAC SYSTEM

TECHNICAL SPECIFICATION

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1. EQUIPEMENTS:-

1.1 Window Air Conditioning Units

A. Scope:-

The scope of this section comprise the supply, erection, testing and commissioning of Window Air conditioning Units conforming to these specifications and in accordance with the requirements of Drawings and Schedule of Quantities.

B. Type:-

The Window Air conditioning Units shall consist of rotary compressor, motor, air cooled condenser, integral refrigerant piping and wiring, all mounted on a steel frame.

C. Capacity :-

The refrigeration capacity of Window Air Conditioners shall be as shown on Drawings and in Schedule of Quantities.

D. Compressor and Motor:-

Compressor shall be rotary, serviceable type and shall have dual pressure stat, and an operating oil charge. The motor shall be suction gas cooled and shall be sealed against dirt and moisture. The motor shall be suitable for or 230±6 % volts, 50 Hz, A.C. supply.

E. Fan motor and drive :-

Fan motor shall be suitable for 230±10% volts, 50 Hz, A.C.Supply, Single phase, motors shall be provided with permanent capacitor. Motors shall be especially designed for quite operation and motor speed shall not exceed 1440 rpm.

F. Fan:-

Fan wheels and housing shall be fabricated from heavy gauge steel. Fan wheels shall be of double-width, double inlet forward-curve, multi-blade type enclosed in a housing and mounted on a common shaft. Fan housing shall be made of die-formed steel sheets with stream-lined inlets to ensure smooth air flow into the fans, fan shaft bearing shall be oil/grease lubricated. All rotating parts shall be dynamically balanced individually, and the complete assembly shall be statically and hydraulically balanced. Fan speed shall not exceed 1000 rpm and maximum fan outlet velocity shall be 550 meters per minute.

G. Cooling Coil :-

Cooling coils shall be of fin and tube type having aluminum fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and air velocity across each coil shall not exceed 100 meters per minute. The coil shall be pitched in the unit casing for proper drainage. Each coil shall be factory-tested at 21 Kg. per sq.cm air pressure under water. Tube shall be mechanically / hydraulically expanded for minimum thermal contract resistance with fins. The no. of fins per cm. shall be 4 to 5.

H. Vibration Isolators :-

The Window air conditioning units shall be provided with ribbed rubber pad vibration isolators.

I. Painting:-

Window air conditioning units shall be factory finished with durable alkyd spray enamel. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

J. Performance Rating :-

The unit shall be selected for the lowest operating noise level. Capacity rating and power consumption with operating points clearly indicated shall be submitted with the tenders and verified at the time of testing and commissioning of the installation. **Contractor to carry out CFD Analysis to verify the rising temperature due to stacking of units above each other and wind resistance at the higher floors. Final Out door unit capacities shall be based on the result of CFD analysis.**

1.2 Dx Outdoor Units For Hi-Wall Units

A. Scope :-

a. Scope of this section comprises the supply, installation, testing and commissioning of outdoor units suitable for specified AC system.
b. **CFD Analysis to verify the rising temperature due to stacking of units above each other and wind resistance at the higher floors. Final Out door unit capacities shall be based on the result of CFD analysis.**

B. General Requirements :

a. All outdoor units shall be supplied with the following from the factory:
    1) Clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting inclusive of anti vibration pads.
    2) Paper pattern for installation.
    3) Installation manual.
    4) Operation manual.

C. Materials and Construction :

a. Outdoors units of constant volume flow system shall be compact air cooled type.
b. All compressors of the outdoor units shall be hermetically sealed Rotary / Scroll type. Each module of outdoor unit shall have separate scroll compressor with necessary control, suitable to operate at heat load proportional to indoor requirement.
c. Aluminum fins of condenser coils shall be provided with suitable factory installed protective coating for corrosion prevention.
d. Outdoor units shall be suitable for required refrigerant piping not less than 15 M between outdoor unit & the indoor units.
e. Outdoor units shall employ system of equal run time for all the compressors, within each outdoor unit ï Single Module or Multi Module.
f. Outdoor units shall be suitable to operate within an ambient temperature range of ï 5 Deg C to 50 Deg C in cooling mode.
g. Air cooled condensers shall have Axial Flow, horizontal throw fan, directly coupled to fan motors with minimum IP 55 protection. Outdoor unit condenser fans shall be able to develop external static pressure up **to 6mm or above of w. g to overcome the wind pressure.(if fan pressure is less we will not get proper cooling)** Condensers will have elevation treatment louvers in front of them and it shall work without any deration of capacity of the DX system.
h. The entire operation of outdoor units shall be through independent remote control of indoor units. No separate Start/ Stop function shall be required.
i. Starter for the outdoor unit compressor shall ñDirect on Lineò OR Star delta based on the motor rating as specified in the electrical specification.

j. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.
k. Filter drier with sight glass shall be installed in the liquid line to protect the expansion valve & compressor against the dirt. It also dries the refrigerant. Sight glass with moisture indicator is normally installed after the filter drier.
l. Noise level of outdoor units shall not exceed 60 dB (A) at a distance of 5ôfrom the unit.
m. Outdoor units shall conform to Technological Guideline for Harmonic Suppression ï JAEG 9702 1995. High Harmonic Environmental Target Level for Power Distribution system shall be 5%.
n. Coils of outdoor unit shall have blygold or equivalent corrosion resistance coating.
o. Selected outdoor condenser fans shall have sufficient static pressure to discharge the hot air out and overcome the wind pressure at higher elevations
p. Outdoor units shall be complete with following safety devices:

1) High pressure switch
2) Fan driver overload protector
3) Over current relay
4) Fusible plug
5) Sight glass
6) Filter & Drier.
7) Shut off valve.

1.3 DX Indoor Units - Hi-Wall

A. Scope :

Scope of this section comprises the supply, installation, testing and commissioning of indoor units for Split A.C. System.

B. General Requirements :

a. All units shall be supplied with the following from the factory:
1) Drain hose/ clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting inclusive of anti vibration rubber mounts.
2) All indoor units coil shall have anti corrosive coating
3) Paper pattern for Installation.
4) Installation manual.
5) Operation manual.
6) Selected unit shall maintain NC 30 at low speed.
7) All Indoor units shall be complete with IR with extended neck sensors and associated control caballing.

b. All units shall have cordless remote. The remote should include but not limited to following standard functions-
1) Unit Start / Stop
2) Temperature setting.
3) Operating mode
4) 24 hour on/off timer
5) Airflow swing activation.
6) Fan speed adjustment.
7) Memory restart.
8) Sleep mode.

C. Wall & Ceiling Mounted Indoor Units

a. Wall mounted indoor units shall be compact and stylish design that does not detract from the décor of the room.
b. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

c. Units shall have provision of adding drain pump kit if required and specified. Drain pumps shall be suitable to lift drain up to 1000 mm from the bottom of the unit.
d. Units shall be insulated with sound absorbing thermal insulation material. Noise level of unit at the highest operating level shall not exceed 35 dB(A), at a vertical distance of 1.5 m from the grille of the unit.
e. Units shall be supplied with maintenance free long life filter, Resin Net filter with Mold Resistance. The filter shall be easy to remove, clean & re install.
f. Unit grilles shall be washable with soap solution.
g. It shall be possible to set minimum 5 steps of discharge angle by remote controller.
h. It shall be possible to fit drain pipe from either side of the unit (left or right).
i. Units shall be connected in series to a suitable outdoor unit and it shall be possible to operate the unit independently, through cordless remote control specified in the bill of quantities.

1.4 DX Outdoor For Ductable Units

A. Scope :

c. Scope of this section comprises the supply, installation, testing and commissioning of outdoor units suitable for Constant Volume Refrigerant System.
d. **CFD Analysis to verify the rising temperature due to stacking of units above each other and wind resistance at the higher floors. Final Out door unit capacities shall be based on the result of CFD analysis.**

B. General Requirements :

a. All outdoor units shall be supplied with the following from the factory:
    1) Clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting.
    2) Paper pattern for installation.
    3) Installation manual.
    4) Operation manual.

C. Materials and Construction :

a. Outdoors units of constant volume refrigerant flow system shall be compact air cooled type.
b. All compressors of the outdoor units shall be hermetically sealed scroll type.
c. Aluminum fins of condenser coils shall be provided with suitable factory installed protective coating for corrosion prevention.
d. Outdoor units shall be suitable for up to 20m (straight length) refrigerant piping between outdoor unit & the farthest indoor units. Allowable level difference between outdoor unit & indoor units shall be 5 meter (minimum).
e. Outdoor units shall employ system of equal run time for all the compressors, inverter or on/ off type, within each outdoor unit ï Single Module or Multi Module.
f. Outdoor units shall be suitable to operate within an ambient temperature range of ï 5 Deg C to 50 Deg C in cooling mode .
g. Air cooled condensers shall have Axial Flow, horizontal throw fan, directly coupled to fan motors with minimum IP 55 protection. Outdoor unit condenser fans shall be able to develop external static pressure up to 15 mm of wg. Condensers will have elevation treatment louvers in front of them and it shall work without any deration of capacity.
h. The entire operation of outdoor units shall be through independent remote control of indoor units. No separate Start/ Stop function shall be required.
i. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.
j. Noise level of outdoor units shall not exceed 60 dB (A) at a distance of 5 feet from the unit.

k. Outdoor units shall conform to Technological Guideline for Harmonic Suppression ï JAEG 9702 1995. High Harmonic Environmental Target Level for Power Distribution system shall be 5%.
l. Coils of outdoor unit shall have blygold coating.

a. Selected outdoor condenser fans shall have sufficient static pressure to discharge the hot air out and overcome the wind pressure at higher elevations

m. Outdoor units shall be complete with following safety devices:
1) High pressure switch
2) Fan driver overload protector
3) Over current relay
4) Inverter overload protector
5) Fusible plug

1.5 DX Indoor - Ceiling Mounted Ductable Units

A. Ceiling mounted Ductable indoor units shall be ceiling suspended with suitable supports along with anti-vibration mounts to take care of the operating weight of the unit, without causing any excessive vibration and noise. Cold air from the units shall be supplied to the area to be air conditioned, through duct system specified in these
B. tender documents.
C. Unit casing shall be Galvanized Steel Plate.
D. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.
E. Units shall be insulated with sound absorbing thermal insulation material. Noise level of unit at the highest operating level shall not exceed 48 dB(A), at a vertical distance of 1.5 m below the units with duct connected to the unit.
F. Unit shall have thermal fuse for fan motor protection, in case of motor heating.
G. Unit shall be able to develop external static pressure of 25 mm, at the specified air quantities. Upon award of the contract, Contractor to submit the ESP calculation along with the fan selection for Engineerôs and Employerôs approval.
H. Unit shall be connected in series to a suitable outdoor unit and it shall be possible to operate the unit independently, through corded/ cordless remote control specified in the bill of quantities.
I. All units shall have corded remote. The remote should include but not limited to following standard functions-

a. Unit Start / Stop
b. Temperature setting.
c. Operating mode
d. 24 hour on/off timer
e. Airflow swing activation.
f. Fan speed adjustment.
g. Memory restart.
h. Sleep mode

1.6 DX Indoor - Hide Away / Concealed Split

A. Ceiling mounted Hide away type indoor units shall be ceiling suspended with suitable supports along with anti-vibration mounts to take care of operating weight of the unit, without causing any excessive vibration and noise. Cold air from the units shall be supplied to the area to be air conditioned directly through duct collar and grille or through duct system specified in these tender documents.
B. Unit casing shall be Galvanized Steel Plate.
C. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.
D. Units shall be insulated with sound absorbing thermal insulation material. The noise level of unit at the highest operating level shall not exceed 42 dB(A), at a vertical distance of 1.5 m below the units with duct connected to the unit.
E. Unit shall have thermal fuse for fan motor protection, in case of motor heating.

F. Units shall have provision to set external static pressure in three stages as per the system requirements depending on the air supply system.
G. Units shall be supplied with maintenance free long-life filter, Resin Net with Mold Resistance. The filer shall be easy to remove, clean and re-installed.
H. Units shall include as standard equipment, a drain pump kit suitable to lift drain water up to 750 mm from the drain pipe opening.
I. Units shall be connected in series to a suitable out door unit and it shall be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities.
J. Unit shall be able to develop ESP of 5mm at the specified air quantities.

K. All units shall be supplied with the following from the factory:
   a. Drain hose/ clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting inclusive of anti-vibration rubber mounts.
   b. All indoor units coil shall have anti-corrosive coating
   c. Installation manual.
   d. Operation manual.
   e. Selected unit shall maintain NC 25-30 inside the conditioned space
   f. All Indoor units shall be complete with IR with extended neck sensors and associated control caballing.
   g. Refrigerant shall be Environment friendly R22/R407C / R410A.
   h. All units shall have cordless remote. The remote should have following standard functions including but not limited to the following-
   i. Unit Start / Stop
   j. Temperature setting.
   k. Operating mode
   l. 24 hour on/off timer
   m. Airflow swing activation.
   n. Fan speed adjustment.
   o. Memory restart.
   p. Sleep mode.

