Gujarat University

TECHNICAL SPECIFICATIONS

HVAC WORK

Tender No: GU/ESTATE/PHY/2025-26/01

Tender Document

OF

Renovation & up-gradation of Physics Building at Gujarat University , Ahmedabad.

1. VARIABLE REFRIGERANT FLOW/VOLUME (VRF / VRV)

General Description

1. All Variable Refrigerant Volume Air Conditioners shall be totally Factory assembled, charged with refrigerant, wired, piped and tested at the factory by OEM.

2. The System shall comprise of Air-Cooled scroll, rotary, inverter / digital compressors type Outdoor units, and a variety of indoor units connected by Common Refrigerant Piping, refnets, piping, etc. and Power and Control Cabling.

3. All bolts, nuts, screws, washers, plates, etc. and all other fittings for all VRV system components shall be plated or passivated to resist corrosion.

VRV/ VRF System

1. The VRV System shall provide stable, trouble free and safe operations, and provide flexibility in operation of Indoor Units with independent control of each Indoor Unit, including steeples partial operation.

2. It shall be possible to switch on only those Indoor Units that require Cooling in individual Areas, zones or shops.

3. The capacity of Indoor and Outdoor Units shall be matched, sleeplessly, and shall include multi-Compressor cut off / speed control, by pass or any other means of capacity Control for stable operations of the System.

4. The System shall be capable of automatic operation even with varying Outdoor and Indoor requirements and make up of low Outdoor Temperatures to achieve lower Power Consumption, without any manual adjustments.

5. All Systems shall be modular in nature and easily upgradeable / inter connectable for larger capacities.

6. Units shall have hermetically sealed Scroll/Rotary Compressors, to ensure high EER.

7. The refrigerant gas shall be necessarily R 410a

8. All Units shall be Air Cooled type.

9. The System shall incorporate all required controls for parallel operation of Compressors, Condensers, Fans, and Indoor Units as well as Refrigerant liquid control.

Power Supply

1. All the units shall be suitable for operation with 415V+ 10%, 50Hz + 3%, 3 phase A.C. supply.

Outdoor Units

The Condenser coil shall be Air-cooled type with copper tubes and aluminum fins. The condenser coils shall be of adequate size and shall have an integral sub cooler circuit for sub cooling of the liquid. Condenser coil shall have a refrigerant side working pressure of 400 psig with anti-corrosive treatment. Condenser shall have multiple piping and cabling connection option. Pump down facility should be provided in the refrigerant system by providing good quality hand / shut off valves to avoid loss of Refrigerant gas during maintenance. The condenser fans shall be propeller type, with aluminum blades, low speed, and low vibration levels and quite in operation with IP 55 Protection.
All the compressors of the outdoor units must be hermetically sealed scroll type. Each module of outdoor unit must have separate 1 No. of inverter compressor, suitable to operate at heat load proportional to indoor requirement.
"Anti-Corrosive" treatment (Blue Fins) for Al fins of Condenser Coils is mandatory and shall carry warranty of at least Five (5) years. The treatment should be suitable for areas of high pollution and salt laden air.

The outdoor units must be suitable for more than 150 Meter Refrigerant piping between outdoor unit & the farthest indoor units and total piping of 300 Meter for all the indoor units. Allowable level difference between outdoor unit & indoor units shall be 50 Meter in case of outdoor unit on top & 40 Meter in case of outdoor unit at bottom. Allowable level difference between various indoor units connected to one outdoor unit shall be up to 15 m.
Back up operation, in case of failure of one of the compressors of outdoor unit, for single module outdoor units or failure of one of the modules in case of multiple modules outdoor units shall be possible. The VRV outdoor unit shall always be supplying at least 33% of back up operation, of the full load capacity.
The outdoor unit shall employ system of equal run time for all the compressors, inverter or on/ off type, within each outdoor unit – Single Module or Multi Module.
Starter for the Outdoor Unit compressor shall "Direct online" type. Inverter compressor of the unit shall start first & at the minimum frequency, to reduce the inrush current during starting.
Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.
The outdoor units shall confirm to Technological Guideline for Harmonic Suppression – JAEG 9702-1995. High Harmonic Environmental Target Level for Power Distribution system shall be 5%.

Safety Devices to be provided such as High-Pressure Switch, Overload protector, Fusible plug, Overload relay etc. Should be part of standard fitments in VRV systems.
ODU shall have all variable speed compressors with its controls to work at 415+_ 20 Volts with all necessary protections for overload, voltage fluctuations.

VRF Systems should meet or exceed the efficiency requirements as per below table.
Reference: ANSI/AHRI standard 1230 (ECBC Code-2017, pg. 42, Table No 5-6)

ECBC REQUIREMENTS	PROPOSED
AIR COOLED VRV	AIR Cooled

Indoor Units

Hiwall:

With decorative look to match with the interior Layout of Corded Remote type complete In PVC construction. Evaporating unit comprising of DX Cooling coils, blower, electric motor, insulated sandwiched drain Tray, and junction box for electrical connections, 20-micron HDPE washable filter The noise level of Hiwall unit at the highest operating level shall be maximum 47 dB (A). etc

Cassette Unit

These units shall be installed between the bottom of finished slab & top of false ceiling. The maximum allowable height for the cassette type units shall be 250 mm. The unit must have in built drain pump, suitable for vertical lift of 750 mm. The unit casing shall be Galvanized Steel Plate. Unit must be insulated with sound absorbing thermal insulation material, Polyurethane foam. The noise level of unit at the highest operating level shall not exceed 47 dB (A), at a vertical distance of 1.5 m from the grille of the unit.The unit shall be supplied with suitable decorative panel.

2. DOUBLE SKIN AIR HANDLING UNITS

Casing

Casing shall be of Double skin construction. Double Skin wall panels shall be 46+/-2 mm thick made of GSS, pressure injected with polyurethane foam insulation of density 38 kg/cum and K factor not exceeding 0.02 W / M2 ° C. Double skin wall panels shall be fixed to 2.5 mm thick aluminum alloy twin box section structural framework with stainless steel screws. Outer sheet of the panels shall be made of 0.6mm thick GSS pre-plasticized or powder coated. Inner sheet shall be 0.6mm thick plain GSS.

The entire framework shall be mounted on a 100mm (minimum) aluminum alloy channel base. The panels shall be sealed to the framework by heavy-duty “O” ring neoprene 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 on-site assembly match drilled, with bolts, nuts and continuous neoprene rubber gaskets. All fixing and gaskets shall be concealed.

Sloping condensate drain pan shall be fabricated from 1.2 mm (18g) stainless steel sheet and stainless-steel nipple for drain connection. It shall be isolated from bottom floor panel through 25mm thick heavy duty Treated for Fire (TF) quality expanded polystyrene or polyurethane foam. Drain pan shall extend beyond the coil.

Casing shall be of air-tight construction and sufficiently rigid to exclude vibrations, throughout the working capacity range of the AHU. Cooling Coils are to be connected to VRF system

The coil section of the AHU shall be of the cartridge-type, removable from the side of the casing and supported over the entire length of the coil. Chilled water coil shall be plate fin type with aluminum ripple corrugated fins and staggered cleanable tubes with not more than 5 Fins per centimeters. Fins shall have collars, belled and firmly bonded to the tubes by having the tubes mechanically expanded into the fins.

