

## **Chapter 13**

### **TECHNICAL SPECIFICATION FOR HVAC WORKS**

### 1.0.1 GENERAL REQUIREMENTS

1. Piping material shall be as per technical specifications.
2. Piping shall be given one primary coat of Red Oxide / Zinc Rich Primer paint (As per piping material requirement) and given two (2) coats of finish paints of approved shade after installed. Pipes shall be sloping towards drain points.
3. All equipment and valve connections etc. shall be through flanges / unions as required for mating connections.
4. All welding of piping is subject to approval of client.
5. Strainers shall be Y – type / Pot fabricated / Casted steel body designed to test pressure specified. These shall have removal stainless steel (SS316) screen with 1 mm perforation and a permanent magnet.
6. The drawings indicate schematically the size and location of pipes. Contractor shall prepare detailed working drawings showing sections, details of fittings, hanger & supports, location of isolating, drain valves etc.
7. Piping shall be properly supported or suspended from brackets, hangers, stand, clamps etc. as per site requirement. The supports shall be steel, prime coated with rust preventive paint and given two (2) coats of finish paints.
8. Extra supports shall be provided at the bends and at heavy fitting like valves etc. to avoid undue stress on pipes. Insulated pipe shall be supported in such a manner as not to put undue pressure on the insulation.

Spacing of pipe supports shall not exceed the following:

<b>Pipe (mm)</b>	<b>Spacing (meters)</b>
Up to 15 NB	1.2
15NB to 25NB	1.8
32NB to 65NB	2.5
80NB to 125NB	2.5
150NB & Above	3

9. All fitting such as branches, reducers etc. shall have same dia. & thickness as the main pipe and its length shall be at least twice the pipe diameter.
10. Blank ends shall be formed with flanged joints with blank between flange pair.
11. Valves/capped connection shall be provided for all low points in piping system, necessary or required for draining all systems and also to permit repairs without interference with rest of the system.
12. During construction, open ends of pipes shall be temporarily closed with sheet metal caps to prevent debris from entering piping system.

13. Pipe sleeves of Galvanized Steel Pipe and 50 mm larger than OD of pipe shall be provided where pipes pass through walls, floor slab, beams etc.
14. Piping work shall be carried out with minimum disturbance to other works at site. A programme of work shall be chalked out in consultation with the RE (Resident Engineer) –in - charge.
15. Drain valves shall be provided at all low point in piping system and shall be minimum 25 mm size.
16. Pressure testing of pipe work, valves etc. shall be carried out at twice the working pressure of the particular system for a period of **24** hours as specified. All tools, labor, equipment, materials required shall be provided by contractor. Test reports shall be prepared for approval after testing has been carried out in presence of the RE (Resident Engineer) –in-charge. Test shall be repeated till the entire system/s is found satisfactory. After tests have been completed, the system shall be drained & flushed 3 to 4 times and cleaned of all dust, debris, foreign matter etc.
17. All pipes, supports, fittings etc. shall be given two coats of red oxide & then two (2) coats of finish paint in approved shade/color. All work of indication on piping, valves etc. shall be carried out by the contractor including proper labeling. Color coding and arrow marking.
18. Pressure gauges shall be not less than 100 mm dial, appropriate range and accuracy, complete with 100 mm needle valves as per system requirement and duly calibrated before installation.
19. Vibration Isolators shall be provided to eliminate vibration & stresses in various piping system & equipment.

SINO	Pipe Lines	Ground/Base color	First Band color	Second Band color
1	Treated water	Sea green	Light orange	
2	Raw Water	Sea green	French blue	
3	Hot Water	Sea green	Dark Violet	
4	Fire water	Fire red	Crimson red	
5	Compressed Air	Sky blue		
6	Vacuum Air	White		
7	Oxygen	Canary yellow	White	
8	Light Diesel	Light brown	Brilliant green	
9	Drainage	Black		

## 2.0 TECHNICAL SPECIFICATION FOR HVAC

### 2.0.1 GENERAL REQUIREMENTS

The Special / Particular Instruction and Conditions of Contract as described in this document are intended to amplify the General conditions of Contract and shall be read in conjunction with specifications of work, drawings and all other documents forming part of this Contract wherever the context so requires. The following clauses shall be considered as an extension and not in limitation of obligation of the Contractor.

All expenses incurred by the contractor in connection with obtaining information or submitting his tender including visits to the site or efforts in compiling the tender shall be borne by the contractor and no claims for reimbursement shall be entertained.

Notwithstanding the sub-division of the documents into separate sections and volumes every part of each shall be deemed to be supplementary to and complementary of every other part and shall be read with and into the contract.

Wherever it is mentioned in the specification, that the contractor shall perform certain work or provide certain facilities, it is understood that the contractor shall do so at his own cost.

The obligation of Contractor in fulfillment of HVAC works are stated below:

1. Procurement, fabrication and supply.
2. Inspection and testing.
3. Expediting and co-ordinating with other agencies.
4. Scheduling and Monitoring.
5. Training the Client in the Operation & Maintenance of the Plant.
6. Erection, checking and testing.
7. Commissioning.
8. Carrying out performance tests to meet the specification requirement and to the full satisfaction of CLIENT.
9. Providing Guarantee, Maintenance during Guarantee/Defects Liability period & Final documentation.

### 2.0.2 VRV SYSTEM

The scope of this section comprises the supply, erection testing and commissioning of Variable Refrigerant Flow System conforming to these specifications and in accordance with the requirements of Drawing and Schedule of Quantities.

Type: Units shall be air cooled, variable refrigerant volume air conditioner consisting of an outdoor unit and multiple indoor units. Each indoor unit shall have the capability to cool independently for the requirement of the rooms.

Compressor installed in each modular outdoor unit shall be equipped with multi inverter compressors for higher reliability, improved life, better backup and duty cycling purpose. The system shall be capable of changing the rotating speed of inverter compressor by inverter controller to follow variations in cooling and heating load.

Outdoor unit shall be suitable for mix match connection of all type of indoor units.

Both indoor units and outdoor unit shall be factory assembled, tested and filled with first charge of refrigerant before delivering at site.

### **2.0.2a OUTDOOR UNITS**

The outdoor unit shall be factory assembled, weather proof casing, constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired, tested with all necessary controls:

Each modular inverter outdoor shall be DC twin rotary compressor/ Scroll.