1.7 Variable Refrigernt Flow (Vrf) / Variable Refrigernt Volume (Vrv) System

A. Scope:

Scope of this section comprises the supply, installation, testing and commissioning of VRF/VRV. System as follows:

a. Indoor units as per the drawings with mounting brackets/supports.
b. Air-cooled condensing units as per drawings with outdoor support structure. Outdoor support structure shall be painted with 2 coats of epoxy primer and 2 coats of epoxy paint.
c. All indoor units shall have anticorrosive coating and outdoor unit shall have bly-gold coating.
d. **CFD Analysis to verify the rising temperature due to stacking of units above each other and wind resistance at the higher floors. Final Out door unit capacities shall be based on the result of CFD analysis.**
e. Fan motor, evaporator motor interlock local isolators for motors.
f. Hard copper refrigerant piping between outdoor and indoor units as specified elsewhere.
g. Electrical panels with starters etc., for compressors motors, condenser fan motor and evaporator fan motors.
h. Digital thermostats and safety controls.
i. Single phase preventors.
j. Installation accessories, mounting brackets, filters, drier etc.
k. First charge of refrigerant gas and oil.
l. Ducting with insulation and air terminal devices as specified elsewhere.

m. Drain piping for evaporator units.
n. Insulation of indoor unit, refrigerant piping and drain piping.
o. Electrical wiring from isolator power supply provided by others, within 3 Meters away from the outdoor units.
p. Testing and commissioning.
q. For detail specification of indoor and outdoor unit kindly refer to point no. G and H

Tenderer shall submit the technical data sheets as published by manufacturer along with the tender.

B. Materials and Construction:

The system selected shall be a modular with multiple compressors in each module, with number of indoor units connected to centrally located outdoor units, as per detailed designing given in the tender. Outdoor units for all the systems shall be air cooled type and mounted as shown in the drawings. Indoor units in various areas shall be as per enclosed drawings/ Bill of Quantities.

a. VRF/VRV air conditioners shall be fully factory assembled, wired, internally piped & tested. Outdoor units shall be pre-charged with R 410A/R22 refrigerant. Additional charge shall be provided as per refrigerant piping at site. All the units shall be suitable for operation with 415 V + 6%, 50 Hz + 3%, 3 Phase supply for outdoor units and 240 V + 6%, 50 Hz + 3%, 1 Phase supply for indoor units.

b. VRF/VRV. System shall provide stable, trouble free & safe operation, with flexibility of operating desired indoor units. Outdoor units shall be capable of delivering exact capacity proportional to the number of indoor units switched on and the heat load in the air conditioned area. The proportional operation shall be achieved by varying speed of the compressor in the outdoor units (variable frequency drives). Electronic expansion valves shall be provided in the system.

c. Selected outdoor unit condenser fans shall have sufficient static pressure to discharge the hot air out and overcome the wind pressure at higher elevations
d. The system shall be suitable for delivering the design capacity without deration, upto the following distances.

1)	Distance between outdoor and farthest indoor unit	-	150 mts.
2)	Vertical distance	-	50 mts.
3)	Horizontal distance	-	130 mts.
4)	Total refrigerant piping in each system	-	min 500 mts.

e. Operation of the VRV/VRF system shall be through independent wired/ wireless remote controllers.
f. All units shall be supplied with the following from the factory:
   1) Connection pipes & accessories.
   2) Clamps
   3) Installation manual
   4) Operation manual
   5) VRV/VRF controller
   6) Communication modules for the home automation units.

C. General Features

Following features shall be provided for all VRV/VRF systems.

ON / OFF Control	ON / OFF control for each individual indoor unit.
Central Control	Central or local control shall be individually selected. In built duty cycling shall be provided.
Mode Selection	Simulated COOL/HEAT operation.
Temperature Setting	Temperature selection from `0ôDeg.ï 30 Deg.C in cooling mode.
Fan Speed Setting	HIGH-MEDIUM-LOW-OFF
Timer	Multiple daily time ON/OFF settings where temperature, fan speeds can be selected.
Remote Controller Group	Indoor units with remote controller.
Group Setting	Multiple indoor units shall be group set with the same settings by inputting the information on one of the units in the group.
Auto Configuration	All indoor units connected to the network shall automatically be identified and registered.
Fault Status	If a fault occurs, the screen shall display the fault details within 3 minutes and a fault log shall be created. Facility to print the log automatically shall be provided.
System Status	Actual operating conditions for each indoor and outdoor unit shall be monitored on the system display graphics.
Password	A password to prevent unauthorized access to the program.
Search	Where many indoor units are controlled by NETWORK, a search function shall be available to find specific unit locations
Languages	ENGLISH
Help Files	Help files shall be provided in the respective languages.
Error Log	All faults reports shall be stored with date and time information providing a historical record.
Unit Registration	Information concerning the unit models, serial numbers shall be entered for each unit making after sales service easier.
Energy Consumption	Shall allow the demand of individual units to be calculated as a percentage of total system energy consumption over selected time periods.
Historical Information	Operation conditions shall be recorded at selected time intervals for help with monitoring and trouble shooting.
Filter Maintenance	An indication shall appear, at selected time intervals, when it is necessary to inspect the filter.

D. Testing:

a. Unit capacity in Tons Refrigeration shall be computed from the temperature readings.
b. All instruments, services needed for the tests required for the computation of capacities and power consumption shall be furnished by the Contractors themselves. All instruments shall be calibrated and the Contractors shall produce calibration certificates in support.

E. Painting:

All equipment including mounting frames, etc., shall be painted with two coats of a suitable paint of approved color. All steel members/parts shall be given an undercoat of zinc chromate before the application of 2 coats of paint.

1.8 Supply/ Extraction / Pressurization Fans

Scope

The scope of this section comprises the supply, erection, testing and commissioning of centrifugal, Tube axial, in-line and propeller type fans and roof mounted units conforming to these Specifications and in accordance with the requirement of Drawings ,Equipment schedule and schedule of Quantities.

Selected fans shall have sufficient static pressure to discharge / intake the air out and overcome the wind pressure at higher elevations. Upon award of the contract, Contractor to submit the ESP calculation along with the fan selection for Engineerôs and Employerôs approval.

Capacity

The air-moving capacity of fans shall be as shown on Drawings, Equipment schedule and in Schedule of Quantities.

Type

Centrifugal fans and roof mounted units shall be of the type as indicated on Drawings, Equipment schedule and in Schedule of Quantities.

A. Tube Axial Flow Fan

Fans shall be direct driven **Tube axial** type. Fans shall be complete with motor, drive arrangement, motor mount, and vibration isolation arrangement as per approved for construction shop drawings.

NORMAL VENTILATION / Lift well pressurization fans.

– Casing shall be constructed of 14 gauge sheet steel. Fan casing and motor mount shall be of welded steel construction. Motor mounting plate shall be minimum 12 mm thick and machined to receive motor flange. Casing shall be provided with wide hinged doors which should open easily for removal of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be primed and finish coated with enamel paint.

Rotor hub and blades shall be cast aluminum construction. Blades shall be die formed airfoil shaped for maximum efficiency and shall vary in width from hub to top to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5 mm. Rotor blades shall be whirl tested to a speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow values as specified and quoted.

Motor shall be squirrel cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, suitable for 415 ± 6% volts 50 cycles, 3 phase power supply as per latest IS specifications. Motor nameplate horsepower shall exceed brake horsepower by a minimum of **20%.**. Motors shall be quiet operation and motor speed shall not exceed 1500 rpm. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible conduit.

Motor starters shall be automatic direct on line for rating up to 7.5 H.P. and automatic Star Delta for motors 10 HP & above. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventer and are to be included in the prices of starter panels.

Drive to fan shall be direct driven.

Vibration Isolation: The assembly of fan and motor shall be suspended from the ceiling or mounted on walls by vibration isolators.

Accessories: The following accessories shall be provided with all fans:

1) Outlet cone for static pressure regain.
2) Inlet cone.
3) Fan silencers, if required.
4) Wire guards on fan outlet / inlet not connected to duct work and shall be made freely accessible for maintenance.

Fans shall be factory assembled and shipped with all accessories factory-mounted.

FOR SMOKE EXTRACTION –

The specifications mentioned for smoke extraction fans are to be read in conjunction with the Axial fans

Motor for smoke extraction fan shall be rated at 250 deg C for 2 hour or 3000C for one hour

Fan shall have certification for rating at 250 deg C for 2 hours or 3000C for one hour

For smoke extraction fans, the gaskets shall be suitable for continuous operation in an air stream temperature of 250 °C for two hour or 3000C for one hour.

Compete fan shall comply BSEN-1210-3-2002 and ISO 21927-3 for high temperature performance

Drive sets shall be isolated from smoke stream.

The relevant authority certification and specifications should met and complied.

B. Inline Exhaust Fans :

Fans shall be direct driven Inline axial type. Fans shall be complete with motor, drive arrangement, motor mount, and vibration isolation arrangement as per approved for construction shop drawings.

Fans shall be capable of accommodating static pressure variations of plus or minus 10 percent.

Static - pressures given in the equipment Schedules are only for guidance. The Contractor should submit static pressure calculations for all fans for approval before ordering the equipments. The Contractor should give the required fan and motor HP Without additional cost. The contractor may propose lower motor HP as per the calculations and as approved.

Contractor shall select fans for low noise application and shall provide all necessary measures such as provision of sound attenuators, Acoustic enclosures, acoustic lining to limit sound to acceptable noise levels. Contractor shall submit noise calculations for the selected fan and attenuators/and or acoustic enclosures for the approval prior to ordering the equipment.

C. Propeller Type Wall Exhaust Fans :

Propeller type fans shall be ring mounted and of the capacities shown in the schedule of Equipment. Exhaust fans shall be provided with gravity type
louvers unless otherwise stated.

Fan drive shall be single phase or threephase motors as indicated in the Schedule of Equipment and shall be complete with starter.

D. Centrifugal Fan

Centrifugal fan shall be DWDI Class I construction arrangement 3 (i.e. bearings on both the sides) for DWDI fans complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

Housing shall be constructed of 14 gage sheet steel welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans, however neoprene / asbestos packing should be provided throughout split joints to make it air-tight.

18 gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

NORMAL VENTILATION

Fans shall be non-overloading type. The fan capacity, static pressure, arrangement, width, direction of rotation, mode of discharge, etc. shall be as indicated in the schedule and in the applicable drawings or as required.

Centrifugal fans shall be of the backward curved blade having a fan of total efficiency greater than 70%.

Fan casings shall be constructed from 1.6 mm GSS construction and shall be able to permit withdrawal of impeller after fan installation. Fans shall be provided with flanged outlet connections. Permanent indication shall be provided to show the correct direction of rotation of the fan impeller. Fan casings shall be provided with air tight removable access panels. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller.

Fan shaft shall be of EN - 8 steel constructions.

Impellers shall be of 2 mm thick mild steel or aluminum alloy of riveted welded or other approved construction, with spiders or hubs of robust design. Impeller shall be statically and dynamically balanced.

Fans shall also be provided with heavy duty adjustable outlet dampers mounted in a separate frame.

Fans shall be driven by a TEFC Sq. cage motor as per latest IS specifications. Motor ratings are only tentative and where a fan requires a higher capacity motor, the contractor shall clearly point out the requirements and make their offer accordingly. Motor ratings shall be at least 20% over limit load.

Motor starters shall be automatic direct on line for rating as indicated in electrical specification. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventor and are to be included in the prices of starter panels.

All class I fans shall be provided with sleeve bearings with generous oil reservoir, drain plug, oil level indicator, etc. Class II and III fans shall be provided with heavy duty ball bearings.

Drive to fan shall be through oil resistant type belts with adjustable multi speed pitch motor pulley and approved belt guard. Pulleys shall be well balanced and properly aligned.

1) Vibration Isolation : MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through approved vibration isolators. The concrete foundation shall be at least 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings

E. <u>Cabinet Type Air Fans:</u>

Cabinet type fans shall be complete factory - assembled and tested of approved manufacturer.

The fan shall be centrifugal backward curved, double inlet double width type. Fan casing shall be made of galvanized steel sheet. Fan wheels shall be made of galvanized steel. Fan shaft shall be grounded C40 carbon steel and supported in self-aligning lummer block operating less than 75% of first critical speed, grease lubricated bearings. Fan wheels and pulleys shall be individually *t*ested and precision balanced dynamically.