Coil face velocity shall not exceed as specified on the coil schedule. The number of fins provided should be the minimum needed to meet the performance requirements to minimize the pressure drop across the coil. Coil casing shall be 1.5mm thick galvanized, steel with drain holes in the bottom channels to insure condensate drainage. Coil tubes shall be copper mechanically expanded into aluminum plate fins. No soldering or tinning shall be used in the bonding process. Coils shall be mounted in the unit casing on non- corrosive aluminum slide rails to allow for easy removal when required. Coils shall be

designed to utilize the full available unit cross section area. Coils shall have automatic air vents, the vent outlets beings piped to the drain pan with a copper pipe. Each coil shall be proof tested at 26 bar (375 psig) leak tested at 17 bar (250 psig).

Fan

Fan wheels and scrolls shall be fabricated from best quality sheet steel. The fan wheels shall be of the backward curved / Plug type enclosed in housing and mounted on a solid shaft. (Type of fan as mentioned in BOQ)

Fan scrolls shall be fitted with die formed side sheet streamlined inlet and to ensure smooth airflow into the fan.

Fan shall be selected to achieve highest efficiency & lowest noise level. Selection shall be subject to Contractor's approval during detailed engineering by contractor without extra cost.

Filters – As mentioned in BOQ

Fan motors

Fan motors shall be 3 phase, sq. cage, and T.E.F.C. induction type, together with starters. The motors shall be capable of high initial starting torque requirement of fans & suitable for VFD application where ever specified.

Accessories

Air Handling Units shall be complete with all accessories & shall also include the following

- Expansion valves for cooling coils, Drain valve & drain piping.
- Vibration eliminators and flexible connections.
- Inspection glass on each section.
- Marine light dully interlocks with doors.
- Pressure sensing nipples on each section.

The exterior surface of air handling unit/s shall be powder coated.

CANVASS CONNECTION:

Double canvass-connection and GI collar of suitable length shall be provided at the outlet of each AHU. A zipper shall be provided in the canvass connection to facilitate measurement of supply air temperature.

UVGI LAMP FOR AIR HANDLING UNIT COIL CLEANING

CSA/UL/ETL certified, 254 nm UV-C UVGI (Ultra Violet Germicidal Irradiation) Lamp/s installed downstream of cooling coil for cleaning of cooling coil and drain pan of AHU. Irradiation intensity to be selected for effective performance right until the end of lamp life and considering normal fouling of lamp in AHU duty, with a rust-proof, sturdy frame/stand/clamps and aluminum parabolic reflector for >90% reflection. Ti-O2 coating on lamps to filter out O3.

Power source mounted outside the AHU.

Safety Interlocks, ON/OFF/ERROR indicator, UV Intensity display, Total Run Time Indicator, RTC, Lamp-change reminder.

Min. 5-Year Performance Guarantee in continuous (always ON) operation, power source/ballast life: min. 5 years, lamp life: min. 8760 hours operation

Irradiation intensity/UV dosage to be selected for effective performance till the end of lamp life.
Min UV Irradiation intensity of 350-400 μW/Cm2. Software selection to be submitted along with Quotations.

3. Refrigerant Piping & Insulation:

All refrigerant piping shall be in high Gauge (1.21 grade copper 18 mm) including all connections, Tees, Reducers, etc. Required nos. of Refrigerant joints with insulation should be provided for uniform flow of refrigerant through all Indoor units.

All refrigerant piping shall be insulated with minimum 19mm thick insulation for the entire length; and flexible braided pipe (for external runs of pipe). Insulation shall be nitrile rubber covered with glass-cloth having density of 200GSM. All exposed piping insulation shall be with UV Protection/UV Coating with glass cloth fabric. Pipes should be installed in an accessible position wherever possible. Exposed to sun & visible piping shall be covered by braided PVC pipes/sleeves for mechanical protection and aesthetics. Additionally, pipes on terrace shall be covered with minimum 24G GI sheet cover for mechanical protection. GI cover shall be painted for rust-prevention.

Necessary filters, driers, gauges, sight glass, safety cut-outs, etc. shall be provided in each refrigerant circuit as per the manufacturer's standards. Number of joints shall be kept to a minimum, and all joints must be located in the accessible runs of the pipes. Continuous, joint-less pipes must be used for all concealed/buried/inaccessible piping. Adequate extra length of pipes shall be left during piping work to avoid unnecessary joints during installation of indoor & outdoor units.

Provide high-density insulated pipe supports (e.g., Armafix-T) supplied by the insulation manufacturer, at each pipe support and clamp to prevent insulation compression, thermal bridging and condensation. Alternatively provide PVC pipe sleeves over the normal insulation at all supports cable ties & clamps to prevent insulation compression.

Pipes or ducts entering into the building through external wall cutouts should slope away from the building cutout, to stop rain water entering the building along through any gap between duct/pipe and the closed cutouts.

Pipe and duct ends shall be kept closed at all times before and during installation to prevent ingress of moisture, dust and construction debris.

All pipe supports shall be strong enough to withstand bending stresses in the pipes and shall be spaced not more than 1800mm apart.

Each support shall be isolated from the supported pipe or fitting by anti-vibration springs or durable, non-deteriorating liner of rubber or neoprene.

Wherever pipes are laid in two layers, an additional strip/support to be provided between the two layers so the pipes do not rest on each other.

Before gas charging, the entire piping system should be vacuumized and pressure tested with nitrogen at 10 Kg/sqm (or as required for the system pressure rating) for 24 hours.Air tight factory supplied rigid

insulation should be provided on all Ref-Net Joints / Y-Joints after pressure testing. Each Ref. Joint / Y-Joint should be properly supported to keep it in perfectly horizontal position.

All copper pipes except 6mm diameter shall be insulated with minimum 19mm thick Nitrile Rubber insulation for the entire length. Pipes up to and including 6mm may be insulated with 13mm thick Nitrile Rubber insulation

PVC sleeves or high-density insulation sleeves to be provided wherever pipes passes through cutouts in walls or wooden partitions to avoid compression of insulation.

Avoid installing pipes directly above the A/C machines.

All exposed insulation on terrace or in open shafts should be protected with UV paint / UV coating & glass cloth having density of 200GSM (Arma Chek GC or equivalent), and finally covered with removable GI sheet cover for mechanical protection. UV protection must be applied immediately after installation of insulation to prevent damage from sun-light. Sufficient valving shall be included to allow compressors to be removed for service & to allow the refrigerant to be pumped in to and contained in the condenser. The unit shall be equipped with a liquid line shut off valve, filter drier, liquid line sight glass, and solenoid valve & insulation where required to prevent condensation forming.

Pressure Testing & Evacuation

After brazing of the complete piping, the next step is to the test the system for leakages if any. Complete leak testing and proper evacuation is a must as non-condensable gases and moisture in the system will have ill-effects on system behavior as below:

- Pressure in the system rises.
- Operating current rises.
- Cooling or heating performance drops drastically.
- Moisture in the system may freeze and block the small opening of valves and capillaries.
- Moisture in the system reacts with oil in presence of refrigerant and forms organic and

inorganic acids, which in turn react with copper. Copper gets deposited on hot surfaces like bearing surface of compressor shaft, discharge side of scroll set etc. and can damage the compressor severely.