1. In case of modular outdoor units, the 20 HP outdoor unit shall have at least 1 inverter compressor so arranged that the operation is not disrupted with failure of any inverter compressor and if one inverter compressor malfunctions, other continues to provide emergency operation smoothly till repair is affected.
2. It should also be provided with duty cycling for multiple inverter compressor switching starting sequence for better stability and prolonging equipment life.
3. The outdoor unit shall be modular in design and should be allowed for side-by-side installation.
4. The unit shall be provided with its own microprocessor control panel.
5. The outdoor units should have anti-corrosion paint free base plate for easy mounting of unit.
6. The machine must have a sub cool feature to use coil surface more effectively thru proper circuit/bridge so that it prevents the flushing of refrigerant from long piping due to this effect thereby achieving energy savings.
7. The outdoor unit should be fitted with low noise, aero spiral design fan with aero fitting grill for spiral discharge airflow to reduce pressure loss and should be fitted with DC fan motor inverter type for better efficiency.
8. The condensing unit shall be designed to operate safely when connected to multiple fan coil units.

### **COMPRESSOR**

The compressor shall be highly efficient Rotary/ Scroll type and capable of inverter control. The inverter compressor shall change the speed in accordance to the variation in cooling or heating load requirement:

All outdoor units shall have multiple steps of capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated stock. Forced lubrication may also be employed.

Oil heater shall be provided in the compressor casing.

### **HEAT EXCHANGER**

The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminum fins to form a cross fin coil.

The aluminum fins shall be covered by suitable anti-corrosion resin film.

The unit shall be with e-pass heat exchanger to optimize the path of heat exchanger and for better efficiency of condenser.

The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical discharge. Each fan shall have a safety guard.

### **REFRIGERANT CIRCUIT**

The refrigerant circuit shall include liquid & gas shut-off valves and a solenoid valves at condenser end.

The equipment must have in built refrigerant stabilization control for proper refrigerant distribution.

All necessary safety devices shall be provided to ensure the safely operation of the system.

Refrigerant shall be R410a or R 407.

#### **SAFETY DEVICES**

All necessary safety devices shall be provided to ensure safe operation of the system.

Minimum requirements shall be high-pressure switch, fuse, fan drive overload protector, fusible plug, over load relay, overload protection for inverter.

#### **OIL RECOVERY SYSTEM**

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigeration piping lengths.

The system shall be provided with oil balancing circuit to avoid poor lubrication.

### **2.0.2b INDOOR UNITS**

This section deals with supply, installation, testing, commissioning of various type of indoor units confirming to general specification and suitable for the duty selected. The type, capacity and size of indoor units shall be as specified in detailed Bill Of Quantities.

**All the indoor units such as Wall split unit, Cassette, ceiling suspended unit, etc., must have inbuilt drain pump provision, if inbuilt is not available, drain pump accessories must be provided.**

Indoor units shall be either ceiling mounted cassette type, or ceiling mounted ductable type or floor standing type or wall mounted type or other as specified in BOQ. Each unit shall have electronic control valve to control refrigerant flow rate respond to load variations of the room.

The address of the indoor unit shall be set automatically in case of individual and group control.

In case of centralized control, it shall be set by remote controller.

The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having supported from housing.

The cooling coil shall be made out of seamless copper tubes and have continuous aluminum fins. The fins shall be spaced by collars forming an integral part. The tubes shall be staggered in the direction of airflow. The tubes shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fins. Each coils shall be factory tested at 21kg/sqm air pressure under water.

Unit shall have cleanable type filter fixed to an integrally moulded plastic/ Aluminium frame.

The filter shall be easily serviceable.

#### **CEILING MOUNTED CASSETTE TYPE UNIT (MULTI FLOW TYPE)**

The unit shall be ceiling mounted type. The unit shall include pre-filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized steel. The body shall be light in weight and shall be able to suspend from four corners.

Unit shall have an external attractive panel for supply and return air. Unit shall have four way supply air grilles on sides and return air grille in center.

Each unit shall have high lift drain pump, fresh air intake provision.

Low gas detection system and very low operating sound.

All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view. It should have provision of connecting branch ducts.

**CEILING MOUNTED DUCTABLE TYPE UNIT**

Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for Ductable arrangement. Each unit shall have high lift drain pump, fresh air intake provision.

**CEILING SUSPENDED TYPE**

Unit shall be suitable for ceiling suspended arrangement below false ceiling.

The unit include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. Each unit shall have high lift drain pump, fresh air intake provision.

**HIGH WALL MOUNTED UNITS**

The units shall be wall-mounted type. The unit includes pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

Unit shall have an attractive external casing for supply and return air.

Each unit shall have high lift drain pump, fresh air intake provision.

**FLOOR STANDING TYPE**

Unit shall be suitable for floor standing arrangement. The unit include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling and heating.

Each unit shall be with wired LCD type remote controller. The remote controller shall memorize the latest malfunction code for easy maintenance. The controller shall have self-diagnostic features for easy and quick maintenance and service. The controller shall be able to change fan speed and angle of swing flap individually as per requirement.

**2.0.2CENTRALISED REMOTE CONTROLLER ( TOUCH SCREEN)**

A multifunctional compact centralized controller shall be provided with the system. The Graphic Controller must act as an advanced airconditioning management system to give complete control of VRF airconditioning equipment, It should have ease of use for the user through its touch screen, icon display and color LCD display.

It shall be able to control up to 64 groups of indoor units with the following functions :-

Starting/stopping of Airconditioners as a zone or group or individual unit.

Temperature settling for each indoor unit or zone.

Switching between temperature control modes, switching of fan speed and direction of airflow, enabling/disabling of individual remote controller operation.

Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble shooting information.

Display of air conditioner operation history.

Daily management automation through yearly schedule function with possibility of various schedules.

The controller shall have wide screen user friendly color LCD display and can be wired by a non polar 2 wire transmission cable to a distance of 1 km. away from indoor unit.

**2.0.2dREFRIGERANT PIPING, INSULATION& CONTROL CABLING**

All refrigerant piping system shall be seamless copper pipe 18 gauge up to 19.1 mm and hard drawn copper pipe of 1 mm wall thickness beyond 19.1 mm. All fittings shall be copper. The piping shall be carried out following good engineering practice, and shall be neatly and adequately supported at intervals not exceeding 2500 mm.

The bends shall be preferably of long radius bends.

The piping shall be complete with charging connections, suction line insulation, and all other items reasonably considered necessary.

Before joining any piping, the internals shall be thoroughly cleaned, by passing a cloth by means of a cable or wire, through the entire length. The piping shall be continuously kept clean during erection. After the joints are constructed, the entire system shall be blown with dry nitrogen.

**Stage I:** The refrigerant piping shall be subjected to a pressure testing to a pressure of 200psi / 14.06 Kg/sqcm, Pressure shall be maintained in the system for not less than 24 hours.

**Stage II:** After connecting the refrigerant pipe with indoor units, piping shall be subjected to a pressure testing to a pressure of 350psi / 24.6 Kg/sqcm, Pressure shall be maintained in the system for not less than 24 hours.

**Stage III:** After connecting the refrigerant pipe with outdoor units, piping shall be subjected to a pressure testing to a pressure of 580psi / 40.7 Kg/sqcm, Pressure shall be maintained in the system for not less than 24 hours.