Both fan and motors assemblies shall be mounted on a deep section aluminum alloy or galvanized steel (depending on size) base frame. Isolation shall be provided from the unit casing by combination spring and rubber anti vibration mounts and flame retardant, waterproof neoprene impregnated flexible connection on the fan discharge.

Fan section, including wheels and housing, shall be fabricated from 16 Gauge steel.

Fan motor shall be mounted on an adjustable vibration isolating base located on the discharge panel of the fan section. A standard belt guard shall be provided to enclose the pulley, sheaves and belts. Fans shall be driven by electric motors as specified in the Schedule of Equipment. Motor ratings are only tentative and where a fan requires a higher capacity motor, the Tenderer shall clearly point out the requirement and make his offer accordingly. Motor ratings shall be at least 20% over BKW plus transmission losses.

All fans shall be dynamically trim-balanced to ISO1940 and AMCA 204/3 - G2.5 quality grade after assembly. A computer printout with the vibration spectrum analysis shall be attached to the fans.

Cabinet shall be PR12 coated for outdoor installation.

Fans shall be provided with volume control dampers in ducting.

Supply fan shall be Double Skin Cabinet type belt driven DIDW Backward Centrifugal fans with MERV 4 filter.

Toilet Extract fan shall be Double skin Cabinet type belt driven DIDW Backward Centrifugal fans.

Motors shall be Efficiency class II.

F. Roof Mounted Fan

Roof mounted fan shall be propeller type or centrifugal fans, direct driven or belt driven as shown on drawing and in Schedule of Quantities, complete with motor drive, and housing with weather-proof cowl.

a. Housing: shall be constructed of 16 gage steel sheet. The housing shall have an adjustable flange to facilitate installation and shall be especially adapted to receive fan, motor, and drive. The housing shall have a low silhouette. For belt driven units, motor shall be installed in ventilated water proof housing outside the air stream. The discharge cowl shall be hinged along one edge for easy access to motor and drive, for inspection and maintenance. The entire assembly shall be weatherproof and raised from the roof terrace sufficiently to prevent down flow of rain water accumulated on the terrace. 18 gage galvanized steel mesh bird screen shall be provided on all discharge cowls around the outlet area.

b. Fans: shall be backwardly inclined centrifugal wheel or propeller type as required, designed for maximum efficiency, minimum turbulence and quiet operation. Fan shall be statically and dynamically balanced.

c. Motor: shall be shaded pole, of split capacitor type with lubricated sleeve or ball bearings, designed for quiet operation. Bearings shall be designed for vertical mounting. Motor name-plate horse-power shall be such that the motor shall not be overloaded in the entire range of rated speed. Motor and fan assembly shall be easily removable. Motor power supply characteristic and maximum speed shall be as specified for propeller fans and as indicated in the Schedule of Quantities.

d. Fan Bearings: shall be heavy duty, self aligning sleeve/ball bearings designed for thrust load and sealed for grease retention.

e. Back draft Damper : Where called for in the Schedule of Quantities, roof-mounted fan shall be equipped with a rattle-free backdraft damper to prevent air from re-entering the fan when fan is not in operation, thus sealing completely in closed position. Damper shall be chatterproof under all conditions.

f. Vibration Isolation: The motor and fan assembly shall be isolated from the base with vibration isolators.

G. FANS INSTALLATION :-

a. Before installing the fan assembly, check that it has not been damaged in transit, that there is no deformation of the fan casing, that the impeller rotates freely, and that the fan and motor nameplate data complies with the requirement of its use. If the fan assembly has been stored the resistance of the motor windings to earth should be measured (at 500V d.c). If any reading is less than ten megohms the motor should be dried and re-checked before it is switched on.

b. The fan assemblies can be heavy (between 270 kg and 8000 kg, depending on fan and motor size, with ancillary equipment such as silencers, guards, bellmouths, adding to the weight), are sometimes unwieldy, and should be lifted slowly to prevent damage and distortion. Proper precautions must be taken, and certified lifting aids used, to ensure the fan is well supported and stable before lifting into position. Flange holes or mounting feet holes can be used for lifting but more than one hole must be used to spread the load. If special lifting points are provided they must be used. The fan must be installed such that it is correctly positioned in accordance with the required airflow direction. An airflow indication arrow is shown on the fan name plate.Sharp bends in the ductwork close to the fan must be avoided. Adequate room must be allowed round the fan for inspection and maintenance

c. The component parts of the fan assembly, including (if fitted) anti-vibration mounts, silencers, bell mouths, flexible connectors (and their clips), purlin boxes, weather proofing, platforms, supports, chains and harnesses, etc. must be fully aligned before being bolted together so that no distortion or stress is placed on the equipment. Appropriate fixings, with the correct torque applied, must be used to secure the fan into position. If in doubt about the torque of a particular fixing, contact manufacturer for advice. The final position of the fan must be strong and rigid enough to take the weight of the fan and any other weight applied during installation. Vibration isolators, appropriate for the weight of the fan, are recommended in order that any vibration of the fan is isolated so that no resonant frequencies are generated in surrounding fixtures. If vibration isolators are used, flexible connectors and flexible electrical conduit should also be used. The vibration isolators and flexible connectors must not be used to align fixing points that are clearly misaligned. If any component parts do not easily fit together the cause must be investigated and rectified.

d. Motors are fitted with a drain hole in each end cover, and in the terminal box. The motor drain hole should be at the lowest point of the motor when it is installed. Plugs that cover the drain holes should either be removed entirely if condensation is liable to occur due to large variations in operating temperature, or removed periodically to allow any general build-up of condensation to drain away. The frequency of plug removal will be dictated by environmental conditions, a record should thus be kept

e. Before switching confirm that the electrical supply is fully compliant with the requirement of the motor as detailed on the motor nameplate, that the fan is correctly installed, all component parts and fixings are secure, safety guards are in place and no loose articles are present in the vicinity.

f. Immediately on switch-on check the assembly for smooth, low-vibration running, and check that the current consumption is within the full load current specified on the nameplate. A trial connection of the three-phase supply should be made to check that the fan rotates in the required direction. If the rotation is incorrect interchange any two phases of the incoming supply at the motor terminal block. If after correctly connecting the single-phase supply the fan is found to be rotating in the wrong direction, the motor winding leads U1 and U2 should be interchanged at the motor terminal block. The fan must not be switched on and off in a manner that could cause overheating of the motor or its wiring.

1.9 Double Skin Air Handling Units

A. Scope

The scope of this section comprises the erection, testing and commissioning of double skin construction air handling units, conforming to these Specifications and in accordance with requirements of drawings

B. Type

The air handling units shall be double skin construction, draw-thru type comprising of various sections, mixing section, filter section (pre with MERV 4 and final with MERV 8), and DX coil section, and fan section, Open mixing box with inside perforated sheet to provide acoustics. The AHU shall be selected for ultra low pressure drop.

C. Capacity

The air handling capacity (CFM), maximum motor horse power, minimum required static pressure, filtration stages, humidification / dehumidification package etc. shall be as shown on Drawings.

D. Casing

Double skinned panels shall be minimum 50mm thick made of galvanized steel, pressure injected with foam insulation (density 40kg/m3) with K factor not exceeding 0.02 Watt/Mc shall be fixed to 1.5 mm thick aluminum alloy twin box section structural framework with stainless steel screws. Outer sheet of panels shall be made of galvanized pre-plasticized sheet of 0.63mm thick, and inner sheet of 24 Gauge plain GI Sheet. The entire framework shall be mounted on an aluminum alloy or galvanized steel (depending on size) channel base as per manufacturerôs recommendation. The panels shall be sealed to the framework by heavy duty `Oôring gaskets held captive in the framed extrusion. All panels shall be detachable or hinged. Hinges shall be made of die cast aluminum with stainless steel pivots, handles shall be made of hard nylon and be operational from both inside and outside of the unit. Units supplied with various sections shall be suitable for onsite assembly with continuous foam gasket. All fixing and gaskets shall be concealed.

The Casing leakage shall be in accordance with relevant standard.
Units shall have hinged, quick opening access door in the fan section and also in filter section where filters are not accessible from outside. Access doors shall be double skin type. Condensate drain pan shall be fabricated from 18 gage stainless steel sheet with all corners welded. It shall be insulated from bottom floor panel through 13mm nitrile rubber.

E. Mixing Box

AHUôs requiring mixing boxes as specified in Schedule of Equipment shall be complete with fresh and return air dampers.

F. VI. Thermal Break Profile

AHUôs such as heat recovery units, AHU with mixing box having return air ducted shall be provided with thermal break profile.

G. Damper

Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminum sections with integral gasket and assembled within a rigid extruded aluminum alloy frame. All linkages and supporting spindles shall be made of aluminum or nylon, turning in teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectionalized to minimize blade warping.

Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

H. Motor and Drive

Fan motors shall be energy efficient and shall be 415±6% volts, 50 cycles, three phase, totally enclosed fan-cooled class F, with IP-55 protection. Motors shall be especially designed for quiet operation and motor speed shall not exceed 1440 rpm. Drive to fan shall be provided through belt-drive arrangement. Belts shall be of the oil-resistant type. Motor shall be of **EEF 2** class.

Motors shall be mounted inside the AHU casing on slide rails for easy belt tensioning, and be totally enclosed, fan cooled, to be class `Fôinsulation. Motors shall drive heavy duty V-belt, constant pitch, drive selected at 16% of motor horsepower.

I. Fan (Free cooling and Supply air fan)

The fan shall be centrifugal backward curved, double inlet double width type. Fan casing shall be made of galvanised steel sheet. Fan wheels shall be made of galvanised steel. Fan shaft shall be grounded C40 carbon steel and supported in self-aligning lummer block operating less than 75% of first critical speed, grease lubricated bearings. Fan wheels and pulleys shall be individually *t*ested and precision balanced dynamically.
. Both fan and motors assemblies shall be mounted on a deep section aluminum alloy or galvanised steel (depending on size) base frame. Isolation shall be provided from the unit casing by combination spring and rubber anti vibration mounts and flame retardant, waterproof neoprene impregnated flexible connection on the fan discharge.

J. Cooling Coils (DX)

Coils shall be of the Direct Expansion (DX) type as indicated in the B.O.Q. and of the fin And tube type having aluminum fins firmly bonded to copper tubes. Capacity of the coils shall be as required under the Schedule of Equipment. Velocity of air across coil face shall not exceed 152 MPM (500 FPM). Tubes shall be either 16mm (5/8ò) or 12mm (1/2") O.D. as per manufacturerôs standards but with 5 fins/cm. Number of rows of coils shall be as given in the Schedule of Equipment. Coils shall be fitted with thermostatic expansion valves and other accessories /controls. All AHU coils shall have blygold coating. Refrigerant shall be CFC/HCFC free and ozone friendly.

K. Filter

Each unit shall be provided with a factory assembled filter sections containing washable synthetic type air pre and fine filters having anodized aluminum frame. The pre filter shall be **MERV 4** and fine filters shall be **MERV 8** Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from aluminum alloy.

L. Accessories & U-Trap.

Each air handling unit shall be provided with required accessories. Trap to be provided with the unit matching with the specified ESP.

M. Isolators

Vibration isolators shall be provided with all air handling units. Vibration isolators shall be cushy foot mounting type.

N. Painting

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.

O. Performance Data

Air handling unit shall be selected for the lowest operating noise level (55 dB at one meter distance) of the equipment. Fan performance rating and power consumption data, with

operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

P. On Site Testing

Cooling capacity of various air handling unit models be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by an anemometer and temperature measurements by accurately calibrated mercury-in-glass thermometers. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

Q. XVII. Laboratory testing

Test one of the largest capacity typical floor mounted air handling unit as specified by consultant for acoustics in factory. Detailed written test procedures shall be submitted to the Engineer for review 60 days prior to the test.

Sound power levels shall include contributions from air volume controllers and/or dampers, drives and motors, filters, and other accessories or components provided.

Sound power levels shall be based on the air handling unit operation at total static pressure and fan CFM indicated.
If the unit is found to exceed required acoustic sound power limits at any point in its normal operating range make modifications (at no additional cost to the Owner) to bring the unit to within the specified limits. Pay for all costs of subsequent testing required to verify results of the modifications.
Air handling unit shall create no significant pure tones with a significant pure tone defined as any one band more than 5dB above the two adjacent full octave bands.
Indicated sound power levels shall be achieved at the air handling unit (AHU) inlet and for the discharge after the first AHU sound attenuator installation which may be integral to the AHU or separate from the AHU.

1.10 Dedicated Outdoor Air Handling Unit (DOA)

A. Scope

The scope of this section comprises of the supply of double-skin ñDedicated Outdoor Air Systemsò conforming to the specifications below. The unit shall be suitable for Installation as shown in the typical GA drawing.