- Therefore the tubing connecting the indoor unit and outdoor unit must be pressure tested and evacuated properly to expel the non-condensable gases and moisture from the system.

Pressure Testing

Check visually that all piping is properly brazed.

Note that all service valves of the outdoor unit are closed at this stage.

• Use a TEE connection for connecting both liquid and suction service valve.
• The Oil balance tube leak test is not necessary if only one outdoor unit is installed.
• Add a Pressure Test Oil Equalizer line also in case of multiple ODUs installation.
• Always pressurize both suction and liquid side of piping system.
• Pressurize the system in steps of 100, 200, 300, 400 and 550 psig. Check for any leak at each step using soap bubbles. Pressure must be within 2 psig after two hours.
• Do a leak-test of all joints of the tubing; any bubbles indicate a leak. Wipe off the soap with a clean cloth after a leak test.
• Keep pressurized for 12-24 hours and check for any drop in pressure.
• After the system is found to be free of leaks, release the nitrogen pressure by loosening the charge hose connector at the nitrogen cylinder.
• When the system pressure is reduced to normal, disconnect the hose from the cylinder.

Pressure testing shall be carried out thrice: on completion of piping work, on installation & connection of Indoor Units, and on installation & connection of Outdoor Units.

Drain Piping for Ceiling Suspended/Wall mounted units:
Condensate from the Indoor unit shall be drained through properly installed drain piping designed to prevent any accumulation of condensate in the drain pan. Drain piping shall be made of rigid PVC pipe of 6 Kg/cm sq. pressure rating with water tight threaded connections& 9 mm thick nitrile rubber insulation. Leading from the Indoor unit to a suitable drain point. Complete drain piping shall be made leak proof and water tight by means of precise installation and the use of leak proof sealant / adhesives.

All Drain pipe shall be rigidly and securely supported, in an approved manner, with 8mm galvanized steel rods. The spacing between supports should be not greater than 2.0 meter.

Drain Piping for floor mounted AHUs:40mm dia GI "B" Class drain piping insulated with 8mm Class O Nitrile Rubber insulation; from each AHU to nearest drain point. Provide suitable U traps.

4. SHEET METAL DUCT WORK - Factory Fabricated Ducts as per IS-655

Material
All the ducts shall of LFQ (Lock Forming Quality) grade prime1 G.I. raw material furnished within accompanying Mill Test Certificates. Galvanizing shall be lead free sheets having min. 120gms\sqm. (Total coating on both sides). Approved manufacturer for GSS coil are National\Tata\Jindal\Ispat.
In addition, if deemed necessary, samples of raw material, selected at random by owners' site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.
The G.I. raw material should be used in coil-form (instead of sheets) so as to limit the longitudinal joints at the edges only, irrespective of cross-section dimensions.

Governing Standards
Unless otherwise specified here, the construction, erections, testing and performance of the ducting system shall conform to the IS – 655.

Duct Connectors and Accessories

All the transverse duct connectors (Flanges) and accessories related hardware such as support system shall be zinc coated (galvanized).

Fabrication Standards

All the ductwork including straight sections, tapers, elbows, branches, shoe pieces, collars, terminal boxes and other transformation pieces shall be factory-fabricated. Equivalency will require fabrication by utilizing the following machines and process to provide the requisite quality of ducts and speed of supply.

Coil Lines to ensure location of longitudinal seams at corners\folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any side of the ducts.

All ducts, transformation pieces and fittings shall be made on CNC profile cutters for required accuracy of dimensions, location and dimensions of notches at the folding lines.

All edges shall be machines treated using lock-formers and rollers for furning up edges.

Selection of G.I. and Transverse connectors.

Duct Construction shall be in compliance with IS – 655.

All transverse connectors shall be 4-bolt system.

To avoid any leakage additional sealant shall be used.

The specified class of transverse connectors and duct gauge for a given duct dimensions shall be 1" (250 Pa) pressure class.

Non-toxic, AC-application grade P.E. or PVC gasketing shall be provided between all mating flanged joints. Gasket sizes shall conform to flange manufacturer's specifications.

Duct Construction

The fabricated duct dimensions shall be as per approved drawings and all connecting sections shall be dimensionally matched to avoid any gaps.

Dimensional Tolerances: All fabricated dimensions shall be within + 1.0mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerance shall be + 1.0 mm per meters.

Each duct pieces shall be identified by coded sticker, which shall indicate specific part numbers, job name, drawing number, duct sizes and gauge.

Ducts shall be straight and smooth on the inside. Longitudinal seams shall be airtight and at corners, which shall be either Pittsburgh or snap Button Punch as per SMACNA practice, to ensure air tightness.

Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7) Turing vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

Plenum shall be factory fabricated panel type and assembled at site.

Factory fabricated ducts shall have the thickness of the sheet as follows and length of the piece not more than 1200 mm and should have beading at every 300 mm

The gauges, joints and bracing for sheet metal ductwork shall further conform to the provisions as shown on the drawings.

Ducts larger than 600 mm shall be cross broken, duct sections upto 1200 mm length may be used with bracing angles omitted.

Changes in section of ductwork shall be affected by tapering the ducts with as long taper as possible.

All the branches shall be taken off at not more than 45 DEG. Angle from the axis of the main duct unless otherwise approved by the Engineer-In-charge.

Recommended IS-655 Standard at 4 Feet Transverse Joint Reinforcement

Duct Sizes	Duct Gauges	Flanges
0-750mm	24g	TDF
751—1500mm	22g	TDF
1510—2250mm	20g	TDF
2251 & above	18g	TDF

Documentation to Measurement
For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill material indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.

Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.

All duct pieces shall a part number, corresponding to the serial number assigned to it in the measurement sheet. The above system shall ensure speedy and proper site measurement, verification and approvals.

SHEET METAL DUCT WORK – AS PER I.S. STANDARD (MANUAL FABRICATION)
Material specifications:
Ducts shall be made out of galvanized steel sheets of ducting quality. The galvanized sheet shall have thickness as specified below and zinc coating of minimum 120 gms/sqm.

FABRICATION OF DUCTS:
The ducts shall be fabricated as per following specifications:

Max. Side (mm)	Min. Thickness of sheet (SWG)	Type of joints	Bracing
Up to 750	24 G	25mm x 3mm MS Angle Flange	None
751 to 1000	22 G	40mm x 3mm MS Angle Flange	25mm x 3mm MS Angle at 1.2m centers.
1001 to 1500	20 G	40mm x 3mm MS Angle Flange	40mm x 3mm MS Angle at 1.2m centers.
1501 to 2250	18 G	40mm x 6mm MS Angle Flange	40mm x 6mm MS Angle at1.2m centers.

INSTALLATION OF DUCTS:
Ducts shall be supported on hangers as per following specifications:

Duct Size (mm)	Spacing of Supports (m)	Size of M.S. Angle (mm)	Dia. of Hanger Rod (mm)
Up to 750	2.4	40 x 40 x 3	10
751 to 1500	2.4	40 x 40 x 6	10
1501 to 2250	2.4	50 x 50 x 6	15

Duct hangers shall be fixed to roof by means of anchor fasteners and M.S. angle. Hangers for ducts running below pitched sheet roof shall be fixed to M.S. angle welded to roof structure. Soft neoprene rubber gasket of uniform thickness and width shall be used as gasket between flange joints. The gasket will be fixed with a suitable adhesive to the flange.
Galvanized hexagonal full threaded nut-bolts of minimum 6mm dia. shall be used for fastening the flanges. Spacing between two nut-bolts shall not exceed 125mm.
All ducts shall be rigid and shall be adequately supported and braced where required with cross breaking of M.S. angle bracings of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.