All joints shall be checked for leakages with soap solution. Leaks shall be marked, pressure released and rectified. System shall be recharged and tested till no leak exists. No measurable drop in pressure should be detected after pressure readings are adjusted for temperature charges. Pressure gauges and controls may be valved off during pressure testing.

**Stage IV:** After pressure testing is completed, evacuation shall be carried out with a 2 stage rotary vane vacuum pump connected to both the low and high sides of the system. Vacuum pump shall be operated to reduce the pressure to 750 microns absolute and allowed to operate at this pressure for 3 hours. System shall then be isolated and allowed to stand for 1 hours. Insulation for the suction line shall be done after the plant has been run for about 48 hours.

Refrigerant lines then be given 2 coats of enamel paint of the following colours:

Discharge lines	-	Cherry Road
Suction lines	-	Marine Blue
Liquid lines	-	Pale Yellow

Pressure testing and vacuumising are required to be done in the presence of the RE (Resident Engineer) / CLIENTs or their authorized representatives. Test certificates shall be duly signed by the contractor and endorsed by the concerned.

Control Cable must be looped between the indoor units and connected to the outdoor machine, then all the outdoor machines are looped then connected to the central remote controller. The looping must be done with 2x1.0sqmm copper wire in a PVC conduit, taken all along the refrigerant line.

The piping quantities indicated in the Schedule are only approximate and for the purpose or proper evaluation of the tenders. It will be the responsibility of the tendered to design the entire piping system, utilizing only those piping indicated under the Schedule.

All piping supports shall be adequately designed and shall have anchor fasteners, vibration isolators etc.

Elastomeric Nitrile rubber insulation of 19mm thickness shall be provided for the refrigerant lines. To protect this insulation, the same shall be covered with poly shield coating with at least two coats of resin and hardener. Fibreglass tape shall be helically wound over this and further shall have two coats of finish resin for smooth finish.

Drainpipes shall be with suitably sized PVC pipes and insulated with 6 mm thick Elastomeric Nitrile Rubber.

U traps, wherever required, shall be provided for the drainpipe

The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, etc. shall be insulated with 19mm /13 mm thick elastomeric nitrile rubber as specified in BOQ.

Drain pipes carrying condensate water shall be insulated with 6 mm thick elastomeric nitrile rubber insulation.

For proper drainage of condensate, U Trap shall be provided in the drain piping (wherever required). All pipe supports shall be of pre fabricated & pre painted slotted angle supports, properly installed with clamps etc.

## **2.0.3 VENTILATION SYSTEM**

Fans shall be of the type, size, arrangement and capacity as indicated in the schedule and/or as shown on the drawings.

Unless specified, fan performance rating data shall be tested accordance with AMCA Standard 210-85(Air Movement and Control Association), ANSI/ASHRAE Standard 51-1985 “Laboratory Methods of Testing Fans for Rating”. Sound ratings shall conform to AMCA Standard 300-85, “Reverberant Room Method for Sound Testing of Fans”.

A computer printout of fan performance rating corresponding to the AMCA licensed data, with corrected ratings for altitude and temperature, fan operating speed, bearing life, etc. shall be submitted for approval.

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.

Fan motors shall comply in all respects with continuous rating in accordance with IEC34 or equivalent. Motor bearings shall be of ball or roller type, grease or lubricant sealed for life. Fan and drive shall be earthed to prevent accumulation of static charge.

### **2.0.3aDUCTABLE INLINE FANS**

Inline fans shall be preferably be single skin with Insulation box Fan with backward curved blades & external rotor / TEFC motor suitable for outdoor installation based on capacities. These fans shall be complete with casing, motor & impeller.

Casing - Fans casing should have an outer casing of hot-rolled galvanized sheet steel complying with EN 10142/10147. The sheet steel must have a layer of 20 µm of zinc for protection against corrosion. The Insulated model should have 20mm acoustic and thermal insulation consisting of mineral wool with a density of 25Kg/m<sup>3</sup>.

Impeller should be backward curved with aluminum blades. These blades should be mounted on a galvanized steel plate. The impellers should be press fitted directly onto the rotor of the external rotor motor. In case of TEFC motor impeller should be placed on extended carbon

steel shaft of the motor and impeller should be balanced dynamically in two planes in accordance with DIN ISO 1940.

MOTOR - Fan motor should be external rotor type motor with built in thermal contacts for protecting against overheating. Compact in size and its construction should allow motor to be cooled by transported air. Three phase motors should be D/Y connected for two speed operations. Thermal contacts for overload protection should be provided and need to be connected to an external motor protection device for models with external rotor motors.

The motor bearings should be completely maintenance free and can be used at any installation position at indicated maximum temperature of transported air. The life expectancy of the bearing should be at least 41500 hours (L10).

Winding insulating shall be class F with degree of protection IP44 / IP54.

Motor speed shall not exceed 1450 rpm. Motor service factor shall be minimum 1.05.

Motor shall not operate within the service factor under normal operating conditions.

Drive- Fan should be direct drive to have reduced losses in transmission and higher efficiency.

Mounting and Installation– Fan should have a circular opening for inlet with square outlet for exhaust. Fan should be installed with weather protection cover when installed outdoor.

Noise level of fan should not be more than 55 db(A) @ 3m for fans with External rotor Motors

All fans shall be selected for the lowest operating noise power levels. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation. All the technical data of fans should be approved as per AMCA & ISO standards.

### **2.0.3b WALL AXIAL FANS**

Fan shall be of sickle blade impellers manufacture from galvanized steel, wall mounted with square plate, protection guard in the inlet, external rotor motor, allowable decibel range is less than 72db from 3.0mtr.

Fans should be factory assembled wired, ready to fit.

Motor shall be external rotor type for power supply 220~240V/50Hz/Single.

Fan motor should be external rotor type motor with built in thermal contacts for protecting against overheating. Compact in size and its construction should allow motor to be cooled by transported air.

Fan should be speed controllable in five steps.

### **2.0.3c CIRCULAR FANS**

Fan shall be of backward curved blades, external rotor motor, the fan must have inbuilt overheating protection with electrical reset switch. it should operate quietly, allowable decibel range is 40-50db from 3.0mtr.

Fans should be factory assembled wired, ready to fit.

Motor shall be external rotor type for power supply 220~240V/50Hz/Single.

Fan casing should be folded for achieving close to air tight casing. Fan must be tested for tightness class C for air leakage.

should be backward curve having polyimide blades. These blades should be mounted on a galvanized steel plate. The impellers should be press fitted directly onto the rotor of the external rotor motor. The motor and impeller should be balanced dynamically in two planes in accordance with DIN ISO 1940. Fan impeller should have self cleaning facility.

All fans shall be selected for the lowest operating noise power levels. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at

the time of testing and commissioning of the installation. All the technical data of fans should be approved as per AMCA & ISO standards.