B. Type

The DOAS units shall be two stream units in double skin construction, comprising of supply air section, return air section and Heat Recovery Section. The supply air section shall include the following sections as defined in the Schedule of Equipment:

Fresh Air Inlet Damper, MERV 4 pre-filter, 3ºA Molecular Sieve Desiccant Coated Enthalpy Wheel, Inspection Section, cooling coil section, Fan section comprising Supply Air fan and motor.

The Return Air section shall include the following sections: Return Air inlet damper, Enthalpy Wheel, Fan section comprising of Exhaust Fan with motor.

All DOA AHUôs fans shall have factory fitted motor with pulley. One set of loose belt shall be kept in AHUs. Return air fan section will have by pass arrangement with fan (1w) and MFSD to isolate the AHU in case of fire in the apartment.

C. Capacity

The DOA units shall be of such capacities and static pressures as mentioned in the Schedule of Equipment / Drawings.

D. Casing

The units shall be made of extruded Aluminum hollow profile frames. The profile box size thickness shall be of minimum 50 mm for capacities up to 22000 CMH, such that it provides the required mechanical strength and rigidity. The unit should be devoid of any welded construction and should be of cabinet type. All the frames should be assembled using pressure die cast aluminum joints/corners to make a self-supporting frame. The Casing leakage shall be in accordance with relevant standard that is CLASS B. The panels shall be of double skin construction with both inner and outer steel sheets being minimum 0.8mm thick pre coated & plasticized. Minimum 50 mm thick fire retardant, fibre glass insulation shall be sandwiched between the sheets. The fibre glass density shall be 48 kg/m3. Materials emitting toxic gases like PUF shall not be used for insulation.

The Inspection and access panels shall be hinged type. The hinges shall be casted, powder coated Zinc alloy. Flushed Locks and Handles shall be of galvanized steel. Other panels will be screwed on to the frame with sealant and soft rubber gasket thus making the joints air tight . All screws used for panel fixing shall be covered with PVC caps.
Special hollow gaskets and seals shall be used on inspection doors and to create separation between the airstreams to ensure negligible air leakage and mixing.
The entire casing shall be mounted on electro galvanized channel frame work with level screws. Condensate drain pan shall be fabricated from 18 g GSS/SS construction.
Option for fire resistance Class of A-30 shall be available, if required in the Schedule of Equipment / Drawings.

E. Supply Air Section

The supply air section shall comprise of the following:

Fan Section

The fan shall be centrifugal backward curved, double inlet double width type. The impeller and the fan casing shall be made of hot galvanized sheet steel.
The impeller shall be mounted on a solid shaft supported to housing with angle iron frame and pillow block heavy duty ball bearing. The impeller shall be statically and dynamically balanced. The fan shall be selected such that unit noise level is less than 85 db. Fan housing and motor shall be mounted on a common galvanized steel or aluminum block base which can be drawn out from side for ease of maintenance. A quarter pin lock arrangement between the slide and guide pin lock arrangement between Fan and TFA outlet should be provided.

All DOA AHUs fans shall have factory fitted motor with pulley. One set of loose belt shall be kept in AHUs.

Motor And Drive

Fan motor shall be energy efficient and suitable for 415±6% volts, 50 cycles, 3 phase squirrel cage, totally enclosed fan cooled with IPï 55 protections. Motor shall be designed for quiet operation and Efficiency class EFF2. Drive shall be provided through belt ï drive arrangement. Belts will be of oil resistant type.

F. Cooling Coils

Coils shall be of the Direct Expansion (DX) type as indicated in the B.O.Q. and of the fin And tube type having aluminum fins firmly bonded to copper tubes. Capacity of the coils shall be as required under the Schedule of Equipment. Velocity of air across coil face shall not exceed 152 MPM (500 FPM). Tubes shall be either 16mm (5/8ö) or 12mm (1/2") O.D. as per manufacturers standards but with 5 fins/cm. Number of rows of coils shall be as given in the Schedule of Equipment. Coils shall be fitted with thermostatic expansion valves and other accessories /controls. All AHU coils shall have bi gold coating. Refrigerant shall be CFC/HCFC free and ozone friendly.

G. Filter Section

The filter section shall be normally designed for deep folded disposable synthetic pre-filters for Class **MERV 4.**

H. Damper Section

Damper section shall contain a built in damper of aluminum profile with leakage class III. The damper blades shall be connected with plastic gear wheels with a gasket of silicon rubber to produce tightness between the blades.
The piping accessories of drain shut off valve, sight glass to be provided in loose.

I. Inspection Section

The Inspection section shall be for inspection of other functional sections. It shall be available in two options; long and short version and shall be selected as defined in the Bill of Quantities.

J. Return Air Section

The return air section shall comprise of above sections. Return air fan section will have by pass arrangement with fan (1w) and MFSD to isolate the AHU in case of fire in the apartment.

K. Heat Recovery Section: (Enthalpy Wheel)

The Heat Recovery section shall include enthalpy wheels and shall have minimum recovery of 75 % of total heat, i.e. both sensible and latent(each being 75 %) . The recovery of sensible and latent shall be equal . Necessary computerized selection of the wheel should be provided along with the bid to justify the same . The wheel shall be made of pure aluminum foil coated with molecular sieve desiccant with pore diameter of 3oA.The cross contamination between the two air streams shall be nil and leakage less than 0.04%. The vertical and radial run of the wheel shall be less than 1 mm per meter of diameter. The wheels shall have non contact labyrinth seals for effective sealing between the two air streams.

1.11 Heat recovery wheel (enthalpy)

Rotor/wheel matrix shall be :-

The substrate: The substrate or wheel matrix should be only of pure aluminum foil so as to allow:

1) quick and efficient uptake of thermal energy.
2) sufficient mass for optimum heat transfer
3) maximum sensible heat recovery at a relatively low rotational speed of 20 to 25 rpm.

Non metallic substrates made from paper, plastic, synthetic or glass fibre media, will therefore, not be acceptable.
The substrate shall not be made from any material which is combustible or supports Combustion like synthetic fibrous media.
The wheel has to be certified as per DIN EN ISO 846 with 0% fungal and bacterial Growth at 95% Relative humidity and above.
Fire rating :
NFPA - 90A certification with 0% for Flame spread classification should be confirmed by manufacturer.

Pressure drop :The pressure drop across the rotary heat exchanger shall not exceed 0.1 inch for every 100 FPM face velocity, or part thereof, for the minimum stated / requiredlatent recoveries / efficiencies
Necessary software selection of the wheel has to be enclosed to justify the pressure drop and efficiency calculations**.**

A. The Desiccant : The desiccant should be water molecule selective and non migratory. The desiccant should be molecular sieve 3Å . so as to keep the cross contamination to absolute minimum and also ensure the exclusion of contaminants from the air streams, while transferring the water vapor molecules. The desiccant, of sufficient mass which should not be less than 5 kg per 1000 cfm of air, should be coated with non masking porous binder adhesive on the aluminum substrate so as to allow quick and easy uptake and release of water vapor. A confirmation has to be provided by manufacturer of wheel to this effect. A matrix with desiccants impregnated in non metallic substrates, such as synthetic fibre, glass fibre, etc. will not be accepted. The rotor/wheel matrix shall have equal sensible and latent recovery. The weight of desiccant coating and the mass of aluminum foil shall be in a ratio so as to ensure equal recovery of both sensible and latent heat over the operating range. Accordingly, a rotor matrix which has an etched or oxidised surface to make a desiccant on a metal foil and results in insufficient latent recovery and hence unequal recovery, or a rotor matrix made from desiccant integrated in a synthetic fibre matrix which results in insufficient sensible recovery, high rotation speed, and unequal recovery, will not be accepted.

B. Rotor : With optimum heat and mass through matrix formed by desiccant, of sufficient mass, coated on an aluminum foil, the rotor should rotate at lower than 20 to 25 RPM, thereby also ensuring long life of belts and reduced wear and tear of seals. The rotor shall be made of alternate flat and corrugated aluminum foil of uniform width. The rotor honeycomb matrix foil should be so wound and adhered as to make a structurally very strong and rigid media which shall not get cracked, deformed etc. due to change of temperature or humidity. The rotor having a diameter up to 2800 mm shall have spokes to reinforce the matrix. From 2000 mm diameter upwards, the option of a special wing structure, to prevent the rotors from wobbling or deforming due to the successive pressure differentials, will be available. Sectioned wheels, with pie segments, capable of being assembled in the field, shall be available as an option, above 2000 mm in diameter. The surface of the wheel/rotor should be highly polished to ensure that the vertical run out does not exceed + 1 mm for every 1 meter diameter, thereby ensuring, negligible leakage, if labyrinth non contact seals are provided, and minimal drag, if contact wiper seals are provided. The radial run out also shall not exceed + 1 mm for every 1 meter diameter, thereby minimizing the leakage/drag on the radial seals, and minimizes the fluctuation in the tension of the drive belt. The number of wraps (of alternative corrugated and flat foil) for every inch of rotor radii shall be very consistent so as to ensure uniform air flow and performance over the entire face in the air stream. Flute height and pitch will be consistent to a very tight tolerance to ensure uniform pressure drop and uniform airflows across the rotor face. The rotor shall be a non clogging aluminum media, having a multitude of narrow aluminum foil channels, thus ensuring a laminar flow, and will allow particles up to 800 microns to pass through it. The media shall be cleanable with compressed air, or low pressure steam or light detergent, without degrading the latent recovery.

C. The Cassette / casing :The recovery wheel cassette/casing shall be manufactured from tubular structure to provide a self supporting rigid structure, complete with access panels, purge sector, rotor, bearings, seals, drive mechanism complete with belt. The rotor/wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust and other pollutants, from the exhaust air to the supply air. It shall be possible, with proper adjustment, to limit cross contamination to less than 0.04% of that of the exhaust air concentration. The face and radial seals shall be four (4) pass non contact labyrinth seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring infinite life of the seals.

1.12 Air Curtain

A. Scope :

Scope of this section comprises the supply, installation, testing and commissioning of air curtain system suitable for system.

B. General Requirements :

All air curtains shall be supplied with the following from the factory:

a. Clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting inclusive of anti-vibration pads.
b. Paper pattern for installation.
c. Installation manual.
d. Operation manual.

C. All air curtains shall be supplied with the following accessories

a. Remote switch unit ï This unit allows the air curtain to be powered ON/OFF and to select any one of the three speeds
b. Door Limit Switch ï The device with Switch the unit ON/OFF as the door open close.
c. Joining Kits ï to be used when making parallel installations. This will provide the illusion of looking at single long unit instead of multiple units mounted together
d. Power controller ï Which optimizes the energy use of the system

D. Materials and Construction :

a. The units shall be surface / recessed mounted based on the door details .
b. The units shall be front entry bottom throw or top entry bottom throw as per the site requirement.
c. The casing cabinet shall be constructed from 20 Gauge corrosion resistant polished stainless steel with internal 16 Gauge galvanised metal frame work reinforcement to produce a stiff casing.
d. The discharge grille shall be produced from the extruded tear drop profile section and fitted with turning vanes to generate Good air velocity projection with high uniformity
e. Units shall be painted to any RAL color or supplied in brushed stainless steel
f. Units shall be with IP 21 rating
g. Grilles shall be separate for discharge and inlet of air
h. The fans shall be forward curved metal bladecross flow impellors. The fans shall be powered with 4 pole induction motors on resilient mountings ,suitable for continuous heavy duty operation, protected by an automatic reset thermal switch with sealed for life pre-lubricated sleeve bearings.
i. The specific fan power of the fan for the air curtain shall be less than 0.55 W/l/s on high fan speed.
j. Noise level of air curtain shall not exceed 54 dB (A) at a distance of 10ft from the unit

1.13 Automatic Controls and Instruments

The scope of this section comprises the supply, erection, testing and commissioning of automatic controls and instruments conforming to these Specifications and in accordance with the requirements of Updated Control schematics, Drawings and Schedule of Quantities.

All automatic controls shall be electric controls as described in the various sections of these Specifications. All instruments shall be as described in the various sections of these Specifications.

A. Automatic Controls

Automatic controls required for various types of machines have been described in the various sections of these specifications and shown on the Drawings. The individual safety controls and selected automatic controls may be installed within the machines by the manufacturers before shipment. However, the following automatic controls, if not already installed on the machines, may be installed at site by the contractor, as indicated in Schedule of Quantities.