Ducting over false ceiling shall be supported independently from the roof structure above. In no case a duct shall be supported from the false ceiling hangers or be permitted to rest on a hung ceiling.

Bottom level of all ducts should be maintained as shown in the drawing. Levelling of ducts should be checked with a PVC tube water level from a reference point.

Fans shall be connected to duct work by a double canvass sleeve. Each sleeve shall be minimum 150mm long, securely bolted to duct and units. Each sleeve shall be made smooth and the connecting duct work rigidly held in line with unit inlet or outlet.

Installation practice

All ducts shall be installed 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 Owner's 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 there is interference/fouling with other beams, structural work, plumbing and conduits, the ducts shall be suitably modified as per actual site conditions.
Ducting over false ceilings shall be supported from the slab above, or from beams. In no case shall any duct be supported from false ceilings 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 contractor's work in the building.
Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick appropriate

insulation around the duct and totally covered with fire barrier mortar for complete sealing.
All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork 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.

Documentation & measurement for ducting
All ducts fabricated and installed should be accompanied and supported by following documentation:

1. For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill of materials indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct area by gauge and duct size range as applicable.
2. Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
3. All duct pieces to have a part number, which should correspond to the serial number, assigned to it in the measurement sheet.

The above system will ensure speedy and proper site measurement, verification and approvals.

FLEXIBLE DUCTWORK
The flexible ductwork shall have a liner and a cover of tough tear-resistant fabric equal in durability and flexibility to glass fiber fabric. The fabric shall be impregnated and coated with plastics. It shall be reinforced with a bonded galvanized spring of stainless steel or other approved wire helix between the liner and the cover an outer helix of glass fiber cord or equal shall he bonded lo the cover to ensure regular convolutions, flexible ductwork without a liner may not be used.
In no cases shall materially containing asbestos fabric he used.
Alternatively, flexible ductwork shall consist of flexible corrugated metal tubing of stainless-steel, aluminum, tin plated steel or aluminum coaled stud. The metal surface(s) may be coated with a plastics material.
The leakage from any section of flexible ductwork shall not exceed 1% of the local design air flow rate at the local maximum static pressure. Flexible ductwork shall be suitable for an operating temperature range of-5° C to 90° C and shall comply with BS 476 Rating Class P; Part 6 having an index of performance not exceeding 12 of which not more than 6 should derive from the initial period of test; Part 7 Class 1 (surface of very low flame spread) unless otherwise indicated.

AC Timer
SPECIFICATIONS:-

Mains Supply :-230 VAC +/- 10% , 50 Hz
O/P contacts :-Separate o/ps for 2 A/Cs.
Output Contact rating :-25 Amps
Protections :-OV :- Cutoff 270 V & Cut in 260V
UV :- Cutoff 160 V & Cut in 170V
Indications :-A/C ON , On timer,OV,UV,Auto,Manual mode

Working :-

1. If Auto/man switch is at Auto position& Test/Timer sitch is in Timer position then each AC runs for Hrs.selected.
2. If Auto/man switch is at Auto position& Test/Timer sitch is in Test position then both AC runs for 10 minutes one by one.
3. If Auto/man switch is at Man position then the A/C will be ON which is selected by third DIP switch. It will be continuously ON.

5. GRILLES AND DIFFUSERS- General

The grilles and diffusers shall be rated in accordance with ASHRAE standard 3672.
All grilles and differs shall have concealed fixing system and shall have quick release frame to facilitate cleaning.
All supply grilles and diffusers shall he mounted on substantial frame and shall be provided with soft rubber or felt joining ring inserted under the frame to prevent air leakage and the formation of condensate on the fitting,
All grilles and diffusers shall not be less than the size indicated; where no size is given they shall be capable of handling the air flows and distribution indicated without producing unacceptable air flow noise. The Contractor shall select the supply air grilles and diffusers to achieve good air distribution and adequate air movement in the conditioned space.
In order for the ceiling grilles and diffusers to match with the false ceiling layout pattern, the actual size of the grilles and diffusers shall he confirmed by the Architect/Contractor before ordering.
For all grilles and diffusers which are smaller than the ceiling tile on which they are installed, they shall be located in the center of the ceiling tile. The exact location of the ceiling grilles and diffusers shall be co-ordinate with other services. The Contractor shall confirm the exact location with the Architect/Contractor before works commence.
Where grilles and diffusers are to be incorporated into false ceilings before any grilles or diffusers are installed into ductwork or fan coils, the Contractor shall ensure that the Building Contractor marks out the ceiling line on the adjacent plastered walls or columns and also indicates where ceiling tee bars line up or the ceiling joints occur in order that such datum can be worked to.

The finishing colour of the grilles and diffusers shall be approved by the Architect as different colours may be specified in different areas. The Contractor shall co-ordinate with the Building Contractor and other specialist Contractors especially the ceiling and electrical Contractor for the integration of the air diffuser into the ceiling and luminaire (for light troffer diffuser).

GRILLES
Grilles shall be of steel, aluminum, PVC or as otherwise indicated. Steel grilles shall he protected against rusting and supplied in fully finished stove-enameled or otherwise specified condition.
Each supply air grille shall have two sets of separately adjustable louvres, one set horizontal and one set vertical, and shall be complete with an opposed blade multi-leaf damper. Alternatively, in lieu of the opposed blade multi-leaf damper a rhomboidal air controller may be provided; this air controller shall control both the volume of air passing and the distribution of air across the grille lace. The louvers and the damper or air controller shall be adjustable from the front of the grille.
Return air grilles shall have either a single set of louvre or bars (either vertical or horizontal) or a lattice, egg crate or expanded metal from.
Each return air grille shall be complete with/without an opposed blade multi-leaf damper or a rhomboidal air controller operable from the front as specified.
Where return air grilles are fitted for fan coil units, they shall be arranged such that the central core of the grille hinged and demountable for access to the filter for cleaning.
Mounting frames for these grilles shall include provision for fixing the filter in position.