### TESTING OF VENTILATION FANS

Functional test shall be conducted at site by the contractor.

The performance tests to determine whether or not the full intent of the specification is met shall be conducted by the contractor. The contractor shall conduct tests in the presence of Client / Project Managers' representative to establish the capacity of fans and various equipments.

The contractor shall operate test and adjust appliances and also effect adjustment of dampers etc.

All test equipment, labour, operation personnel required for these tests shall be shifted by the contractor to enable the system to be put in continuous running test for a period of two days or as required after all other tests and adjustments have been made.

Contractor shall be fully responsible for any damage to the fans during handling / installation and the same shall be rectified by the contractor without any extra cost.

### AIR BALANCING

After installation, quantity of air through every outlet shall be measured.

### TEST READINGS

The following readings shall be recorded during the tests and thereby capacity of the system shall be computed.

i.	Fan speed	RPM
ii.	Air quantity	CMH (CFM)
		Motor
a.	Rated KW/HP	KW/HP
b.	Rated Current	Amp
c.	Rated Voltage	Volt
d.	Actual Current	Amp
e.	Actual Voltage	Volt
f.	Starting Current	Amp

## 2.0.4 SHEET METAL WORKS VCDs AIR TERMINAL UNITS

### 2.0.4a SHEET METAL

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at manufacturer's works, delivery at site, installation, testing, commissioning and carrying out performance test at site of Air Distribution system.

All ducts shall be FACTORY FABRICATED. The accepted factories are listed in the approved manufacturer list.

### CODES and STANDARDS

The design, materials, construction features, manufacturer, inspection, testing and performance of air distribution system shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the system is to be installed. Nothing in this specification shall be construed to relieve the Contractor of this responsibility. In particular, the air distribution system shall conform to the latest edition of following standards.

IS 277 Galvanised Steel Sheet (Plain and corrugated).

IS 655 Metal Air Ducts.

IS 737 Wrought Aluminium and Aluminium Alloy sheet and strip for general engineering purposes.

SMACNA	HVAC Duct construction standards – Metal and Flexible.
SMACNA	HVAC Air duct leakage test manual.
SMACNA	HVAC systems – Testing, adjusting and balancing.
UL 181	Factory – Made Air ducts and connectors.
UL 555	Fire Dampers.
ASHRAE 70	Method of testing for rating the performance of Air Outlets and inlets.

### MATERIAL REQUIREMENT

Ducting shall be fabricated from Galvanised steel sheet (GSS) stainless steel (SS) sheet as specified.

GSS duct shall be of lock forming grade, zinc coated conforming to IS 277 coating grade 200 or better. AL sheets shall be of grade 31000 as per IS 737. SS duct shall be of SS 304 as per ASTM A 167.

### CONSTRUCTION FEATURES

Fabrication details shall be generally in accordance with the details given here under.

### RECTANGULAR DUCT

For Low Pressure System (upto Fan external static pressure of  $\pm 75$ mm WC).

LARGER SIDE OF DUCT mm	THICKNESS OF SHEET mm/G		TYPE OF TRANSVERSE JOINT	TYPE OF REINFORCEMENT
	GSS / SS	AL		
Upto 250	0.63 / 24	0.80 / 22	Rolamate / TDF	As per SMACNA
251 to 750	0.63 / 24	0.80 / 22		
751 to 1000	0.80 / 22	1.00 / 20		
1001 to 1500	0.80 / 22	1.00 / 20		
1501 to 2100	1.00 / 20	1.25 / 18		
2101 to 2415	1.25 / 18	1.50 / 16		
Greater than 2401	1.25 / 18	1.50 / 16		

For Factory fabricated ducts (for all sizes), the transverse joint shall be Rolamate / TDF flange only. C&S and C&SS type flanges are not acceptable for any size of ducting.

Ducts to be brought to site as Box sections including flanges. No longitudinal joints and flange assembly at site allowed.

For High pressure system duct (Fan external static pressure of +76 to +250mm WC) – Not Applicable

LARGER SIDE OF DUCT mm	THICKNESS OF SHEET mm/G		TYPE OF TRANSVERSE JOINT	TYPE OF REINFORCEMENT
	GSS / SS	AL		
Upto 600	0.80 / 22	1.00 / 20	40x40x3mm MS angle flanged joint	40x40x3mm MS angle @ 750 to 800 mm c/c.
601 to 1200	1.00 / 20	1.25 / 18	50x50x3mm MS angle flanged joint	50x50x3mm MS angle @ 600 mm c/c

1201 to 1500	1.25 / 18	1.50 / 16	50x50x3mm MS angle flanged joint	50x50x3mm MS angle @ 600 mm c/c
1501 to 2000	1.50/16	1.80 / 14	65x65x6mm MS angle flanged joint	50x50x3mm MS angle @ 600 mm c/c
Greater than 2001	1.50 / 16	1.80 / 14	50x50x3mm MS angle flanged joint with tie rod(s) of 10 mm diameter.	50x50x3mm MS angle @ 600 mm c/c with tie rod(s) of 10mm diameter, evenly spaced along reinforcing angle, spacing not exceeding 1500 mm.

Longitudinal seams shall be Pittsburgh lock type at corners as shown on sheet. Longitudinal joints shall not be provided for rectangular ducting at locations other than corners, except where larger side of duct exceeds 2500mm. Longitudinal joints of ducting having side larger than 2500mm other than corner shall be grooved or standing seam as shown.

If specified, sealing of the longitudinal seams shall be accomplished-using Dow corning RTV 732 Silastic or equivalent.

All circumferential joints shall be MS angle flanged joints.

Flanges used for transverse joints shall be joined with each other with Galvanised Steel (GS) bolts, washers and nuts. The bolts shall be of minimum M8 size and the spacing between bolts shall be maximum 150 mm for low-pressure system and 100 mm for high-pressure system.

For transverse angle flanged joints, neoprene gasket (3mm uncompressed thickness and width equal to flange face) adhered to the flange face shall be used. The boltholes in gasket shall be the same as bolt diameter and shall be punched prior to insertion of gaskets.

All flanges shall be applied with two coats of zinc-chromate, silver or zinc paint. (Red oxide is prohibited)

Angles shall have welded corners and shall be riveted to the ducts at 300mm centres. (Maximum).

For SS ducts all related appurtenances such as transverse joint angles, reinforcement angles, fasteners, turning vanes, access doors, etc. shall be of the same material as of duct.