B. Air Flow Switch will be supplied by BMS vendor to the HVAC contractor for installation wherever shown on updated BMS Control schematics and included in Schedule of Quantities.

a. Thermostat shall be electric, fixed differential cooling / heating type as specified herein, with sensing element located in the return air stream. All thermostats shall be supplied with the standard mounting boxes, as recommend by the manufacturer. The profiles, mounting arrangement and exact location of thermostats shall be approved at site. Requirement of thermostats shall be as shown on Drawings and included in Schedule of Quantities.

b. Humidistat will be supplied by BMS vendor to the HVAC contractor for installation with air handling unit for areas which require constant indoor humidity or humidity control, as shown on Drawings and included in Schedule of Quantities. One humidistat shall activate the necessary control in case the space humidity rises beyond the preset limit. These humidistat shall also de-energize these devices when the desired humidity is reached. Humidistat shall be snap acting or modulating type as per the requirement, 20-80 percent relative humidity range with differential of 5 percent. Humidistat shall have removable knob to prevent tempering of set point

c. **Combi sensors**: Combi sensors shall be supplied by BMS vendor to the HVAC contractor for installation with air handling units for areas which require constant temperature and humidity control as shown on drawings and included in the schedule of quantities.

d. **Instruments:**

Instruments required for different types of machines have been described in the various sections of these Specifications and shown on the Drawings. Following instruments may be provided as per the requirements indicated in the Schedule of Quantities.

e. Room Thermometer : shall be dial type, wall-hung temperature indicator, of appropriate range for cold stores and deep freezers, in accordance with the requirements of Drawings and Schedule of Quantities.

f. Room RH Indicator : shall be dial type, wall hung, relative humidity indicator of appropriate range, for special areas, in accordance with the requirements of Drawings and Schedule of Quantities.

g. Electronic Thermometer: shall be electronically operated Digital Temperature Indicator in accordance with requirement of Drawings and as included in Schedule of Quantities. The display shall be 3-5 digit Liquid Crystal Display. The thermometer shall consist of fully solid state integrated circuit. The thermometer shall have front LED `onô indication and automatic low battery indication. The resolution shall be 1° centigrade. Thermometer shall be complete with suitable electronic sensor to accurately sense the temperature with sensor housed in suitable air well / thermo well for air temperature / water temperature measurement. The thermometer shall be suitable for operation on 9V DC / 230V AC. The display unit shall be housed in attractive sheet metal cabinet with prominent display of conversion charts of °F & °C on front plate. Thermometer shall be complete with separable socket type interconnecting cables of 2 m length suitable for installation within a radius of 2 m of the thermo well or air sensing point.

h. Calibration and Testing

All automatic controls and instruments shall be factory calibrated and provided with necessary instructions for site calibration and testing. Various items of the same type shall be completely interchangeable and their accuracy shall be guaranteed by the manufacturer. All automatic controls and instruments shall be tested at site for accuracy and reliability before commissioning the installation.

2. PIPE & FITTINGS.

The scope of this section comprises the supply and lying of pipes, pipe fittings and support, and refrigerant piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards. Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes have been indicated on the Drawings, these are for Contractorôs guidance only and shall not relieve contractor of responsibility for providing smooth noiseless balanced circulation of fluids.

References:

- ASTEM B68/1995 and ASTM-B75/1983- copper tubes used for Refrigerant purpose .
- ASTM-E243 - Standard Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes
- BS 864-Part II - Specification for Capillary and Compression Fittings for Copper Tubes
- BS EN 29453 - Soft solder alloys. Chemical compositions and forms
- 1723 - Brazing. Methods for non-destructive and destructive testing

2.1 Refrigerant Pipes & Fittings: - Products:

A. All refrigerant piping shall be of copper tubes conforming to ASTM B68 / 1995 and ASTM ï B75/1983
B. Copper tubes shall be seamless, bright annealed with clean inside surface, free from all impurities.
C. Material of the tube shall be Phosphorous Deoxidized High Residual Copper with minimum 99.9% copper and 0.015% to 0.040% phosphorous.
D. Copper tubes shall have the following properties:

Sr. No.	Properties	Soft Annealed	Hard Drawn
		(ASTM-B68)	(ASTM-B75)
a)	Tensile strength	30 ksi (min)	45 ksi (min)
b)	Elongation	40% (min)	Not required
c)	Hardness	60 HV5 (max.)	55 HV5 (min)
d)	Grain size	0.040 (min.)	Not required
e)	Expansion	40% (min)	Not required

E. All tubes shall be 100% eddy current tested as per ASTM ï E243 and test certificate submitted.
F. All tubes shall be carbon film tested and test certificate submitted. Maximum residual carbon shall be 0.1 mg/dm2.
G. All tubes shall be deburred at both ends.
H. All tubes shall be free from carbon oxide or any other contaminant. Tubes for Non-CFC gas such as R134a, R410a, R600 etc. shall not be subjected to paraffin, wax, acids, chromium etc. in the factory and shall be cleaned & supplied without residues / oxides or carbon in the ID.
I. All tubes shall be pre-filled with nitrogen and capped on both sides before supply.
J. Tubes shall be ROHS complied as per EC directives for hazardous substances including mercury, lead, cadmium &hexavelent chromium.
K. Contractor shall submit all test certificates including Hazardous Substance Compliance **Certificate.**
L. **All hard tubes shall be printed with manufacturer's name,** specifications, size, hardness at regular intervals.
M. Tubes shall be duly capped and packed in polythene bags. Capillary and compression fittings of copper and copper alloys shall conform to BS 864-Part II. Solder wire and brazing alloys shall conform to BS EN 29453 and BS 1723 respectively.

N. Selected piping material shall have sufficient corrosion resistance and shall work for at least 15 years without any change in property for sea climate.
O. Line velocities for pipe sizing shall be as follows:

a) Suction - 6 to 20 MPS
b) Discharge - 10 to 17.5 MPS
c) Liquid - 0.5 to 1.25 MPS

Contractor shall submit a schematic piping diagram for each type of refrigeration Machine.

2.2 Refrigerant Pipes & Fittings: - Execution.

A. Design Drawings indicate schematically the size and location of pipes. The Contractor, on award of the work, shall prepare detailed shop drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. The pipe size shall be as per the machine manufacturers recommendation. He must keep in view the specific openings in the building through which pipes are designed to pass.

B. The selection of pipe size as per the shop drawing and the actual length of the pipes between indoor/outdoor tube calculated.

C. Piping shall be properly supported on, or suspended from, stands, clamps, and hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, clamps and hangers and be responsible for their structural sufficiency.

D. Wherever pipes pass through a fire rated wall / slab openings, the gaps shall be sealed with fire sealant of approved make.

E. All refrigerant piping shall be laid in cable trays. Direct clipping of pipes on ceiling or wall shall not be acceptable.
F. Refrigerant piping will be installed in following manner
   a. Cut the correct length of pipe with a tube cutter. End of the tube shall be cut at right angle to the axis. All burrs shall be removed with a file.

   b. Clean the outside and inside surface using cleaning pads or fine sand paper.

   c. Apply water soluble thin film of flux to the tube and fittings, to prevent copper from oxidizing and to ensure that the molten solder bonds the tubes and fittings.

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   d. Insert the tube into the fitting and push until the stop is reached.
      Wipe off excess flux with clean cloth.

   e. Apply heat on the assembled joints using lamps emitting clean, blue and soot free flame, till complete ring of the solder appears around the mouth of the fitting.

   f. Allow the joint to cool without disturbing the joint.Wipe off excess flux and other foreign matter

   g. Avoid any joints in non accessible areas such as shafts. All refrigerant pipes to be pressure tested before charging refrigerant.

2.3 Condensate Pipes & Fittings :- Products

All drain pipe and fittings shall be UPVC pipe conforms to IS 4985 class 3 for pipes sizes up to 50 mm and where as for pipe sizes from 63 mm and above material shall be UPVC SWR type B. The supports for drain piping shall be red oxide painted MS supports. Fittings shall be of pressure rating suitable for the piping system. In plant rooms condensate drain pipe to be G.I class B.

A. All pipes to be used for cold water (makeup), drain, condensate drain and fittings shall be GI / uPVC as indicated in BOQ.

B. All jointing in the pipe system shall be by threaded joints and/or by threaded flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.

C. All pipes supports shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed.

D. Fittings shall be galvanized steel `medium classô malleable casting of pressure rating suitable for the piping system. Flanges shall be of approved make. Supply of flanges shall include bolts, nuts, and gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections, or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping and are not separately identified in Schedule of Quantities.

E. Gate valves, globe valves, check valves and strainers shall be similar to those specified for chilled, condensing and hot water piping.

F. For proper drainage of AHU and FCU Condensate, öUô trap shall be provided in the drain piping.

G. All condensate drain piping shall be insulated and painted as per the other sections in this specifications (ñInsulationò, painting)

2.4 Condensate Pipes & Fittings: - Execution.

A. Design Drawings indicate schematically the size and location of drain pipes. The Contractor, on award of the work, shall prepare detailed shop drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in the building through which pipes are designed to pass. Suitable U Trap shall be provided to condensate drain piping and calculation of the same shall be as per approved ESP calculation.

B. Condensate drain should be shall be connected to nearest drain point as indicated in drawing.

The joints shall be properly sealed so that there is no leakage

2.5 REFRIGERANT & CONDENSATE DRAIN PIPING INSULATION: - PRODUCT.

A. Nitrile Rubber (for Refrigerant & Condensate Drain Piping)

Material shall be insulated with flexible, closed cell, elastomeric, class ó0ô nitrile rubber tubing or equivalent, of uniform density 60 t0 70 kg/cu.mt with the following properties:

a. Thermal Conductivity:

Less than 0.037 w/m.K at 0 DEG C (as per BS 874 Part 2 1986 or DIN 52613).

b. Water vapour permeability: **As per Din 52615**, shall not exceed **0.15ng/m.sec.pa**.

c. Water absorption: Less than 1% by volume.

d. Fire performance:

a) Surface spread of flame: Class 1 (BS476 Part 7, 1987)
b) Fire propagation (Total index) : Less than 12 (BS476 Part 6, 1989)

e. The material shall be rated as **class 1**, as per **BS 476 part 7**. the rating as per **din 4102** shall be **b1**.

f. The **smoke density** of the material as per **AS-1530.3** shall not exceed **1.**

g. The material shall have a fire approval from CBRI/fire advisor (Govt Of India)/chief fire officer.

h. For providing UV protection the insulation shall be cladded with minimum 30 micron aluminium pe foil. The cladding shall be factory finished to avoid site work. The minimum thickness will be as per specs. The insulation material will be provided with self-adhesive covered peel off paper, (as an alternative).

i. Temperature Range: 0^0C to 50^0C

B. Drain piping shall be insulated with 9 mm thick insulation applied in the same manner as specified for refrigerant.

C. All valves, fittings etc. for refrigerant piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified above. Valves, joints, yokes and spindles shall be insulated in such a manner as not to cause damage to the insulation when the valves are used or serviced.

D. All Refrigerant pipe work shall have minimum 19 mm thick insulation and higher sizes shall be as per the manufacturerôs recommendations.

E. Vapour barrier coating shall be applied to insulated refrigerant pipework coming in contact with atmospheric conditions (i.e outside the air conditioned area).

F. 26 G Aluminum cladding shall be applied to exposed pipework insulation of LMR and other pipings exposed to sunlight.

G. Drain piping shall be insulated with 9mm thick nitrile rubber insulation applied in the same manner as specified for refrigerant piping. Guaranteed absence of condensation in chilled water pipes at 5^0C in Mumbai ambient air conditions.

H. Above thickness shall be followed while selecting material for different applications.

2.6 REFRIGERANT & CONDENSATE DRAIN PIPING INSULATION :- EXECUTION.

A. Scope of this section comprises the supply, installation and testing of insulation as herein Specified and as per the requirements of Indian Standards.

Application of Refrigerant pipe insulation shall be as follows:

a. No insulation shall be applied until the pipe is satisfactorily pressure tested.

b. Pipe shall be thoroughly cleaned with wire brush and rendered free from all rust and grease.

c. Sleeve the insulation tube onto the pipes.

d. Seal all joints by proper adhesive.

e. For pipe insulation the material should be cut using a die /template to be provided by the manufacturer to ensure proper 45^0 angle is cut and the joining/overlapping of the insulation does not cause any buldging, or stretching

f. All valves, fittings, etc. for refrigerant piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified above. Valves, joints, yokes and spindles shall be insulated in such a manner as not to cause damage to the insulation when the valves are used or serviced.

g. Vapour barrier coating and aluminium cladding shall be applied to insulated refrigerant pipework coming in contact with atmospheric conditions (i.e. outside the air conditioned area).

h. All tests like pressure testing should be completed and recorded and all systems approved by the Owner/ Consultants before insulation is applied to the equipment, piping and ducting. Insulation material shall be manufactured by approved manufacturers and shall be of the type intended for the services specified.

i. Insulation materials and finishes shall be inherently proof against rotting, mould, fungal growth and attack by vermin, be non-hygroscopic and in all respects be suitable for continuous use throughout the range of operating temperatures and within the environment indicated.

j. Unless otherwise indicated, all thermal insulating materials used within the building shall, tested in accordance with ISHRAE. Alternatively, all thermal insulating materials used within the building shall be noncombustible with a facing of combustible material provided the facing is not more than 0.8 mm thick. Thermal insulating materials used within the building shall be free from substances which in the event of a fire would generate appreciable quantities of smoke, noxious or toxic fumes. When instructed by the Owner/ Consultants, evidence of fire classification, obtained from an approved testing laboratory, shall be provided by the Contractor in order to certify that materials comply with this clause.

k. Thermal insulation shall be applied to refrigeration pipe distribution system and to components within distribution system.

l. Where thermal insulation is applied to the outside of pipes, ducts, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated in the documents, a water vapor barrier shall be provided. The vapor barrier shall be applied such that it will be continuous and will give protection to the whole surface of the insulation, which it will be protecting. The vapor barrier shall not be pierced or otherwise damaged by supports or by the application of external cladding. At points of support, means of load distribution shall be provided as necessary.

m. At all points of support, both insulation and out covering shall be continuous and shall not be punctured or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to take the loads transmitted to the supports. The load- bearing insulation shall be extended on each side of the supports.

n. Only reinforced Aluminum tapes shall be allowed for the insulation joints and at the insulation Termination point.

o. At entries into buildings the weather-proofed insulation shall extend not less than 100 MM (4") beyond the inner face of the wall and be sealed to the satisfaction of the Architects/ Consultants.

