TECHNICAL SPECIFICATIONS FOR ELECTRICAL WORK
GENERAL:

These specifications are for work to be done, item to be supplied and materials to be used in the works as shown and denned on the drawings and described herein, to the satisfaction of the Owners / Architects.

1.1 The workmanship is to be the best possible and of a high standard. The contractor shall take all steps immediately to make up deficiency if any noticed by the Owners / Architects. Use must be made of special tradesmen in all aspects of the work and allowance must be made in the rates for the same.

1.2 The materials to be provided by the contractor shall be in accordance with the samples already got approved from the Owners / Architects by the contractor and in conformity with specification and approved list of manufacturers and brand. The contractor shall produce all invoices, vouchers or receipts for any material if called upon to do so by the Owners / Architects.

1.3 Samples of all materials are to be submitted to the Owners / Architect for their approval before the contractor orders or delivers the material to the site. Samples together with their packing are to be provided free of charge by the contractor and should any materials be rejected they will be removed from the site at the contactors expense. All samples will be retained by the Owners / Architects for comparison with materials which will be delivered at site. Also, the contractor will be required to submit specimen finishes of colours, fabrics, etc., for the approval of the Owners / Architects before proceeding with the work.

1.4 The contractor shall be responsible for providing and maintaining temporary coverages required for the protection of finished work. He is also to clean out all wood shavings, cut ends and other waste from all parts of the works before covering or infilling are constructed.

1.5 Contractor shall maintain unformed quality and consistency in workmanship throughout the execution of the work.

SECTION - XI

TECHNICAL SPECIFICATIONS (Electrical – part I)

The Electrical installation work shall confirm to the following I.S. Standards (latest additions), Local Supply Authorities Rules and Regulations and Fire Safety Norms.

1) IS:732 Code of Practice for Electrical wiring installation. (System Voltage not exceeding 650V)

2) IS:1646 Code of Practice for fire safety of buildings (General Electrical Installation).

3) IS:9537 (PART-II) 1981 Rigid steel conduits for electrical wiring.

4) IS:2667 Fittings for rigid steel conduits for electrical fittings.

5) IS:2509 Rigid non-metallic conduits for electrical installations.

6) IS:1293 Pin Plugs and Sockets.

7) IS:694 PVC insulated cables with copper conductors for voltages up to 1100 volts.

8) IS:9532 Specification for conduits for Electrical Installation.

9) IS:3854 5A & 15A Switch socket and accessories.

10) IS:3043 (1981) Earthing.

11) IS:2026 Specification for power transformer.

12) IS:3639 Specification for fittings and accessories for power transformers.

13) IS:2099 Specification for high voltage porcelain bushings.

14) IS:335 Specification for insulating oil.

15) Indian Electricity Act, 1956 and Rules and Fire Insurance Regulations.

A-01. POINT WIRING

a) METAL CONDUITS

All conduit pipes shall confirm to IS 9537, PART-II 1981. Metal conduits shall be ERW black enameled 20mm/25mm as the case may be depending upon the number of wires permitted as table-1. The conduits shall be fixed to walls/ceiling with MS saddles and spacers at an interval of 0.45 meter and on either side of bends, junction boxes, pull boxes etc.,

All conduit accessories shall be 16 gauge & bends shall be of inspection type. All bends, couplers, threaded portions etc., shall be painted with anti-corrosive paint. Bends in the pipes shall be done with bending hickies.

All pipes shall be cleaned for sharp burrs. Switch boxes shall be of GI 16/14 gauge. The switch boxes shall be concealed as per site requirement & as per Architect's/Consultant's Instructions.

Point shall be controlled with 5A switch or directly from DB as specified in schedule of quantities. Where plate type switches are not specified the switch board shall have 3mm thick hylum sheet on which switches shall be mounted.

The point wiring shall be carried out with multi stranded PVC insulated copper wires of 1.5 sq.mm. 2nos (for Phase & Neutral) & 2.5sq.mm. (for Earth). In all cases the earth shall be of green colour and neutral shall be of black colour. All wires used shall be of 660 V grade. The point wiring shall be inclusive of circuit wiring from Distribution Board to the switch board unless otherwise stated in schedule of quantities. The circuit wiring shall be with 3 nos. of 2.5 sq.mm. PVC insulated multi stranded copper conductors colour coded as detailed above. The rate shall also be inclusive of any chasing as directed by the Architects/Consultant/Client's Engineer to conceal the drops and finishing the same.

In case of group control directly from Distribution Board, the primary point shall be considered from DB to the first point and secondary point shall be from first point to the next looped point. The point shall terminate into the 3 plate-ceiling rose.