### ROUND DUCT

Round duct thickness in mm/G for GSS/SS shall be as given below:

DUCT DIAMETER mm	UPTO 50 mmWC STATIC PRESSURE POSITIVE		51 to 250mmWC STATIC PRESSURE POSITIVE		UPTO 50 mmWC STATIC PRESSURE NEGATIVE	
	SPIRAL SEAM	LONGITU DI-NAL SEAM	SPIRAL SEAM	LONGITU DI-NAL SEAM	SPIRAL SEAM	LONGITU DI-NAL SEAM
Upto 200	0.42 / 28	0.42 / 28	0.51 / 26	0.63 / 24	0.42 / 28	0.63 / 24
201 to 350	0.42 / 28	0.51 / 26	0.51 / 26	0.63 / 24	0.51 / 26	0.63 / 24
351 to 650	0.51 / 26	0.63 / 24	0.63 / 24	0.80 / 22	0.63 / 24	0.80 / 22
651 to 900	0.63 / 24	0.80 / 22	0.80 / 22	1.00 / 20	0.80 / 22	1.00 / 20
901 to 1250	0.80 / 22	1.00 / 20	1.00 / 20	1.00 / 20	1.00 / 20	1.25 / 18
1251 to 1500	1.00 / 20	1.25 / 18	1.25 / 18	1.25 / 18	1.25 / 18	1.50 / 16
1501 to 2100	1.25 / 18	1.50 / 16	1.25 / 18	1.50 / 16	1.50 / 16	1.80 / 14

Round duct thickness in mm/G for aluminium sheet shall be as given below:

DUCT DIAMETER mm	MAXIMUM 50 mmWC STATIC PRESSURE POSITIVE		MAXIMUM 50mmWC STATIC PRESSURE NEGATIVE	
	SPIRAL SEAM	LONGITUDINAL SEAM	SPIRAL SEAM	LONGITUDINAL SEAM
Upto 200	0.63 / 24	0.80 / 22	0.63 / 24	1.00 / 20
201 to 350	0.63 / 24	0.80 / 22	0.80 / 22	1.00 / 20
351 to 650	0.80 / 22	1.00 / 20	1.00 / 20	1.25 / 18
651 to 900	1.00 / 20	1.25 / 18	1.25 / 18	1.50 / 16
901 to 1250	1.25 / 18	1.25 / 18	1.25 / 18	1.50 / 16
1251 to 1500	1.50 / 16	1.50 / 16	--	2.25 / 12
1501 to 2100	--	2.25 / 12	--	--

Round duct shall have longitudinal or spiral seam, as specified Data Sheet – A. Longitudinal and spiral seam shall be as shown on sheet.

Angle flanges shall be used for transverse joints and shall be joined with each other with GS nuts and bolts. Angle shall be minimum 25x25x3mm for ducts size upto 250mm and minimum 40x40x3mm for ducts size greater than 350mm.

For transverse angle flanged joints, neoprene gasket (3mm uncompressed thickness and width equal to flange face) adhered to the flange face shall be used. The boltholes in gasket shall be the same as bolt diameter and shall be punched prior to insertion of gaskets.

All flanges shall be applied with 2 coats of zinc-chromate, silver or zinc paint. (Red oxide is prohibited.)

For SS ducts all related appurtenances such as transverse joint angles, reinforcement angles, fasteners, turning vanes, access doors, etc. shall be of the same material as of duct.

Ducts shall be fabricated using lock-forming machine.

#### **DUCT SUPPORTS and HANGERS**

Rectangular Ducts shall rest on supporting 14 G GI Slotted channel and this supporting slotted channel shall be supported by full threaded GI rod from ceiling.

Supporting details for low-pressure system shall be as given below.

LARGER SIDE OF DUCT mm	SUPPORTING ANGLE mm	VERTICAL ROD DIAMETER mm	MAXIMUM SPACING BETWEEN SUPPORTS mm
Upto 900	40x40x6	10	2415
901 to 1500	40x40x6	10	2415
1501 to 2415	40x40x6	10	2415
2401 and above	65x65x6	12	2415

The GI slotted channel thickness shall be 14 G.

Supporting details for high-pressure system shall be as given below: - Not Applicable

LARGER SIDE OF DUCT mm	SUPPORTING ANGLE mm	VERTICAL ROD DIAMETER mm	MAXIMUM SPACING BETWEEN SUPPORTS mm
Upto 1250	50x50x6	15	2415
1251 to 2100	65x65x6	15	2415
2101 and above	Mc 75x6	15	2415

Round duct shall be supported using single or two hanger straps or rods. Straps and rods shall be of GSS.

Supporting details for round duct shall be as given below.

DUCT DIAMETER mm	STRAP			ROD	
	Nos.	WIDTH mm	THICKNESS G	Nos.	DIAMETER mm
Upto 600	1	25	22	1	7
601 to 900	1	25	20	1	10
901 to 1250	2	25	20	2	10
1251 to 1500	2	25	18	2	10
1501 to 2100	2	25	16	2	10

Zinc coated anchor fasteners or embedded plates shall be provided for upper attachments to the building. Anchor fasteners shall be provided by Contractor. Embedded plates shall be provided by Contractor. Contractor shall provide duct supports from angle cleats welded to the embedded plates. Anchor fasteners shall be loaded to maximum 20% of the maximum rated capacity specified by the manufacturer. Site RE (Resident Engineer) shall approve all anchor fasteners used for supporting duct.

In case of insulated duct, anchor fasteners shall be selected based on actual total load.

Duct supports shall be qualified and sized for seismic forces, if specified in Data Sheet – A.

#### **FLEXIBLE CONNECTIONS (Metal Duct connections to Supply / Exhaust Fan)**

Where sheet metal duct connects to the intake or discharge of fan units, a flexible of fire retarding double layer heavy duty canvas of at least 150mm width shall be provided. The material shall be attached to angle frames by means of steel and over the end of the flexible connection. The material shall be secured between the band and the angle frame by bolting. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both ends. The flexible connection shall be suitable for fan intake and outlet pressures. This shall be part of the equipment supplier.

#### **TRANSFORMATION**

Duct transformation shall be used to change the shape of duct and shall be made for easy and noiseless flow of air. Maximum slope of transformation shall be 1:4

#### **BENDS, OFFSETS and BRANCH CONNECTIONS**

All bends, offsets and branch connections shall be made for smooth and noise less flow of air and minimum pressure drop. In case of full radius elbow optimum ratio of centreline radius of elbow to duct dimension of 1.25 shall be considered. However, due to space constraint shorter radius constraint shorter radius elbow or square elbow with guide vanes may be provided. Contractor shall furnish the details of guide vanes i.e. number of vanes, location

etc. in the drawing. The flow of air to the branch duct shall be regulated by a splitter damper or volume control damper.