3. Air Distribution

3.1 Ducts and Fittings.

A. Gi Ducts & Fittings - Products

a. Scope
The scope of this section comprises supply fabrication, installation and testing of all sheet metal / Pre insulated , supply, installation, testing and balancing of all grilles, registers and diffusers. All to be in accordance with these specifications and the general arrangement shown on the Drawings.

b. Duct Materials and Fabrication of GI ducts
Galvanizing shall be Class VIII ï light coating of zinc, confirming to IS-655-1963, nominal 120gm/Sq.M surface area and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at random by Employerôs Representative/consultant shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

Fabrication of ducts shall be through well conditioned Triplex lock former or multiple lock formers, conforming to relevant SMACNA Codes.

Rectangular Ducts G.S.	**External Pressure 250 Pa**		
	Duct Selection Length 1.2 Meters (4 feet)		
Maximum Duct Size	**Gauge**	**Joint Type**	**Bracing Spacing**
1-750 mm	26	C & SS	Nil
750 - 1000mm	26	4 Bolt Transverse Duct Connector - E (TDC) with built in sealant	Nil
1001-1200mm	24	4 bolt TDC ï E	Nil
1201 - 1500 mm	24	4 bolt TDC ï H	Nil
1501 - 1800 mm	22	4 bolt TDC ï H	600mm from joint
1801 - 2100 mm	20	4 bolt TDC ï J	600mm from joint
2101 - 2700 mm	18	4 bolt TDC ï J	600mm from joint

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat; 'AI' -Angle Iron in mm

*Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.
Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.

All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.
All edges to be machine treated using lock formers, flanges and rollers for turning up edges.
All ducts shall be fabricated and installed in workmanlike manner, generally conforming to relevant SMACNA Codes. Round exposed ducts shall be die-formed for achieving perfect circle configuration.
Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section ñInsulationò and as indicated in Schedule of Quantities. Duct dimensions shown on Drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of Quantities.

Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight.

All exposed ducts up to 60 cm width within conditioned spaces shall have slip joints - or flanged joints. The internal ends of slip joints shall be in the direction of air flow. Ducts and accessories within ceiling spaces, visible from air conditioned areas shall be provided with two coats of mat black finish paint.
Changes in dimensions and shape of ducts shall be gradual. Air-turns (Vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulenceõs. Ducts shall be fabricated as per details shown on Drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.

All sheet metal connection, partitions and plenums required to confine the flow of air to and through the filters and fans shall be constructed of 18 gage GSS / 16 gauge aluminum, thoroughly stiffened with 25 mm x 25 mm x 3 mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Doors shall be not less than 45 cm x 45 cm in size.

Plenums shall be panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards G S sheet and riveting shall be done from outside.
Self adhesive rubber lining minimum 5 mm thick instead of felt shall be used between duct flanges and between duct and duct supports in all ducting installation.

All ducts shall be installed generally as per tender Drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor.
The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of Ownerõs site representative in all its parts and details.

All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the Drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed,divided or curved to one side (the required area being maintained) all as per the site requirements.

If a duct cannot be run as shown on the Drawings, the Contractor shall install the duct between the required points by any path available, in accordance with other services and as per approval of Ownerõs site representative.
All duct work shall be independently supported from building construction.

All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel under ducts at no greater than 2 meter centre. All vertical duct work shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel

cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles/ channels shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash /anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.

Ducting over furred ceiling shall be supported from the slab above, or from beams, after obtaining approval of Ownerôs site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractorôs work in the building.
Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality expanded polystyrene around the duct and totally covered with fire sealant such as fire barrier mortar for complete sealing.

All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of flame retardant, water proof, silicon rubber impregnated flexible connection at least 10 cm long securely bonded and flange bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.
Suitable arrangement shall be provided in duct for fixing of duct smoke sensor (supplied by other vendor).
Toilet exhaust duct shall be provided with goose necking as shown in design drawings and exhaust shall continue operation in case of fire.

B. GI DUCTS & FITTINGS – EXECUTION.

a. All ductwork shall be constructed, reinforced, supported and installed in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible'.

b. All supply and return ductwork within 4.5 m of the air conditioning unit, measured from the unit along the duct, shall be 24 gauge sheet metal or heavier, but shall otherwise meet the aforementioned pressure and seal classes.

c. Ducts with a side dimension greater than 900 mm passing above acoustically rated areas (other than corridors) shall be fabricated from 18-gauge or thicker sheet metal. Ducts thinner than 22-gauge and pre-insulated ducts are unacceptable on this project.

Fire retardant Flexible canvas or rubber connectors with a minimum face length of 100 mm shall be used between the ducts and fans or Ductable units.

d. Make all laps in the direction of air flow. Hammer down all edges and slips so as to leave smooth finished surface inside the ducts.

e. All ducts shall be braced and stiffened and shall be tight so that they will not breathe, rattle, vibrate or sag. Cross-break or transverse bead all rectangular ducts with heights or widths of 300 mm or larger.

f. Duct sealant shall be manufactured by tender specified approved manufacturer and of food grade quality. Brush joints with the compound before and again after assembly. Exposed ducts shall be sealed on the inner surfaces only.

g. 4-bolt duct connection maybe used to connect lengths of square or rectangular Duct. Intermediate reinforcing and longitudinal joints shall be as specified above. These proprietary connections shall be installed as shown in the Manufacturerôs literature.

h. Seal the bottom and side joints of fresh air ducts or plenums to be watertight.

i. Flexible duct connections shall be of Class 1, corrugated aluminum flexible duct suitable for 120 Deg C and 1.5 kPa and shall bear the 'building unit' label of Underwriters' Laboratories. Flexible duct connections shall be insulated with 25 mm fiber glass insulation with density of 24 kg/m3 complete with vapor barrier. Maximum length should not exceed more than 1 meter.

j. Bends in flexible ducts shall have centerline radius of not less than 1 1/2 x diameter. Collars to which flexible ducts are attached shall be a minimum of 50 mm in depth. Metal flexible ducts shall be attached using a minimum of three #8 sheet screws equally spaced around duct. Ducts larger than 300 mm diameter shall have a minimum of five #8 screws. Screws shall be located at least 12 mm from duct end. Insulation and vapor barriers on factory-fabricated ducts shall be fitted over cone connection and supplementally secured with a draw band.

k. Generally more durable and noise-resistant sheet metal ducts are preferable to flexible ducts in connecting ducts to diffusers or boxes. However, flexible ducts may be used under the following conditions:

   Shown on drawings to allow easy location of diffusers does not pass through floors or fire walls and does not exceed 2.4 m in length. Flexible ducts shall not be installed in inaccessible locations, such as above gypsum board ceilings unless specific approval from the Consultant is obtained.

   .Where ductwork passes through a wall or floor, other than when a fire damper is required, pack around the duct using a fire resistant material to ensure a sound and air-tight joint. Cover the opening with sheet metal flange of the same metal thickness of duct, overlap opening on four sides by at least 38mm.

l. All supply linear bar grilles shall have string dampers for control purpose

m. Install ducts with fewest possible joints.

n. Install ducts with a clearance of 1 inch (25mm), plus allowance for insulation thickness.

o. Locate all sheet metal ducts where shown and size as shown. If changes of size or location of ducts are found necessary because of building construction, make a specific proposal for review by the Consultant prior to proceeding with the change.

p. Make changes of direction of horizontal ducts with elbows having an inside radius not less than the width of the duct. Make change of direction from horizontal to vertical duct with elbows having an inside radius equal to the depth of the duct. Where this is not possible due to the building construction, use turning vanes.

q. Provide access ports at convenient locations in all main ducts and main branch takeoffs with airtight covers and extension sleeves through insulation to allow air meter readings. Access ports shall be similar to 32 mm round openings as manufactured by E.H. Price or approved equal.

r. Provide flexible connections as specified at each building expansion joint, air handling unit and fan duct connection.

s. Paint visible internal surface behind each grille or register flat black.

t. Where duct is acoustically lined, duct dimensions shown are net, inside of lining.

u. For duct construction refer to the chart given in section B.
v. Sheet thickness shall be in accordance with SMACNA standard.

w. All duct works support used for the project shall be factory galvanized

C. PRE INSULATED DUCTS.

Pre-Insulated Ducting shall be fabricated from 20 mm thickness air duct panel sheet having dimensions of 3000 (Length) mm by 1200 (Width) mm and produced and Sandwiched with Polyisocyanurate (PIR) first quality insulating Foam having 35 Kg / m3 density. The Ducting Sheet shall have Lacquered & Embossed Aluminium facing on both sides.

Insulating foam material shall be Expanded Rigid Polyisocyanurate foam having Closed cell content not less than 95%, CFC/ HCFC free, Non Toxic, Non combustible, zero ozone depletion, Zero Global Warming Potential and Non ignitable.

Ducting panels shall comply with following or equivalent standards and manufacturer should produce M1 & F1 certification for Fire & Toxicity test results.

- BS 476: PART 6--Fire Propagation for Products
- BS 476: PART 7--- Surface Flame Spread (Class 1)
- Class O Fire Rating as per Building Regulation requirements.
- Thermal Conductivity Coefficient at 10^0C--0.022 W/m. K
- Smoke Opacity Indexð less than 10
- Rigidity class: 200000 Nm m^2/mm
- Water vapor permeability of laminations = 0

All required accessories; Connecting Flanges, Invisible Bayonet, Adhesive, Sealant, Duct Supports shall be part of ducting work for fabrication of the HVAC ducting in Square, rectangle, radius, offset construction etc., appropriate sizes of Aluminium flanges with self-adhesive good quality gasket shall be provided as a joinery or connection of duct pieces.

Excellent quality Silicon Neutral Sealant of Approved make along with fire rated PVC corners shall be used for sealing of all joints & corners.

Complete ducting shall be installed incorporating duct supports such as galvanized angles, threaded rods, self adhesive brackets, Etc.

Panel Specifications: --

Description	Internal Areas	External Areas of Building
Dimensions of panel	3000 x 1200 mm	3000 x 1200 mm
Thickness of panel	20 mm	20/30 mm
Thickness of aluminium laminations	60/60 microns (in /out)	60/200 microns (in/out)
Density of the foam	35 kg/m^3	35 kg/m3
Surface finish	Embossed/Embossed	Embossed/Embossed
Anti-rust lacquer	2 gm/m^2 both sides	**1** gm/m^2 both sides

D. Fire rated duct work

Ducting for kitchen exhaust & fire evacuation, staircase pressurization if not in a separate shaft shall be fire rated as per following specifications.