DIFFUSERS
Diffusers shall be of steel or aluminum. Steel diffusers shall be protected against rusting and shall be stove enameled/powder coated for finished colour approved by the Architect. Diffusers shall incorporate an edge seal, diffusers mounted on ceilings shall have anti- smudge rings. Pan type

diffusers shall be provided except where cone type diffusers are indicated,
Diffusers shall be provided with volume control dampers of the iris, flap or sleeve type which shall be adjustable from the front of the diffuses Where the length of a vertical duct to a diffuser is less than twice the diameter of the diffuser an equalizing deflector shall be fitted.
The design of the supply air diffuser shall be capable to induce adequate air movement and provide the throw to cover the entire air-conditioning space without causing air turbulence and cold draft.
linear diffusers shall be constructed of extruded aluminum section and include a control damper al the rear of the vanes giving volume control down to complete shutoff and operated from the face of the diffuser. Linear diffusers for supply air shall have adjustable blades to give directional control of air flow. The linear diffuser shall be capable of maintaining a horizontal discharge pattern at a turn down ratio down to 20% of the maximum specified air volume without air dumping.
The linear diffuser shall be complete with factory fabricated plenum with suitable inlet connection for flexible ductwork, the plenum and diffuser neck shall be constructed of galvanized steel sheets internally lined with 25 mm 48 kg/m glass cloth faced fiberglass insulation enclosed in galvanized perforated metal liner.
Where linear diffusers are mounted in a continuous line there shall be means of ensuring alignment between consecutive diffusers and of equalizing pressure behind the vanes. The dummy portion of the diffuser shall be internally covered by a demountable galvanized metal enclosure to block the view into the ceiling void from below.
The square face diffuser for VAV system shall be constructed of aluminum and with large turn down ratio.
The linear slot diffuser shall be constructed of extruded anodized aluminum, with multiple slots for the required air flow rate,
All the supply air grilles/diffusers will be provided with opposed blade volume control dampers fabricated from Al. anodized in matt black shade. The damper should be suitable for operation from front face of grille/diffuser. The Diffusers should have also removable core type fixing facility, constructed from the same material of the diffuser. The grilles / diffusers must be submitted to Architect / HVAC Contractor / PMC / Client for prior approval before procurement and installation.

Installation

A good quality expanded polyethylene /rubber of uniform thickness and width shall be used as gasket between flange joints. The gaskets shall be fixed by a suitable adhesive and holes made by passing a heated rod through.
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 the joints shall be made tight and all interior surfaces shall be smooth. Bends shall be made with radius not less than one half the width of the duct or with properly designed interior curved vanes where metal ducts or sleeves terminate in woodwork, brick or masonry openings, tight-flanged collars. Ducting over false ceiling shall be supported from the slab above or from beams.
In no case a duct shall be supported from the false ceiling hangers or to be permitted to rest on a hung ceiling.
All holes in concrete, masonry etc. made by contractor for fixing supports etc. shall be made good and restored to original finish by him.
Air handling units and fans shall be connected to duct work by inserting at air inlet and air outlet a double canvass sleeve. Each sleeve shall be minimum 100mm long, securely bolted to duct and units. Each sleeve shall be made smooth and the connecting ductwork rigidly held in the line with unit inlet or outlet.

TESTING
All the test readings shall be furnished for peak summer and monsoon outside conditions.

After completion all such system shall be tested for leakage.

The entire air distribution system shall be balanced to supply the air quantities as required in various zones and rooms to maintain the specified room conditions. The final readings shall be recorded and submitted to the Contractor for approval before acceptance and taking over of the entire system by the Employer.

PAINTING
Angle iron flanges, stiffeners, hangers and supports shall be painted with 2 coats of anti-rust primer and those remaining uncovered shall be further painted with 2 coats of synthetic enamel paints of black colour.

DOUBLE DEFLECTION ADJUSTABLE BLADE GRILLE:
To be constructed from high quality aluminum alloy extrusions with cleated & mitred frames Vanes should be in double banks are individually adjustable shape of vanes should be teardrop and are held in position with stainless steel spring wire for long life.
Finish of grille should be epoxy polyester powder coated & shade should be as per Architect / interior designer's choice.

LINEAR GRILLES
To be constructed from extruded aluminum sections fabricated into modular assemblies' frames are mitred & cleated.
Finish of grille should be epoxy polyester powder coated & shade should be as per Architect / interior designer's choice.

DAMPERS – GENERAL
The respective functions, types and general constructional requirements of dampers shall be in accordance with the HVAC ductwork specification unless otherwise indicated, sufficient dampers shall he provided to regulate and balance the system. Dampers on grilles or diffusers shall he used for line control only.

All dampers shall he of flanged type for connection to ductwork and shall he sufficiently rigid to prevent fluttering. Air leakage rate for dampers shall be tested according to EN 1751 Section 3 when the damper is in the closed position. For dampers installed for shut- off purpose, the maximum air leakage rate shall be tested according to EM 1751 Section 4.

LOW LEAKAGE DUCT DAMPER
Air volume control dampers shall be of the aero foil, double skin, opposed blade type with low pressure drop and noise regeneration characteristics. Damper blades in rectangular ductwork shall not exceed 225 mm in width and 1500 mm in length. Blades shall be of hollow section constructed from the same material of the ductwork or of stainless steel encapsulating an internal double contoured stud longitudinal reinforcing bar, mounted on square section steel spindles. Bearings shall be of nylon material and the units shall be of low-leakage design by incorporation of synthetic trailing edge seals and a peripheral gasket which shall be tested according to BS 476. All manually and automatically operated dampers shall include a means for indicating externally the position of the

blades. Manual dampers shall include a device for positioning and locking the damper blades. The positions of all dampers 'as-set' after final regulation shall be indelibly marked at the adjusting device.

Each air volume control damper in the ductwork shall be fitted with a non-corrodible label stating the actual air flow in m3/s when in the fully open position, its overall cross-sectional area, and the degree to which the damper has been closed in order to achieve the design or actual air flow.

Unless otherwise indicated, quadrants and operating handles shall be of die-cast aluminum or other material approved by the Architect with the words 'OPEN' and 'SHUT' marked on the quadrant. Quadrants shall be securely fixed and the damper spindles shall be closely fitted in the quadrant hubs to prevent any damper movement when the damper levers are locked.

Access openings with readily removable air sealed covers shall be provided adjacent to all dampers. Subject to limitations of ductwork size the dimensions of access openings shall not be less than 300 mm x 300 mm and shall be located so as to afford easy access for inspection and maintenance.

Fusible link fire damper

Fire Dampers meeting or exceeding the following specification shall be furnished and installed at locations shown in the plans or described in the schedules. Dampers shall meet the fire resistance rating of 2 hours as per UL555 and shall be tested and certified by CBRI. Fire Damper frame shall be galvanized steel of 1.6mm thickness, formed into a C channel in 4-piece construction with flanges suitable for duct connection.

Damper Blades shall be single skin galvanized steel of 1.6mm (2mm for 4 hours) thickness and must have 3 accurately roll formed longitudinal grooves for reinforcement and proper closure and operation. The blades shall be arranged in parallel to provide positive shut off. Each Blade shall have axles supported on both sides with sintered bronze self-lubricating bearings turning in an extruded hole in the frame.

Each Damper shall be operated through a UL stamped fusible link rated at 74 or 100 Deg C. The closing of the fire damper shall be through a suitable rated spring which will be capable to close the blades in the event of fusible link disintegration.
Indication of Blade Position should be made available either through a ManuaI lever or thru an electrically operated open/close switch (if needed by the specifier).

On completion:

On completion of installation of complete air distribution system all ducts shall be tested visually for air leaks. Pressure test shall be carried out for all Clean Room applications during & after installation. Maximum allowable leakage rate shall be within the limits specified by standards.
The entire air distribution system shall be properly balanced.
Air quantity supplied by the fan unit and delivered through the various outlets shall be as specified and quoted.
Branch duct adjustment shall be made by volume or splitter dampers.
Dampers shall be permanently marked after air balancing is complete so that these can be restored to their correct position if disturbed at any time.