### **2.0.4bGRILLES & DIFFUSERS**

1. All (supply) side air grilles shall be of approved make with single deflection vanes and approved dampers. Supply air grilles shall be provided with non-adjustable type horizontal bars and adjustable type volume control multi louver damper which shall be key operated from the front of the grilles.
2. All return air grilles shall be identical to supply air grilles except that they do not incorporate volume control dampers.
3. All exhaust air grilles shall be of approved design with adjustable dampers.
4. All ceiling outlets shall be of approved make. Ceiling outlets for supply air to be equipped with volume control dampers, fixed grid and blanking baffles, where desired.
5. All grilles and diffusers shall be complete with powder coated painting (Color scheme will be provided by the Client.)
6. All air diffusers and grilles shall be purchased only from Air master or from established sources with full application literature available and fixed with fasteners which are not visible from outside and dampers which are operated from the face.
7. All MS frames rectangular or circular for fixing thereon of supply and return air grilles and diffusers shall be supplied by the Air-conditioning contractors. All grilles/diffusers shall be fixed using brass screws only.
8. All grilles/diffusers shall be selected in consultation with the Client/RE (Resident Engineer). Different spaces shall require horizontal or vertical face bars and different width or margin frames.

### **2.0.4cVCDS**

Contractor shall supply and install all dampers where necessary for proper control of volume and balancing of air distribution system. These dampers shall be separate from any other dampers provided with supply and return air diffusers, registers and grilles.

A multi leaf opposed blade type damper shall be installed in each supply air duct / return air duct / fresh air entry near the air handling unit outlet to adjust the total supply air cfm.

Dampers shall be of rigid construction free of all rattling and vibrations with edges crimped or creased for stiffness. It should be possible to adjust and lock the damper in any position. Fully open and fully closed position shall be clearly marked for ease in operation.

Dampers shall be provided with Teflon or brass bushings for blade shaft.

VCD (manual or motorised) shall be measured by their cross-sectional area perpendicular to air flow based on the approved drawing I as built drawing and paid per unit area. Quoted rates shall include necessary collars and flanges for mounting etc. No special allowance shall be payable for extension of cross-section outside the air stream. Volume control dampers in supply and exhaust fan units are part of fan units and no separate payment will be made for the same.

### **2.0.4dLOUVER**

Louvers complete with bird screen etc., shall be measured from the approved drawings / as built drawing on the basis of core area (excluding margin flanges) and paid per unit area.

Louvers in supply and exhaust fan units are part of fan units and no separate payment will be made for the same.

## **2.0.5 THERMAL INSULATIONS**

### **INSULATION FOR SHEET METAL DUCTING**

For Thermal Insulation for ducts, acoustic insulation (duct liner) & under slab insulation it is proposed to use Class “O” type Armaflex / Eurobatex (no alternative makes are acceptable) make closed cell elastomeric foam structure flexible thermal & acoustic insulation.

Insulation of specified thickness of above specified material manufactured as per ASTM E 84 test & which should also meet NFPA 90A supplementary materials for air distribution system which should not absorb less 0.2% water by volume (ASTM C 209), should not support microbial growth (ASTM C1071, G21, G22) and should emit objectionable odors (ASTM C 665) and should have thermal conductivity of 0.27 ( R - 2.78 in 3.4" thickness) and water vapor permeance of 0.10. All joints of the Insulation material should be further covered with 50 mm wide 3 mm thick self adhesive tape made of similar material & Black Cotton Tape shall not be used. The insulation executed on the ducts inside the AHU Room shall be further finished with fiber glass cloth for mechanical protection.

### **THICKNESS OF INSULATION**

Sheet Metal Ducting:-

- ◆ SA & RA ducts passing through conditioned areas-----20mm
- ◆ SA & RA ducts passing through un-conditioned areas-----40mm

Note: costing shall be included in insulation over that 24G aluminum cladding for protection, no such extra cost paid for cladding.

### **THERMAL INSULATION OF PIPE**

The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, etc. shall be insulated with 19mm /13 mm thick elastomeric nitrile rubber as specified in BOQ.

### **DRAIN PIPE INSULATION**

Drain pipes carrying condensate water shall be insulated with 6 mm thick elastomeric nitrile rubber insulation.

For proper drainage of condensate, U Trap shall be provided in the drain piping (wherever required). All pipe supports shall be of pre fabricated & pre painted slotted angle supports, properly installed with clamps etc.

## 2.0.6 ELECTRICAL EQUIPMENT INSTALLATIONS WORKS

### GENERAL

The scope of work covers execution and completion of the electrical installation work of the proposed project in accordance with drawings and specifications prepared by and under the direction and to the satisfaction of Client.

### RULES & REGULATIONS

The installation shall generally be carried out in conformity with the requirement of Indian Electricity Act 1910 as amended up-to-date and the latest Indian Electricity Rules and supplementary regulations of the State Electricity departments and electricity undertakings. Where the installation is subject to inspection and approval of Fire Insurance and Explosive Authorities, such installation shall be planned and executed to conform their special rules.

### MATERIALS

All materials, fittings and appliances used in the electrical installation shall be of the best quality obtainable and of approved manufacture and shall conform to the latest Indian Standard Specification wherever these exist.

### WORKMANSHIP

Good workmanship and neat appearance are the pre-requisites for compliance with the various sections of these specifications. The work shall be carried out under direct supervision of a person holding certificate of competency issued by the state government and in accordance with statutory rules and regulations in force. The relevant ISI code of practice shall be followed wherever applicable.

### CONTRACT DRAWINGS

The contract drawings indicate only the general scheme of requirement. Exact position of all points, controls, switch boxes and inspection boxes, main and sub-distribution boards etc., shall be got approved by the Client before the commencement of the work. Wherever required, detailed drawings shall be prepared and got approved.

The contractor shall provide detailed general arrangement drawing showing each compartments, modules, location of meters and relays etc. and wiring drawing with location of connectors, ferrule nos. Color code of wires etc., before starting of the manufacturing of panel.

The contractor is requested to obtain necessary approval from the Client before start manufacturing the panel. Any modifications required as per the local authorities shall have to be carried out without any extra cost.

### RATING AND STANDARDS OF MOTORS ( HIGH EFFICIENCY ABOVE 95% )

1. Rating of the motors shall be as indicated under the equipment schedule. Where the equipment supplied needs a higher rated motor, the contractor shall point out the same clearly and make his offer for the higher motor required by his equipment. Ratings shall be on the basis of the specified ambient temperatures, and without exceeding the maximum temperatures specified in IS 325 - 1961 amended upto date.
2. Unless otherwise stated, Indian Standard Specifications shall apply.

### INDUCTION MOTORS ( HIGH EFFICIENCY ABOVE 95% )& STARTERS

1. All motors 11 kw and below shall be TEFC type with class 'B' insulation conforming to IS25, unless otherwise specified.
2. Bearings shall be combination of ball and roller bearings with limit lubricators.

3. Ventilation shall be by means of shaft mounted fans designed to give maximum ventilation with a minimum of noise.
4. Terminals shall be of ample size housed in a terminal box. Modified sheet metal terminal boxes shall be provided to suit for cable or conduit entry as required. Two earth terminals shall be provided for terminal boxes.
5. All motors used for open type compressors and for air cooled condensers, shall be provided with IP 55 protection.