All fire rated ductwork constructed for mechanical or dual ventilation/ pressurization/ basement car park/smoke extract systems and kitchen exhaust shall

a. Insulation materials and finishes shall be inherently proof against rotting, mould, fungal growth and attack by vermin, be non-hygroscopic and in all respects be suitable for

continuous use throughout the range of operating temperatures and within the environment indicated.

b. Unless otherwise indicated, all thermal insulating materials used within the building shall, tested in accordance with ISHRAE. Alternatively, all thermal insulating materials used within the building shall be noncombustible with a facing of combustible material provided the facing is not more than 0.8 mm thick. Thermal insulating materials used within the building shall be free from substances which in the event of a fire would generate appreciable quantities of smoke, noxious or toxic fumes. When instructed by the Owner/ Consultants, evidence of fire classification, obtained from an approved testing laboratory, shall be provided by the Contractor in order to certify that materials comply with this clause.

c. Thermal insulation shall be applied to air distribution ductwork and to components within distribution systems such as fans and cooler casings which convey conditioned air within plant rooms and to ductwork (including recirculation air ductwork) conveying warmed or chilled air through unconditioned spaces or the open air. Distribution system conveying treated fresh air and apartment toilet exhaust air shall be insulated.

d. Thermal insulation shall be applied to refrigeration pipe distribution system and to components within distribution system.

e. Where thermal insulation is applied to the outside of pipes, ducts, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated in the documents, a water vapor barrier shall be provided. The vapor barrier shall be applied such that it will be continuous and will give protection to the whole surface of the insulation, which it will be protecting. The vapor barrier shall not be pierced or otherwise damaged by supports or by the application of external cladding. At points of support, means of load distribution shall be provided as necessary.

f. At all points of support, both insulation and out covering shall be continuous and shall not be punctured or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to take the loads transmitted to the supports. The load- bearing insulation shall be extended on each side of the supports.

g. Only reinforced Aluminum tapes shall be allowed for the insulation joints and at the insulation Termination point.

h. At entries into buildings the weather-proofed insulation shall extend not less than 100 MM (4") beyond the inner face of the wall and be sealed to the satisfaction of the Architects/ Consultants

E. Duct Thermal Insulation.

SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of the thermal and acoustic insulation for ducts and pipes.

MATERIAL

Insulation material of Duct shall be factory laminated Aluminum foil faced resin bonded fiberglass wool. The Thermal conductivity of the insulation material shall not exceed 0.033 W/m K at 25 deg C mean temperature and material Insulation material shall be non-toxic, chemically inert, non-combustible as per BS 476: Part 4, non-ignitable as per BS 476: Part 5, and class ó1Ôôas per BS 476 Part 6 &7 and also shall confirm IS 8183. The thickness and density of insulation shall be as per the table A. The Insulation shall also shall be incompliance with ECBC-2007 & ASHRAE 90.1-2004

TABLE 'A'

Sr.No.	Type Of Duct / Pipe	Area	Insulation Material Properties		Protective Jacket
			Thickness In (mm)	Density (Kg / m3)	
1	Supply and return Air AC Duct	Running In AC Area	25	24	Not Require
2	Supply and return Air AC Duct	Running In Non AC Areas such as enclosed in risers / shafts	50	48	Not require
3	Supply and return Air AC Duct	Running In Plant room / podium (Exposed Ducting) Areas	50	48	Require, 26G Aluminium Cladding

1. The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.
2. The duct should be inspected and all joints should be sealed against leakages.
3. For ducts having width greater than 0.6m, heavy duty self-adhesive pins are to be applied to the duct at appropriate intervals (max 300mm) as per manufacturerós Installation Manual.
4. The duct should be covered with two coats of cold applied bitumen/CPRX or any other equivalent approved product.
5. The insulation of specific R-value and thickness should then be cut to appropriate length and stuck to the duct while the adhesive is still wet. For proper laying technique, refer to manufacturerós Installation Manual.
6. All longitudinal joints and circular overlaps should be sealed with reinforced aluminum foil tape (50mm width) to make the installation leak proof. For large ducts, where adhesive pins have been used, speed washers/clips should be covered completely with Aluminum foil-tape to have an air-tight finish.
7. The insulation should then be secured over the duct using mechanically fastened nylon/steel straps (12mm/50mm) at appropriate intervals (max 1.2m).
8. After the installation the vapor retarding foil should be inspected and all tears should be sealed with Aluminum foil-tape to prevent air leakage.

F. DUCT ACOUSTIC INSULATION

Connecting duct of indoor unit shall be provided with internal acoustic lining for a distance of 3.0 meters (10'0") from the outlet with high temperature resin bonded fiber glass rigid board insulation backed by fiber glass tissue conforming to the following standards and specifications:

a) Thickness : 32 mm for 6Mtrs. length of DX outlets.

b) Density : 32 kg/m3 or 3 lbs/ft3

c) Acoustic Values : Greater than 1dB/m in the frequencies below 250Hz and greater than 5dB/m for frequencies 500 Hz and above in ducts of 600x500mm size

d) Temperature Range : 5^0C to 50^0C

e) Fire Safety : Non combustible in accordance with BS476 (1970)

Class 0Ôfire rating to the Building Regulation SectionE-15.

f) General : Should be chemically inert odorless, rot/ fungi/ vermin proof, should be dimensionally stable and should not be prone to sagging.

Alternately contractor to explore the option for nitrile rubber acoustic insulation and quote as RO in BOQ for acoustic purpose.

1. The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.
2. The duct should be inspected and all joints should be sealed against leakages.
3. Duct acoustic lining shall be provided for a distance of minimum 5 meters.
4. The inside surface for the ducts shall be covered with adhesive, and provided with 22 gauge GI Channels 25 x 25 mm screwed back to back and fixed on the inside of duct, spaced not more than 60 cm center to form a frame work of 60 x 60 cms square.
5. Cut panels 60 x 60 cms of resin bonded fiber glass 25 mm thick shall be fitted in the squares.
6. These insulation panels shall be fixed to the sheet metal with cold setting adhesive compound. The inner most surface shall be covered with fiberglass tissue and 28 gage perforated aluminum sheet having at least 15 percent perforations.
7. The aluminum sheet shall be screwed to GI channels using cup washer and neatly finished to give true inside surface.

G. OTHER INSULATION.

a. Drain Pan Insulation

If insulated drain pan is not part of the AHU, then drain pan shall be insulated as under: 25 mm thick 32 kg/m3 density FM Approved insulation shall be applied over the surface with help of cold setting adhesive. Insulation shall be covered with 20 mm x 24 G GI chicken wire mesh and then finished with two coats, 10 mm thick each of sand cement plaster; Factory supplied insulated Pans shall have similar or better properties.

b. False Ceiling Insulation:

With Rigid Fiberglass packed in Polythene bags. False ceiling shall be insulated with rigid resin bonded fibre glass as per following procedure: Pack resin bonded glass wool slabs in 200 gauge polythene sheets. These bags shall be laid over the false ceiling. The corners of each bag shall be laid with false ceiling skeleton work.

c. Data center insulation

Floor of data centre shall be insulated with 9mm thick nitrile rubber insulation as per specifications. 750mm x 750mm grid shall be made on the floor. This grid shall be made from 25mm wide 22G GI C-section. These C-sections shall be screwed to floor. Depth of screwing in to the floor shall not be more than 5mm. Sections of insulation shall be

sticked to floor with self adhesive / adhesive solution as recommended by insulation manufacturer.

d. Over Deck Insulation

Nitrile Rubber
INSULATION PROPERTIES:

Design Basis: Thermal Transmittance (target U value of composite roof - 0.012 btu/ft2/degF)

Design Conditions: Ambient Temp 45 Deg. C & Conditioned Area temp 22 Deg C. Thermal conductivity as per BS 874 part 2 ï 86 (DIN 52613 52612)of the insulation material shall not exceed 0.036 W/moK at an average temperature of 23 deg C. Density of the nitrile rubber shall be 40-60 Kg/m3. The product shall have temperature range of ï 40oC to 85 oC. The insulation material shall be fire rated for Class 0 as per BS 476 Part 6 : 1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. Water vapour permeability shall be not less than 0.024 perinch (2.48 x 10-14 Kg/m.s.Pa i.e. µ>7000: Water vapour diffusion resistance).

Type of Roof	Required Thickness (mm)	Adhesive Recommended
Metal Sheets 998	32 Two Layers of 16 mm	Armaflex 520 or Pidilite SR ï
Asbestos Sheet 998	32 Two Layers of 16mm	Armaflex 520 or Pidilite SR ï
RCC Slab 998	25 Single layer of 25mm	Armaflex 520 or Pidilite SR ï

e. Under Deck Insulation

Under deck insulation shall be 50mm thick TF Quality expanded polystyrene density 32 Kg/m3 , thermal conductivity 0.031 at 10 deg C or 30mm thick phenotherm density 35 Kg/m3 , thermal conductivity 0.017 at 10 deg C

Design Basis: Thermal Transmittance (target U value of composite roof - 0.012 btu/ft2/degF)
Design Conditions: Ambient Temp 45 Deg. C & Conditioned Area temp 22 Deg C.

Underdeck surface of ceiling shall be cleaned and made dirt free. Insulation panels shall be pasted on this surface with black CPRX compound. 28g wire net shall be tightened around insulation so as to avoid any kind of sagging. Ends of net shall be overlapping by at least 25mm. Overlaps shall be screwed with galvanised screws to avoid rusting.

3.2 Volume Control Dampers

A. All duct dampers shall be opposed blade louver dampers of robust 16 G GI construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.
B. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and easily accessible. Every damper shall have an indicating device clearly showing the damper position at all times.
C. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

D. The VCD shall be located in such a way handle operating mechanism shall be clearly visible.
E. All linear bar grilles shall have string dampers for control purpose.

3.3 Motorized Fire & Smoke Dampers

A. All supply and return air ducts at AHU room crossings, fire wall crossings and at all floor crossings shall be provided with Motorized Fire & smoke damper of at least equal to the fire rating of the wall or floor on which it is installed as per UL555/UL555S 1995 tested by CBRI. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span.
B. Fire damper blades and outer frames shall be of 16G galvanized steel construction fitted with 18 gauge extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheets steel. For preventing smoke leakage metallic compression seals will be provided.
C. Fire resistance rating shall be on the either side of the Fire damper.
D. The electric actuator shall be energized either upon receiving a signal from the Fire Alarm panel. The fire damper shall also close upon sensing temperature rise in supply air ducts through the electronic temperature sensor.
E. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. IP rating of the control panel shall be IP-56 for outdoor applications. This control panel shall be suitable for spring return actuator and shall have at least the following features:

    a. Potential free contacts for AHU fan ON/ Off and remote alarm indication.
    b. Accept signal from external smoke / fire detection system for tripping the electrical actuator.
    c. Fail safe position
    d. Test and reset facility.
    e. Indicating lights / contacts to indicate the following status:
    f. Power Supply On
    g. Alarm
    h. Damper open and close position.

F. Actuators shall be mounted on the external part of the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with its control panel. Control panel shall be wall mounted type.
G. MSFD shall be of low leakage design qualified to UL555S leakage class I. The combination of Fire & smoke dampers shall not exceed maximum temperature rating of 177 Deg C as per NFPA 90A.
H. It shall be HVAC Contractorôs responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Building Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.
I. HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.
J. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.
K. HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site.
L. Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts in accordance with the manufacturerôs recommendations.
M. The Contractor shall also furnish to the Owner, the necessary additional spare actuators and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

3.4 Fire Dampers

A. Whenever a supply/return duct crosses from one fire zone to another, floor crossings it shall be provided with approved fire damper of at least equal to the fire rating of the wall or floor on which it is installed as per UL555 1995 tested by CBRI.

   This shall be curtain type fire damper. For fire zoning kindly refer to the drawings issued by architect.

B. Fire damper blades shall be one piece folded high strength 21gauge galvanised steel construction Body shall be in 20 G and sleeve in 16 G. In normal position, these blades shall be gathered and stacked at the frame head providing 100% air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 71Deg C as specified in NFPA 90A.
C. Fire resistance rating shall be on the either side of the Fire damper.
D. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.

   - Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturerôs recommendation.
   - The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), as recommended by the manufacturer, at the time of commissioning of the installation.

3.5 Supply and Return Air Registers

A. Supply & return air registers shall be of either steel or aluminum sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminum registers shall be either Anodized or Powder Coated as specified in Schedule of Quantities. These registers shall have individually adjustable louvers both horizontal and vertical. Supply air registers shall be provided with key operated opposed blade extruded aluminum volume control damper anodized in matt black shade.

B. The registers shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air register shall be extruded aluminum construction with fixed horizontal bars at 15 Deg. inclination & flange on both sides only (none on top & bottom). The thickness of the fixed bar louvers shall be minimum 5.5 mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminum anodized in black colour shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.

   - All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.
   - All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.
   - Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to +45 degree horizontal arc and up to 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
     - Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.

3.6 Linear Bar Grilles

Linear bar grilles shall be fabricated from aluminum, with 6.4mm wide bars on 12.5mm 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 35mm deep and shall have a visible flange 25.4 mm wide. Mitred 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.

3.7 Linear Slot Diffusers

Linear Slot diffusers shall provide an unobtrusive continuous air diffusion with a pleasing aesthetic appearance. Hairline butt joints shall ensure clean unbroken linear runs for active and dummy sections. Slot width shall be 20 mm, unless otherwise indicated.

The diffusers shall be complete with pattern control blades, fully adjustable from face of diffuser through 180 degrees and shall be fitted with end caps at each end.

The diffuser members shall be constructed from high quality aluminum extrusions to BS le the pattern control blades shall be of black rigid PVC.