6. DUCT THERMAL INSULATION:

External thermal insulation on ducts shall be provided as follows:

Step 1:
Clean the duct surface thoroughly and make all the joints airtight.
Step 2:
Apply the insulation material with Adhesive as per material specified below,
Insulation material shall be Closed Cell Elastomeric Nitrile Rubber.
Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/(mK) at an average temperature of 0□C
The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990
Material shall be FM (Factory Mutual), USA approved.
Moisture Diffusion Resistance Factor or 'μ' value shall be minimum 7,000.

Manufacturer bonded Treated Woven Glass Fiber.
Technical Details:
Temperature Range: 0°C to +105°C Overall (irrespective of the base product)
Colour: Black/white
Treatment: Shall be treated Water Based Acrylic binder to give crisp and non-piling property to the fabric, to help in easy installation, minimize fiber erosion, good aesthetics and resistance to abrasion. Fiber spillage / Thread raveling should be minimum.
Density: 200 +/- 20 gsm
Tensile Strength: 275 +/- 25 Kg / 50 mm (minimum)
Thickness: 0.18 mm / 7 mill
PSA Tape:
Type: Solvent based Acrylic Adhesive
Peel Strength: 1000 gm / 25 mm (minimum) - (Adhesive to steel)
Release Liner: Polyester

Adhesive for Duct Thermal Insulation: (specifications): The adhesive shall be formulated for the Duct insulation application and supplied by insulation (nitrile) manufacturer. The adhesive shall be rubber based, solvent based contact adhesive, free from benzene. The adhesive shall have minimum tear strength resistance of > 20 N / 25 mm when tested as per AFERA – 4001. The adhesive shall be quick drying characteristics for tropical conditions and shall have service temperature of 0^{o} to +85 ^{o} C.

7. ACOUSTIC INSULATION

7.1 ACOUSTIC INSULATION inside AHU panels:

- Material shall be engineered Nitrile Rubber open cell foam.
- The material should be fiber free.
- The density of the same shall be within 140-180 Kg/m3.
- It should have antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180.
- The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C
- The material should withstand maximum surface temperature of +850C and minimum surface

temperature of -200C.

- The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94 (HBF, HF 1 & HF 2) in accordance to UL 94, 1996.
- The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

Thickness of the material shall be as specified for the individual application. The insulation should be installed as per manufacturer's recommendation.

Thickness as mentioned in BOQ.

Adhesive for Acoustic Insulation: (specifications): The adhesive shall be formulated for the insulation application and supplied by insulation (nitrile) manufacturer. The adhesive shall be rubber based, solvent based contact adhesive, free from benzene. The adhesive shall have minimum tear strength resistance of > 20 N / 25 mm when tested as per AFERA – 4001. The adhesive shall be quick drying characteristics for tropical conditions and shall have service temperature of 0 deg to +85 deg C.

Installation Procedure
The inside surface for the ducts shall be covered with adhesive recommended by the manufacturer. Cut Foamed sheets into required sizes apply adhesive on the foam and stick it to the duct surface.

7.2 DUCT ACOUSTIC LINING:

Duct acoustic lining (thickness as mentioned in BOQ) fiberglass rigid boards of 48 kg/cu m density shall be carried out for a minimum distance of 6 m from the outlet of each air handling unit, or as specified. Entire length of fan coil unit discharge duct shall be acoustically lined.

Fiberglass rigid boards shall be covered with minimum 60 GSM RP Tissue Paper and perforated Aluminium sheets of 28 gauge with 3 mm dia holes at 5 mm staggered centers.
Fibre glass rigid boards shall be friction fitted to the sheet metal duct with GI angle grid-work.
Alternatively, for ducts of small cross section, with prior permission of the Contractor, fiberglass and perforated sheet may be mechanically attached to the sheet metal with galvanised bolts and large washers. Bolts shall be at least 35mm from all corners.
External insulation need not be applied where internal duct lining is provided unless otherwise specified.

The above specification is for guidance. Contractor should also carry out necessary acoustical analysis and provide suitable alternative/additional insulation/lining to effectively reduce the noise level of the system to within acceptable limits.

7.3 INSULATION OF AIR HANDLING UNIT ROOMS & WALL & SLAB:

Where specified the equipment room walls shall be provided with insulation to be applied as follows:
Fix GI angles/tee grid-work at 0.6 m x 0.9 m centers to the wall and slab of the room, by means of rawl plugs and GI/brass screws & large washers.
Friction-fit one layer of (thickness as mentioned in BOQ) fiberglass Acoustic Board having density of 48

kg/cu mt factory-laminated with Black Woven Glass Cloth, between the GI angles.
Secure the Acoustic Board with adequate no. of GI wires.
Room acoustic lining shall be terminated approximately 150 mm above the floor level to prevent damage due by water.
Particle or fiber-shedding material (including fiberglass) is not to be used for insulation/lining of ducts or for insulation of AHU rooms; on installations having fine filters.

8. ELECTRICAL WORK

SCOPE

The scope of this section is to define the specifications for the fabrication, supply, erection testing and commissioning of electric panels; wiring and earthing of all components of the air conditioning system and accessories, including supply installation and wiring or remote control-cum-indicating light panel, where specified. The feeder and busbar details shall be as per drawing issued with this tender. The following shall be taken as “minimum” requirements.

GENERAL

Work shall be carried out in accordance with the specifications, local rules, Indian Electricity Act as amended up to date, and rules issued thereunder, regulations of the local Fire Insurance Association and Bureau of Indian Standard Code of practice No. IS 732-1963 (revised). It shall be solely the contractor’s responsibility to comply with all applicable stipulations, notwithstanding anything contained in the specifications and drawings.

Each panel board shall have spare feeders (complete with switchgear, not blank compartment) to the extent of approx. 20% of total no. of feeders for flexibility of connecting additional load as well as ready availability of spare feeder in case of fault in an operating feeder.

WIRING SYSTEM

All power wiring shall be carried out with 1100 volts grade PVC insulated, armored, overall PVC served aluminum conductor cables (unless copper conductor is specified). Cables shall be sized for starting current and continuous running current-carrying capacity and by applying proper derating factor. All control wiring shall be carried out using 650/1100 volts PVC insulated armored copper conductor wires in wire-ways or conduits. Minimum size of control wiring shall be 1.5 sq mm PVC insulated copper conductor wires. Minimum size of conductor for power wiring shall be 4 sq mm PVC insulated aluminum conductor wires suitable for 415+10% volts 50 cycles 3 phase 4 wire supply system.

CONSTRUCTION FEATURES

The control panel shall be CRCA sheet steel, indoor type, dead front, floor mounting/wall mounting type as specified/ called for. The control panel shall be totally enclosed, completely dust and vermin proof. Non ageing gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust proof. Control panels shall be preferably arranged in multi-tier formation. All doors and covers shall be lockable. All mild steel sheets used in the construction of control panels shall be 2 mm thick and shall be folded and braced as necessary to provide rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding slag grounded, oil and welding pits wiped smooth with plumber metal.

The overall height and layout of panel shall be such as to facilitate operation/maintenance of all feeders, components and controls easily and without the need of stools or platform. The depth shall

be adequate for easy maintenance and shall not be less than 400 mm.

All panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with hank nuts. Self-threading screws shall not be used in the construction of control panels. Base channel of minimum 75 mm x 75 mm x 5 mm thick or ISMC 100 (in accordance with the size of panel board) shall be provided at the bottom. It shall be painted black. Minimum clear space of 300 mm between the floor of control panel and bottom-most unit shall be provided. 1100V-grade rubber mat shall be provided in front of the panel board.