### STARTER

- Unless otherwise specified the following starting methods shall be adopted for the various motors.

Type of Motor	KW	Starting	Maximum	Minimum
Squirrel Cage	upto 7.5	D.O.L	5.0 F.L.	1.2 F.L
Induction	9.0 to 30	Star/delta	2.0 F.L.	0.4 F.L

- Where the load torque calls for a higher starting torque, (essentially for compressor drive and centrifugal fan drive) the contractor may provide the appropriate type of motor required to meet the load torque.
- Starters for Sq. cage induction motors shall conform to IS 1822 - 1961 and be the totally enclosed metal clad, dust proof, air enclosed type. The starter shall be suitable for the specified supply system and the ambient conditions.
- Semi hermetic compressors cooled by Refrigerant shall be started with part wind starter.
- Starters shall be complete with the following protection.
  - i. Thermal overload on all the three phases with adjustable settings.
  - ii. Under voltage protection.
- III L & T - ES - 100 / EE Single phase preventors. (These shall be provided separately in the panel as part of Electrical Work for all Starters of centralised AC system and only for compressors in Packaged Air conditioners.
- IV Sufficient extra contacts shall be provided for interlocks, indicating lamps etc.
  - Starters for motors of 11.0 kw and above shall be provided with ammeters with CTs wherever required

### INSULATION FOR MOTORS

- All motors shall be provided with two separate earth connections. Size of copper earth shall be equal to the size suitable for the supply conductor but not less than No. 8 copper.
- Flexible connections shall be provided to all motor wherever the motor is mounted on slide rails and belt drive is adopted. Even in the case of direct drive the connections

shall be flexible enough to prevent transmission of vibration. (Adequate slack to be provided).

### TESTING OF MOTORS (HIGH EFFICIENCY ABOVE 95%)

- Motors shall be tested in accordance with the relevant Indian Standard Specifications and test certificates furnished for routine, type and high voltage tests.
- Induction motor upto 37 KW shall be directly tested with 500 volts D.C meggar for one minute. If the insulation resistance is less than two meg ohms, the motor shall be dried out till a steady I.R. value of not less than two meg ohms is achieved.

### ELECTRICAL WORKS

The equipment schedule calls for electrical work under the following heads.

- Motors and matching starters these shall be offered under the respective heads where called for.
- Switch boards for Air-conditioning/ventilation system
- Electrical power wiring from switch board to individual motors and other equipment.
- Control circuit wiring from switch board to individual motors and other equipment.
- Earthing stations and loop earthing of the equipment.

**Note** Item (b) above is detailed with a starter. It is however clearly understood that this starter and ancillaries are the same as called for in (a) above and no duplication of these items, is to be made. Item (c), (d) and (e) - the electrical scope of work shall include for wiring of all controls, interlocks, cabling, earthing etc. upto obtaining electrical inspectorate approval and all similar formalities.

### GENERAL

Unless otherwise specified in the tender specification the entire equipment shall be suitable for operating on 415 Volts / 230 Volts, 50 Hz, earthed neutral, 3/1 phase AC system.

Electricity quality - motors and other electric equipments shall be operatable at following electricity quality without trouble

Voltage :415V, 3Ph, 230V, 1Ph +5%, -15% variation

Cycle : 50 Hz +1%,-7% variation

voltage dip: 5Hz voltage dip shall be allowed.

Control - if other voltage system for control system is required, necessary inbuilt transformer shall be provided.

- All components, accessories raw materials and finished parts used in the manufacture and assembly of switch boards, power and control circuit wiring and earthing system shall comply with the relevant Indian Standards amended upto date,
- The entire work shall comply with I.E.Rules. Particular care shall be taken to ensure compliance with rules 41,45,51 and 61.
- Site conditions :
- Ambient temperature 46 deg C average with 51 deg C peak
- Humidity 80% maximum
- Maximum temperature and humidity are likely to occur simultaneously

**POWER WIRING**

- Three phase motors and other power circuits of the air-conditioning system shall be connected to the main switch board through 3, 3.5, 4 core PVC insulated sheathed cables conforming to IS 1334. The size selections of these cables shall be made taking into account of the maximum rated current of the equipment, ambient temperatures and the applicable de-rating factors.
- All cables shall be of approved make only. They shall be of the **PVC Copper Armoured and installed in tight** fittings of treated brass glands and sockets. The cable sizing shall be done based on the manufacturer's data.
- Each individual motor feeder shall have a continuous capacity of at least 125% of the motor full load current. The minimum capacity of a cable supplying a group of motors should be at least equal to the sum of the full load current ratings of all the motors plus 25% of the full load current rating of the largest motor in the group.
- Cables shall be laid directly in ground or alternatively clamped in suitable metallic cable trays suspended from the ceiling or mounted on the walls. Wherever cables are laid underground, they shall be of the armoured type. The termination of cable sockets shall be of adequate dimensions. The cable conductors shall be crimped or soldered into these cable sockets. In the case of soldered joints, care should be taken to remove the oxide film through the use of appropriate type of flux.
- Cables shall be laid generally in accordance with Indian Standard Codes of practice.
- Cables shall be laid in trenches or buried or carried on walls as stated in the schedule, or approved by the Client
- Where more than one cable is running, proper spacing shall be provided to minimise the loss in the current carrying capacity.
- The control cables shall be suitably supported with wooden cleats fixed on M.S. supports when run on walls or in a trench.
- The cables in trenches shall not be laid loose or haphazardly and shall be tied up so that cooling of cables can be effective.
- When buried they shall be covered with a layer of soft shifted earth and protected with cement concrete tiles.
- Special care shall be taken to ensure that no undue stress is caused on the insulation. (to a radius of not less than 20 times the overall diameter).
- When cables pass through pipes, wooden bushes shall be provided at the ends. When these pass through floors and walls the cable holes shall be sealed.
- All cables shall have identification tags and shall be supported at close intervals to avoid strain on the glands.
- For the cables to be directly buried in ground, the scope of Air-conditioning contractor shall include excavation of trenches, supply of sand, bricks, concrete troughs, cable markers and back filling of trenches with river sand.

## ISOLATING SWITCHES

- Isolating switches or lockable type on & off stations shall be provided for isolation of each motor in emergency in accordance with IS 900 - "Code of practice for installation and maintenance of induction motors".
- All equipments away from the main switchboard requiring isolators close to their location shall be fitted with such isolators. Isolators will be complete with sheet steel enclosures, mounted in an approved manner on free standing angle iron frames.
- Double door constructions conforming to IP-55 grade of protection and epoxy coated isolators shall be mounted in an approved manner for the equipments located in exposed atmosphere.

## EARTHING

The Contractor shall provide earthing to ISI requirements. All the work shall be done to the satisfaction of the Electrical Inspectorate / concerned authorities.