While laying the conduits in the slab before casting the slab, all drops shall be laid accurately to fall in position of the switchboard. Junction boxes shall be fixed with sand-cement mortar. All joints shall be airtight. Conduits shall be fastened to the re-enforcement properly so that the conduits do not get dislocated while casting the slab. All conduits shall have 18 SWG fish wire.

b) PVC CONDUITS

The PVC Conduits shall confirm to latest IS standards and shall be of medium gauge unless otherwise specified. The conduits shall be joined with PVC adhesive at Joints. The Conduits shall be fixed to walls/ceilings with GI spacers and saddles at an interval of 45 cms& on either side of bends, junction boxes, pull boxes etc., The number of wires drawn in the conduits shall be as per table 1. The point wiring shall be controlled as in (a) above. The wiring shall be done with 2 nos. of 1.5 sq.mm. (for Phase & Neutral) &1.5sq.mm. (for earth) PVC insulated, copper conductors, multi stranded and colour coded with green as earth and black for neutral.

The circuit main wiring shall be with 3 nos. of 2.5 sq.mm.PVC insulated, copper conductors, multi stranded wires laid from distribution board to switch board and the rate shall be included in the point wiring unless otherwise stated in the schedule of quantities. All other details shall be as per metal conduits.

C) CASING CAPPING/ TRUNK AND TRUNKLING

PVC casing shall be fixed to wooden partitions by means of screws spaced not more than 45 cms apart. Holes for fixing the PVC capping shall be done by drilling machine only and these holes shall be plugged with PVC plugs or grips to which the screws shall be fastened. Nowhere less than 1 inch PVC casing shall be used. All bends, tees, joints etc., shall be done in workman like manner with standard accessories. The number of wires in

PVC casing capping shall be limited to a fill factor of not more than 60%. The point shall be controlled by 5amp switch. The switch boards shall either be flush mounted with partitions or surface mounted or concealed mounted as per site requirements and as directed. The wiring shall be carried out as described in (a) and (b) above.

Casing Capping wiring shall not be done for concealed wiring & for wiring over the false ceiling work.

A.2. DISTRIBUTION BOARDS

This specification covers the design, manufacture, assembly, testing at works, supply, installation and commissioning of distribution boards at site.

The system and accessories shall be complete in all respects and any device not included specifically in this specification, but essential for proper operation of the equipment and also to meet statutory requirements shall deemed to be within the scope of the specification whether it is mentioned in the Technical Specification, or not.

If the vendor finds that it is required to undertake any work which is not sufficiently defined in this specification or discovers that this specification conflicts with any other codes, standards and regulations which shall be required to comply, the same shall be clarified in writing from the Owner/Consultant before undertaking the work involved for avoiding the delay.

These shall be of sheet metal and of standard design with copper bus bars. The board shall be fixed at accessible heights. The boards shall be solidly fixed on MS brackets to walls/partitions, concealed or open as directed. All connections inside the distribution board shall be neatly arranged and tied with PVC strings. The MCB's shall be of 9KA for fault level. The distribution boards shall be suitably earthed. Legend shall be written on DB with paint for identification of DB & Circuits.

A.2.1 CONSTRUCTION

The distribution boards shall be fabricated out of 14/16 swg CRCA sheet steel, metal clad, totally enclosed dust damp and vermin proof, dead front, hinged door type of bolted/welded construction suitable for wall or floor mounting.

A.2.2 BUSBARS

The busbar shall be air insulated and made up of high conductivity high strength aluminum or copper busbars liberally sized with high safety factor for the required rating. The neutral busbars shall have adequate number of

terminals for all number of outgoing single-phase circuits and the holes shall be suitable for multi strand wires. In the same way suitable earth bus shall be provided inside each distribution board for earthing of the lighting/power circuits and also earthing of distribution board. In the case of 3 phase distribution boards used for single phase outgoings, three independent neutral bars shall be provided.

A.2.3 MINIATURE CIRCUIT BREAKERS

Miniature circuit breakers (MCB) shall be of heat resistant, moulded type designed, manufactured and tested as per IS-8828.

The MCBs shall have inverse tripping characteristic against overloads and instantaneous trip against short circuits. The MCB shall be of fault current limiting device also.

The MCB shall be slip on type to the DIN rail. The ON & OFF positions of the switch handle shall be clearly marked. The MCB shall be suitable for operating in an ambient temperature of 45 deg centigrade without de-rating. The MCB shall be suitable for 415V, 3 phase, 415Volts, 50Hz system with a fault level of 9-10KA (rms) symmetrical. The terminals of MCBs shall be suitable for use with eye lugs. The 4 pole, 3 pole and 2 poles MCBs knobs shall be trunked with adequate strength tandem pin.