The control panels shall be of adequate size. Knockout holes of appropriate size and number shall be provided in the control panels in conformity with the location of incoming and outgoing conduits/cables. All equipment such as meters and indicating lamps, etc. shall be located adjacent to the unit with which it is associated and subject to this requirement care shall be taken to achieve a neat and symmetrical arrangement. Facility shall be provided for termination of all normal types of cables, from both above and below the panel. Where cables enter below, cable boxes shall be fitted at rear and arranged in the tiers to facilitate making connections to the upper and lower units. Clamps shall be provided to support the weight of the cables. Internal wiring of panel shall be done with minimum 2.5 sq mm tinned copper wires.

All incoming and outgoing feeders shall be brought out to a terminal block of adequate size at suitable location inside the control panel. All wiring inside the control panel shall be colour coded and labeled with approved plastic beads for identification. Circuit diagrams showing the arrangement of circuit shall be pasted on the inside of panel door and covered with transparent plastic sheet and all labeling shall be provided on the front face of the panel board.

CIRCUIT COMPARTMENT

Each circuit breaker, switch fuse unit, contactor and relay shall be housed in a separate compartment and shall be enclosed on all sides. Sheet steel hinged lockable door shall be duly interlocked with the breaker/switch fuse unit in the ON position. Safety interlocks shall be provided to prevent the breaker, switch unit, or contactor from being drawn out when the panel is in ON position. The door shall not form an integral part of the draw out portion of the panel. Sheet steel barriers shall be provided between the tiers in a vertical section.

INSTRUMENT ACCOMMODATION

Separate, adequate compartments shall be provided for accommodating instruments, indicating lamps, control contactors and control fuses, etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, switch fuse unit and busbar.

BUS BARS AND BUS BAR CONNECTIONS

The bus bar and interconnections shall be of electrolytic aluminum E91E grade and of rectangular cross section suitable for full load current for phase bus bars and half the rated current for neutral bus bar, and shall be extensible on both sides. The bus bars and interconnections shall be insulated with heat-shrinkable PVC colour coded sleeves. Maximum current density shall not exceed 1.2 A/sq mm (for copper). Busbars shall be of uniform cross section in the compartment.

All bus bars shall be supported on unbreakable, non-hygroscopic insulated supports at regular

intervals, to withstand the forces arising in case of short circuit in the system. All bus bars shall be provided in a separate chamber and properly ventilated. All bus bar connections in main control panels shall be done by clamping: no holes shall be drilled in bus bars. If holes have to be drilled for making connections, extra cross section of bus bars shall be provided. All bus bar connections in smaller control panels shall be done by drilling holes and connecting by brass bolts and nuts. Additional cross section of bus bars shall be provided in small control panels to make up for the holes drilled in the bus bars. Automatically operated safely shutters shall be provided to screen the live cluster when the beaker is withdrawn form cubicle.

All connections between the bus bars and switches and between switches and contactor, shall be through aluminum strips of proper size to carry full rated current, insulated with PVC sleeves.
An earth busbar running throughout the length of the panel shall be provided.

TERMINALS
The outgoing terminals and neutral links shall be brought out to a terminal block suitably located in the control panel. The current transformer for instruments, metering and for protection shall be mounted on the terminal blocks. Separate cable compartments shall be provided for incoming and outgoing cable. Minimum 20% spare terminals shall be provided in each terminal block.

WIREWAYS
A horizontal wire way with screwed covers shall be provided at the top to interconnecting control wiring between different vertical sections. Any cables/wires that are concealed (e.g., in shafts or above false ceiling), or are encased in wall chases, must be installed in conduits to facilitate replacement in case of any fault in future.

CABLE COMPARTMENTS
Cable compartment of adequate size shall be provided in the control panels for easy termination of all incoming and outgoing cables entering from bottom or top.

Adequate and proper supports be provided in cable compartments to support cables. All incoming and outgoing terminals shall be brought out to terminal blocks in the cable compartment.

MATERIALS & COMPONENTS
All materials shall be of the best quality complying with appropriate Bureau of Indian Standards and British Standard Specifications. Materials used shall be subject to the approval of the Engineer-in-charge and samples of the same shall be furnished where required. All switchgear shall be able to with stand 35 MVA faults level at 440 volts.

a) Rotary Switches
Switches up to 60 amps shall be rotary with compact and robust construction, built up from one or stacks with contacts and a positioning mechanism. The terminals shall be shrouded with insulation to prevent accidental contact with live parts. Rotary switches shall be backed up with moulded type HRC fuse fittings of appropriate rating.

b) Selector Switch
Where called for, selector switches of rated capacity shall be provided in control panels, to give the choice of operating equipment in selective mode.

c) Switches
Switches beyond 60 amps shall be panel mounted, double break type and suitable for load break duty, quick make and break action, manufactured in accordance with IS. Switch contacts shall be silver plated and shall be backed up with HRC fuses of appropriate rating. The switch handle shall be located at the front.

d) HRC Fuses
Fuses shall be of high rupturing capacity and shall be in accordance with IS 3208-1962 having rupturing capacity of not less than 20 MVA at 415 Volts. The back up fuse rating for each motor/heater/equipment shall be so chosen that the fuse does not operate on starting of motor/heaters/equipment. Fuses shall be of the same make as the switches.

e) Starters
Each motor shall be provided with a starter of suitable rating. Starters shall be in accordance with IS 2959-1965.

Unless otherwise specified, Direct on line starters shall be provided for motors up to 7.5 HP. Star Delta Type starters shall be provided for motors 10 HP and above.

Main and auxiliary contacts shall be silver or silver alloy. The insulation for contactor coils shall be of class E.

Operating coils of contactors shall be suitable for 220-415 +/- 10% Volts AC,
50 cycles supply or as called for. The contactors shall drop out when voltage drops to 90% of the rated voltage. The housing of the contactors shall be heat resistant having high impact strength.

f) Over Load Relays
Contactors shall be provided with a three element, positive acting, ambient temperature-compensated, time lagged, hand-reset type thermal overload relay with adjustable setting. Hand-reset bottom shall be flush with the front door closed. Relays shall be directly connected for motors below 30 HP capacity. CT operated relays shall be provided for motors above 30 HP capacity. Heater circuits contractors may not be provided with overload relays.

g) Current Transformers
Current transformers shall be of accuracy class I and suitable VA burden for operation of the connected meter and relays.

h) Single Phase Preventers
Single phase preventers shall be provided for all 3-phase motors and shall be in conformity with relevant BIS Standards. Single phase preventers shall act when the supply voltage drops down to 90% of the rated voltage, or on failure of one or more phases.

i) Time Delay Relays
Time delay relays, where called for, shall be adjustable type with time delay adjustment from 0-180 seconds and shall have one set of auxiliary contacts for indicating lamp connection.