### SIZE FOR EARTHING OF ALL EQUIPMENTS AND SWITCHBOARDS

The main panel shall be connected to the main earth bus by means of two numbers 50mm X 6mm GI strips. All switches, isolators db's and conduits shall be connected to the earth and the sizes of the earth conductors selected for various equipments shall be as follows:

Cross sectional area of the (Current carrying conductor Sqmm )	size of earth conductor
415V motor control centre	50mmX 6mm - GI strip
LT AC motor 150 to 200 kw	50mmX 6mm - GI strip
LT AC motor 110 to 132 kw	40mmX 6mm - GI strip
LT AC motor 55 to 90 kw	25mmX 6mm - GI strip
LT AC motor 15 to 45 kw	25mmX 6mm - GI strip
LT AC motor 3.75to 11 kw	16sqmm stranded GI wire
LT AC motor 0.75to 2.2 kw	6sqmm stranded GI wire
Control desk, control post	50sqmm stranded GI wire
Isolator and socket outlet	50sqmm stranded GI wire Above 16A and upto and Including 100A
Push button station, limit Switches, switch boxes	6sqmm stranded GI wire Isolators and socket outlets Upto 16A

The branch earth lines from the main panel to earth equipments shall be separated and should not criss-cross other lines. Earthing shall not be done by looping from one board. If screws slackens, all connection after that become ineffective. So it should be tied up or welded by running earth bus at convenient places and giving short and rigid lugs to the switches and glands.

The earth resistance of the earth pit shall be measured and the Contractor shall submit a record of measurement so obtained.

## 2.0.7 TESTING

Routine and type test for various items of equipment shall be performed at the Contractor works and test certificates shall be furnished. If required by the Client, his authorized representative shall be permitted to be present during the tests.

After notification to the Client that the installation has been completed, the Contractor shall make under the direction of Client such tests and inspections as have been specified or as the Client shall consider necessary to determine whether or not the full intent of the

Specifications have been fulfilled and whether further tests shall be considered necessary. The Contractor shall bear all the expenses thereof.

The contractor shall operate, test and adjust all Air-conditioning, ventilation and exhaust system units, fan motors, all air handling appliances provided in connection with the installation and shall make all necessary adjustments and corrections thereof including the adjustments of all regulating dampers. A carefully detailed record of the results of these adjustments shall be furnished to and be subject to the approval of the Client

## 2.0.8 MODE OF MEASUREMENTS

Representatives from the Contractor and Department shall conduct a joint inspection of the equipments. All the discrepancies observed either incomplete works or defective work shall be clearly indicated in the joint inspection report. An approved metallic tape shall be used at site and utmost care shall be taken to see that the same is preserved in good conditions throughout the period of execution.

The entire refrigeration unit/Chillers with all accessories, starters, controls, control panels, control wiring, vibration mounts, local control stations, discharge side plenum for direct throw units, floor mounting MS angle iron base, wall mounting MS angle brackets, protection grill for condensing unit, suspension arrangement, refrigerant piping, refrigerant charge oil, erection, commissioning and testing shall be regarded as one unit for the purposes of measurement and payment. Refrigeration piping and its insulation will also form a part of refrigeration/chillers unit and hence no measurement will be carried out for the same.

All sheet metal ducting complete with duct supports, hangers, vibration isolation pads, turning vanes, girth angles, flanges and gaskets, access panels, turning vanes, erected in position shall be measured externally and paid per unit area. All duct dampers shall be included in the duct area.

All manual control / splitter damper sections with operating linkages, locking, quadrant, sheet steel enclosure, frame, erection, supporting etc., shall be measured on the basis of damper cross sectional area and paid per unit area.

Intake louvers with bird screen, sheet steel louvers and control damper, frame, erection etc., shall be measured on the basis of cross sectional area and paid per unit area.

Side wall grilles shall be measured on the basis of the core area excluding the margin flange and the unit rate shall include necessary frames.

Ceiling diffusers also shall be measured on the basis of the core area excluding margin flanges and the unit rate shall include necessary frames and dampers.

Area of duct insulation finished as per specification shall be calculated on the basis of finished duct area before insulation and paid at unit area.

All painting shall form part of the cost of equipment, piping etc. No separate payment shall be admissible.

The unit rate for the cables includes the cost of cables and clamps, installation, commissioning and testing, cable marks or ceiling support.

The distribution board shall be considered as one unit and shall include:

1. Incoming and outgoing feeders
2. Interconnections, controls and instrument wiring

3. Meters, relays, indicating lamps, CTS, control fuses etc.
4. Supporting structure, sheet steel enclosure.
5. Installation and testing.

All water pipes shall be measured net length as laid or fixed and measured linear over all fittings such as bends junction etc., and given in running meters. The length shall be taken along the centre-lines of the pipes and fittings

### 2.0.9 LIST OF RECOMMENDED MANUFACTURER MAKES – HVAC

- |   |  |
|---|--|
| 1. Variable Refrigerant Volume System-                  | Daikin/Ogeneral/Toshiba                          |
| 2. Axial Fans   | - Systemaire/Flakt/Greenheck                     |
| 3. Wall Axial Fans                                      | - Systemaire/Ostberg/Carryaire                   |
| 4. Circular Fans  | - Systemaire/Ostberg/Carryaire                   |
| 5. GI sheet   | - Jindal/Tata/Sail                               |
| 6. Insulated Flexible ducts                             | - Sree venus/Carryaire                           |
| 7. Volume control dampers                               | - Carryaire/Air control industries/<br>Airmaster |
| 8. Duct sealant   | - Faster   |
| 9. Fire stop sealants                                   | - Hilti/Dafulite                                 |
| 10. Duct Acoustic                                       | - Armaflex/Kflex/Eurobatex                       |
| 11. Thermal Insulations                                 | - Armaflex/Kflex/Eurobatex                       |
| 12. Air terminal devices<br>(Grilles,Louvres,Diffusers) | - Airmaster / Aircontrol industries              |
| 13. Electric cables                                     | - Polycab/Universal                              |
| 14. MCBs/MCCBs  | - LT/Schneider/Siemens                           |
| 15. Cable Tray  | - Profab/Hitech                                  |
| 16. Cable glands  | - Comet/Standard metal                           |
| 17. CAV   | - Aldes/Trox/Systemair                           |
| 18. Heat Pipe   | - SPC/Mounter                                    |
| 19. Duct fabrication                                    | - Sree venus/Rolaster/Zeco/Cam                   |
| 20. Copper pipes  | - Mandhev/Rajco/Mehta tubes                      |
| 21. Vibration isolators                                 | - Kanwal / Sai Engineering/Tech<br>products      |

Note:

Recommended Manufacturers are listed above and the contractor is requested Resident Engineer's approval for the selection.

The contractor can select other manufacturers approved by Resident Engineer.