3.8 Louvers

A. Materials of Construction / Fabrication: Louvers shall generally be fabricated from extruded aluminum sections with mitered joints; unless otherwise stated or dictated by selection with minimum free area of 60%.
B. Finishing:

   Louvers shall have anodized / polyester powder coated colored finish, selected to match with the surrounding architectural finishes.

C. Manufactures to submit performance data based on AMCA 500 - Test Method for Louvers, Dampers and Shutters
D. Construction :

   Single angled louvers of 2.5 mm (12 gauge) thick, 100 mm (4 inch) deep blades set at 45° slope with centre baffle and return bend; set in heavy channel frame.

E. Accessories (for air intake):

   i) Exterior flat flange for installation on walls

   ii) 19 mm (3/4 inch) square mesh, bird screen; opposed blade, gang operated, volume control damper with removable key operator, adjustable from the grill face

   iii) 100 mm (4 inch) panel type washable air filter

F. Accessories (for exhaust):

   iv) 13 mm (½ inch) square mesh, bird screen

3.9 Square/rectangular ceiling air terminals:

Square/Rectangular ceiling air terminals shall be made of extruded aluminium construction with flush fixed pattern. The terminals shall have Anti-Smudge ring and spring loaded removable central core in various pattern for air flow direction. The terminal shall be mounted by concealed screw fixing arrangement. The supply air terminal to be supplied with Volume control device of extruded aluminium construction in black mat finish.

3.10 Curved blade terminals

Square /rectangular curved blade ceiling terminals shall be made of extruded aluminium. The terminals shall have individual adjustable blades mounted on nylon bushes which facilitate to adjust the direction of air as per site conditions. The terminals shall have 20 mm wide flanges all around and concealed screw fixing arrangement. The supply air registers to be supplied with Volume control device of extruded aluminium construction in black mat finish.

3.11 Multi slot ceiling air terminals

Multi slot air terminals shall be made of extruded aluminium with various slot width and air pattern deflectors. Deflectors in each slot provide an adjustable air pattern of 180 degree full. A special plenum shall be provided for each supply air terminal. The Linear terminals shall have alignment strips to give straight look while installation.

Volume control device of extruded aluminium construction in black mat finish shall be provided in S.A. duct collars.

3.12 Air transfer door Grille

Extruded aluminium construction air transfer door register will be provided as per approved shop drawings. The register will be complete with single /double register frame to be mounted on door panel from both sides. The central core shall be NO-SEE-THRU type. The register shall be powder coated. The register shall be provided with insect screen to prevent movement of insects from inside to outside or vice versa.

Note- Grille, Diffuser, Register & Louver color code shall be as per the Architect approval. Sample is required prior to ordering air side equipment.

4. Ventilation System.

4.1 Lift Well Pressurization System

In case of fire, the designated fire lifts shall be used by the local fire department staff to evacuate the occupants. Fire Lifts may also provide primary access routes for fire fighters in the event of an emergency. This strategy means these routes must remain clear and serviceable at all times by providing a smoke proof enclosure. This will be achieved using Lift well pressurization systems which will be designed to maintain positive Liftwell pressure relative to any occupied floor to prevent smoke infiltration which will compromise the access routes.

Fans to produce this Lift well pressurization will be located at Roof level and other floor as shown in schematic drawings.

The ventilation system associated with this condition is termed in this report as ñLift well pressurization fansö they can be termed as ñlife safety equipmentò The below mentioned is a philosophy for the emergency ventilation system to be used in case of fire in any floor.

Pressurization Provision is made for the fire lifts of the building, however pressurisation for other lifts to be verified if the same is specified in CFO NOC.

1. The Lift well pressurization fans will start upon receiving the signal from FA panel and pressurize the lift well to maintain 50 Pa. with respect to the lift lobby surroundings.
2. Upon receiving the signal from FA panel, Lift well pressurization fans will start and pressurize the lift shafts Lift well pressurization fans once started will continuously work until manual override. Uniform pressure of 50 Pa will maintain in the lift shaft with the help of Gravity damper. These dampers will be placed on top of the lift shaft, with weighted blades. The arrangement will be such that it will release excess pressure & maintain continuous 50 Pa pressure throughout the lift shaft.

4.2 Stair Well Pressurization System

In case of fire, the primary means of emergency egress is the stairwell. The same stairwell may also provide primary access routes for fire fighters in the event of an emergency. This strategy means these routes must remain clear and serviceable at all times by providing a smoke proof enclosure. This will be achieved using stair well pressurization systems which will be designed to maintain positive stairwell pressure relative to any occupied floor to prevent smoke infiltration which will compromise the access routes.

The Stair well pressurization fans will start upon receiving the signal from FA panel and pressurize the stairwell to maintain 50 Pa. with respect to the Stair well surroundings.

1. Stair well pressurization fans once started will continuously work until manual override. Uniform pressure of 50 Pa will maintained in the Stair well shaft with the help of Gravity damper. These dampers will be placed on top of the Stair well, with weighted blades. The arrangement will be such that it will release excess pressure & maintain continuous 50 Pa pressure throughout the stair well.
2. Standby arrangement for Stair well pressurization system to be provided as s indicated in schematic and equipment schedule.

4.3 Lift Lobby Pressurization System

In case of fire, the primary means of emergency egress is the stairwell& access to the stair well is though Lift lobby .The same lift lobby may also provide primary access routes for fire fighters in the event of an emergency. This strategy means Lift lobby routes must remain clear and serviceable at all times by providing a smoke proof enclosure.

This will be achieved using Lift lobby pressurization systems which will be designed to maintain positive Lift lobby pressure relative to any occupied floor to prevent smoke infiltration which will compromise the access routes.

3. The Lift lobby pressurization fans will start upon receiving the signal from FA panel and pressurize the lift lobby to maintain 30 Pa with respect to surroundings.
4. The Motorized Dampers installed at each floor air outlet shall be in normally closed position (N.C). Once the signal is received from FA panel the Motorized damper of the respective floor shall open to allow airflow to pressurise the lift lobby. Refer the logic diagram provided along with the schematic drawing for the complete working principle of lift lobby pressurisation system.
5. Lift lobby pressurization fans once started will continuously work until manual override. Uniform pressure of 30 Pa will maintain in the Lift lobby of fire affected floor with the help of motorized volume control damper. The control logic for the same & required differential pressure sensors shall be integrated with fan control panel. These dampers will receive the signal from FA panel.

5. Fire stopping And Smoke Seals,

Refer annexure -1 for details.

6. Testing And Commissioning

6.1 Scope

A. Testing, adjusting and balancing of Apartment heating, ventilating and air-conditioning systems at site.
B. Testing, adjusting and balancing of HVAC DX system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : 2007 HVAC Application.
SMACNA : Manual for the Balancing and Adjustment of air distribution system.

6.2 Performance

Verify design conformity, Establish fluid flow rates, volumes and operating pressures.Take electrical power readings for each motor. Establish operating sound and vibration levels, Adjust and balance to design parameters, Record and report results as per the formats specified.

6.3 Definitions

A. Test : To determine quantitative performance of equipment.
B. Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)
C. Balance : To proportion within distribution system (sub mains, branches and terminals) in accordance with design quantities.

6.4 Testing, Adjusting And Balancing (TAB) Procedures

The following procedures shall be directly followed in TAB of the total system. Before commencement of each one of the TAB procedure explained hereunder, the contractor shall intimate the PMC about his readiness to conduct the TAB procedures in the format given in these specifications.

6.5 Description Of System And Requirements

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

a. All supply, return and outside air systems.

6.6 Air Systems

A. Hl-wall Split / Ductable indoor Units Performance

The TAB procedure shall establish the right selection and performance of the indoor units with the following results:

- **a.** Air-IN DB and WB temperature.(degree Fahrenheit)
- **b.** Air-OUT DB and WB temperature.(degree Fahrenheit)
- **c.** Dew point air leaving. (degree Fahrenheit)
- **d.** Sensible heat flow.(Btu/hr)
- **e.** Latent heat flow.(Btu/hr)
- **f.** Sensible heat factor.
- **g.** Fan air volume.(cfm)
- **h.** Fan air outlet velocity.(fpm)
- **i.** Fan static pressure.(in wg)
- **j.** Fan power consumption.(kw)
- **k.** Fan speed.(rpm)

B. Air distribution

Both supply and return air distribution for each indoor units and for areas served by the indoor units shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers and Accubalance for grilles and diffusers.

C. The Preparatory Work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals :

a. All outside air intake, return air and exhaust air dampers are in proper position.
b. All system volume dampers and fire dampers are in full open position.
c. All access doors are installed & are air tight.
d. Grilles are installed & dampers are fully open.
e. Provision and accessibility of usage of TAB instruments for traverse measurements are available.
f. All windows, doors are in position.
g. Duct system are of proper construction and are equipped with turning vanes and joints are sealed.
h. Test holes and plugs for ducting.

i. **Readiness For Commencement Of Tab**

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

6.7 Tab Instruments

A. Air Measuring Instruments

a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.
b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8386/ 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.
c. Pitot tube.
d. Electronic Rotary Vane Anemometer TSI make or equivalent.

e. Accubalance Flow Measuring Hood TSI make or equivalent.
f. [All above instruments shall have a valid certification from a reputed testing institution.

B. Rotation Measuring Instrument

Electronic Digital Tachometer.

C. Temperature & RH Measuring Instrument

TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

D. Electrical Measuring Devices

g. Clamp on Volt ammeter.
h. **Continuity Meter.**
i.

E. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each indoor units/outdoor units and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the PMC. Sound level readings shall be taken at ten (10) locations in the building as selected by the PMC. The readings shall be taken on an Octave Band analyzer in a manner acceptable to him. The contractor shall submit test equipment data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All test shall be performed in the presence of PMC/Consultant.

6.8 Testing & Commissioning of Lift well Pressurization System-

A. As the name implies, the intent is to prevent smoke from migrating into the elevator shaft by pressurizing the shaft with respect to the rest of the building. Typically the pressure differentials are created by actively controlling dedicated supply fans and isolation dampers (if applicable) to supply the elevator shaft with 100% outdoor air.

   Pre functional checklist items include, but are not limited to, the following:

   a. Fan systems and isolation dampers (if applicable) are installed per contract documents and manufacturer's installation instructions.
   b. Control system point-to-point checkout complete to ensure all fan and damper input/output points are wired correctly.
   c. Normal power, and emergency if applicable, is provided to each fan and damper assembly at proper voltage.
   d. All fan systems have been balanced per the contract documents.
   e. All safeties and interlocks, especially fan status and high pressure cut-out, are installed and function per contract documents.
   f.

B. Typically, isolation dampers will open (if applicable) and supply fan will be commanded ON automatically upon an event signal. In order to test proper operation of the elevator shaft pressurization system, initiate an event signal and verify the following:
   a. All isolation dampers open (if applicable) and supply fans turn ON.
   b. The pressure differential exceeds the value required by code. (Measure and record pressure differential across each elevator door with all doors closed.) Note that stack effect; wind speed and direction; and outdoor temperature may all influence measured pressures and system balance.

7. Identification & Labelling

7.1 Color Scheme

Description	Standard and Reference	Lettering Colouring
Exposed duct Work	To architect's	
Air-Conditioning Duct Work	BSS 111 Pale Blue	Black
Ventilation Duct work	BSS 111 Pale Blue	Black
Conditioner Casings, Fan Coil Units, Filter Plenums	BSS 111 Pale Blue	Black
Electrical (Conduit Ducts and Motors)	BSS 557 Light Orange	Black
Drains	Black	White
Beltquards	Black and Yellow diagonal stripes (45 25 mm wide)	
Switchboards - Exterior / Interiors	BS 366 Light Beige White	
Machine Bases, Inertia Bases and Plinths	Charcoal Grey	

7.2 Identification Of Services For Piping Services

Lubricating	14 E 53
Drainage and Other Fluids:	Basic Colour Only
Electrical Services:	Basic Colour Only

In addition to the color bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows :-

Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

Pipe Line Contents	BS.4800 Colour Reference	Colour
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

Color Code indicator bands shall be applied as color bands over the basic identification color in the various combinations as listed below

Pipe Line Contents	Colour Bands to BS.4800
Cooling	00 E 55

7.3 Duct Work Services:

For Duct work services and its insulation the colors of the triangles shall comply with BS .1710:1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than150 mm length per side. One apex of the triangle shall point in the direction of airflow.

Services	**Colour**	**BS.4800 Colour Reference**
Conditioned Air	Red and Blue	04 E 53 / 18 E 53
Ward Air	Yellow	10 E 53
Fresh Air	Green	14 E 53
Exhaust / Extract / Re circulated Air	Grey	AA 0 09
Cold Supply Air	Blue	18 E 53

In addition to the color triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service ,identified as follows:-

Supply Air	S
Return Air	R
Fresh Air	F
Exhaust Air	E

The color banding and triangles shall be manufactured from self adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

----------END OF SECTION – B ----------