j) Indicating Lamps and Metering

All meters and indicating lamps shall be in accordance with IEC regulations. The indicating lamps shall be neon/LED type and of low burden. Each incoming shall be provided with one set of indicating panel, consisting of voltmeter (0-500 volts with three way and off selector switch), CT operated ammeter (of suitable range with three nos. Class 1 CTs of suitable ratio with three way and off selector switch), energy-meter (except for minor panel boards), phase indicating lamps and other indicating lamps as called for. Each phase indicating lamp shall be backed up with 5 amps fuse and toggle switch. Other indicating lamps shall be backed up with fuses as called for. Analog meters shall be Meco make. Digital meters shall be Indo tech/Enercon make.

k) Toggle Switches
Toggle switches shall be in conformity with IS: 3854-1969 and shall be of 5 amps rating.

l) Push Button Stations
Push button stations shall be provided for manual starting and stopping of motors/equipment as called for. Red and Green colour push buttons shall be provided for Starting and Stopping operations. Start or Stop indicating flap shall be provided for push buttons. Push buttons shall be suitable for panel mounting and accessible from front without opening door. Lock lever shall be provided for Stop push button. One set of normally open and one set of normally closed contacts shall be provided in push button stations. The push button contacts shall be suitable for 15 amps current capacity. Outdoor push button stations shall be IP55 protection.

m) Conduits
Conduits shall be mild steel, and shall be solid drawn, stove enameled inside and outside with minimum wall thickness of 1.5 mm for conduits up to 19 mm diameter and 2 mm wall thickness for conduits above 19 mm diameter. GI pull wires shall be installed in the conduit while laying the conduit.

n) Cables
MV cables shall be PVC insulated aluminum conductor armored cables conforming to IS:694 and suitable for underground installation in trenches, duct, and on cable trays as required. MV cables shall be termite resistant. Control cables shall be multi core type PVC insulated copper conductor armored cables. Cable jointing shall not be allowed.

o) Wires
650/1100 volts grade PVC insulated aluminum conductor wires in conduit shall be used where called for.

p) Interfacing with Control System/BMS
All required provisions for interfacing with the control system/BMS, including but not limited to, additional contactors, auxiliary contactors, auto-manual changeover switches, interlocking, etc. shall be provided in the panel board.

CABLE LAYING
Cables shall be laid generally in accordance with Bureau of Indian Standard Cole of Practice. Cables shall be laid in 14-gauge perforated GI/MS cable trays as indicated on the Drawings/BOQ or as approved by the Engineer. GI cable trays shall be minimum 2mm thick and with 110-micron galvanizing. Easy access to all cables shall be provided to allow cable withdrawal/replacement in future. Where more than one cable is running proper spacing shall be provided to minimize the loss in current carrying capacity.

Cables shall be suitably supported with wooden cleats when run on wall/floor/ducts. When buried, they shall be covered with a layer of soft sifted sand and protected with cement concrete tiles. Special care shall be taken to ensure that cables are not damaged at bends. The radius of bend of the cables when installed shall not be less than 12 times the diameter of the cable.
Where cables are run on walls, proper saddling and dressing shall be done. The runs from wall to equipment shall be through suitably sized GI pipes, preferably below the floor surface.

CONDUCTOR SIZES

For all single-phase/three-phase wiring, 650/1100 volts grade PVC insulated aluminium conductor wires shall be used. The equipment inside plant room &
AHU room shall be connected to the control panel by means of insulated aluminium conductor wires of adequate size in exposed conduits. Final connections to the equipment shall be by wiring enclosed in MS flexible conducts rigidly clamped at both ends. An isolator shall be provided near each motor/equipment wherever the motor/equipment is separated from the supply panel by a partition/barrier or through ceiling. PVC insulated single strand
aluminum conductor wires shall be used inside the control panel for connecting components and all the wires inside the control panel shall be neatly dressed and plastic beads shall be provided at both the ends for easy identification.

The minimum size of control wiring shall be 1.5 sq mm PVC insulated armored soft drawn tinned copper conductor. CT secondary wiring shall be done with 2.5 sq mm tinned copper conductor. All power circuits shall be minimum 2.5 sq mm tinned copper conductor.

Minimum power wiring and earthing sizes for different motor ratings shall be as per following table. However, if cable derating is necessitated in any particular situation, suitable higher size cable shall be used.

SUGGESTED MINIMUM SIZES:

Motor Rating	Power Cable	Earthing
Up to 5 HP	3Cx2.5 sq mm Cu	2x4 mm dia GI/12SWG copper
6-7.5 HP	3Cx4 sq mm Cu	2x4 mm dia GI/12SWG copper
10-15 HP	2x3Cx6 sq mm Al	2x6 mm dia GI/10SWG copper
20-25 HP	2x3Cx10 sq mm Al	2x6 mm dia GI/10SWG copper
30-50 HP	2x3Cx25 sq mm Al	2x25x3 mm strip GI
60-75 HP	2x3Cx35 sq mm Al	2x25x3 mm strip GI
90-100 HP	2x3Cx50 sq mm Al	2x25x6 mm strip GI
200 HP	2x3Cx150 sq mm Al	2x25x6 mm strip GI

GI/COPPER EARTHING

Earthing shall be by means of galvanized iron strips/wires, or copper stripes/wires as mentioned in schedule of quantities.
The main panel shall be connected to the main earthing system of the building by means of 2 nos. 25 mm x 6 mm GI strips. All single-phase metal clad switches and control panels shall be earthed with minimum 3 mm diameter GI wire. All 3 phase motors and equipment shall be earthed with two numbers distinct and independent GI wires as per the above table.

All switches shall be earthed with two numbers distinct and independent wires as follows:

- 3 Phase switches and control panels up to 60 amps rating: 2 nos. 2 or 3 mm dia copper wires.
- 3 phase switches and control panels 60 amps to 100 amps rating: 2 nos. 2 or 4 mm dia copper wires.
- 3 phase switches, control panels, bus and ducts 200 amps rating and above: 2 nos. 4 or 6mm x 6 mm copper

The earthing connections shall be tapped off from the main earthing of the electrical installation. The overlapping in earthing strips at joints where required shall be minimum 75 mm. These straight joints shall be riveted brazed in an approved manner. Lugs of adequate capacity and size shall be used for all terminations of wires. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and oily substance and properly tinned.

DRAWINGS

Shop drawings for control panel and wiring of equipment showing the route of conduits/cables shall be submitted by the contractor for approval of Engineer-in- Charge before starting the fabrication of panel and starting the work. On completion, two sets of completion As-Installed drawings incorporating all details like conduit routes, no. of wires in conduit, location of panels, switches, junction/pool and cable route, etc. shall be furnished by the contractor.

TESTING

Before commissioning of the equipment, the entire electrical installation shall be tested in accordance with code of practice IS 732-1963 (Revised) and test report signed & furnished by a qualified and authorized personnel. The entire electrical
installation should be approved by Electrical Inspector and certificate from Electrical Inspector shall be submitted. All tests shall be carried out in presence of Engineer-in-Charge. The safety, functioning and all necessary certificates/approvals shall solely be the responsibility of the contractor. Megger test and high-voltage tests shall be conducted on the panel at the manufacturer's factory. Testing shall also be done to check proper interlocking between various
equipment/safety/control cutouts, as required for the particular duty.

PAINTING

All sheets steel work shall undergo a process of degreasing, de-rusting, rinsing, passivation, drying, thorough cleaning, primer application, and painting with a high
corrosion-resistant/epoxy primer. All panels shall be baked in an oven. The finishing treatment shall be by application of synthetic enamel/epoxy paint of approved shade.