Each distribution board shall have individual hinged/bolted gasketed doors with suitable screws. Removable conduit entry plates shall be provided at top and bottom of the DB to facilitate drilling the conduit holes at site to suit individual requirements or knock out shall be provided.

Protective hylem / bakelite insulated cover plate shall be provided inside the panel to shroud all the live parts. Only the operating handle of the switch and the operating knob of the miniature circuit breakers shall be projecting outside the cover plate in case of ordinary IP20 DB and shall be inside the front door in case of dust tight IP42 DB. The unused outgoing holes / knockouts / cutouts of DB shall be suitably blanked with PVC plates at no extra cost. The incoming switch terminal should be suitably shrouded to avoid accidental contact. Each outgoing in the MCB DB shall have shrouding between Phases. The distribution board shall be factory wired and assembled and local fabricated DB shall not be accepted.

For TPN Distribution Board, four pole isolators shall be provided as incomer. For single phase and neutral Distribution Board, double pole isolator / ELMCB shall be provided as incomer. Earth leakage circuit breaker(s) to be provided wherever called for.

Suitable labels shall be provided to mark the circuit numbers of outgoings circuits.

Wiring Diagram shall be provided inside the DB.

A.2.4 EARTHING

The DB's shall be provided with two numbers of brass earthing terminals with suitable nuts, washers, etc., for connecting to earth bus. The Earth terminals shall be brought outside the DB. In case of flush mounting DB, these shall be provided inside the DB.

A.2.5 PAINTING

The DB sheet steel surface shall be chemically cleaned to remove scale etc., rinsed dried and shall be finished with two coat of powder coat paint over two coats of red oxide / epoxy zinc primer.

A.2.6 TESTS

All necessary factory routine tests shall be performed on the equipment before dispatch. The test results shall be sent along with the supply of DB.

A-03. CABLES

Cables shall confirm to IS 1554-1976. Cables shall be heavy duty, armored, PVC insulated &PVC sheathed 1.1 KV grade aluminum or copper. Cable shall be fixed with GI spacers & saddles at an interval of 30/45 cms and on every side of bends. The bending radius of cables shall be as per manufacturer's instructions and in no case, it shall be less than 12 times the overall diameter of the cable. Cable shall be so installed that they are not subject to any mechanical damage. If there is a bend in the cable enclosed in a conduit, care has to be taken to prevent undue compression of insulation. This applies also to the top of vertical runs of length longer than 5 meters where there could be compression caused by the weight of unsupported vertical cables. Cables may rest without fixing in horizontal runs or ducts or trunkings. The cables run in cable trays shall be fixed with cable ties at intervals of not more than 30 cms. No joints in the cables shall be permitted unless the cables exceed the standard drum length. Joints, if so necessary shall be located in accessible

position. Termination of the cables shall be done with heavy duty copper/Aluminum lugs and brass cable glands.

Cables laid underground shall be to a minimum depth of 750 mm. It shall be ensured that cables laid underground are free of water lines, sewage lines etc. The trenches shall be at least 30 cm wide & filled with 10 cms thick of layer of dry sand on which the cable shall be laid. Further, 10 cms thick sand layer shall be put on the cable over which a brick layer shall be provided. The trench shall than be back filled with soft earth, rammed and consolidated to its original level. Cable route indicators shall be laid at intervals of 15 meters and at all change in directions.

For cables laid on walls aluminum tags shall be fixed showing the size of the cable and the feeder number of the cable. These tags shall be provided at each end and at least one or two places at intermediate positions.

The mode of measurement of the cables shall be as follows:

i) For top entry of the cable, the measurement shall be taken up to the bottom of that switch- gear.

ii) For bottom entry of the cable, the measurement shall be taken up to the top of that switch board. No wastage shall be allowed for measurements.

A-04. SWITCH FUSE UNITS

Switch Fuse Units shall be of sheet metal or iron clad with HRC fuses as described in schedule of quantities. The unit shall be of robust construction of standard specified make, design to withstand adverse working conditions. It shall have quick break type mechanism with ON and OFF position indicators of the operating handle. The switch shall be interlocked so that the unit cannot be opened in ON condition. The interior shall be so arranged that clearances from live parts are adequate and shrouded. Manufacturer's instructions shall be followed for installation of switch fuse units. The switch shall be solidly earthed. The switch shall be mounted on walls on angle iron support grouted to wall. The supports shall be treated for rust treatment & painted with 2 coats of synthetic enamel paint. The height of the switch board shall be such that it is accessible for operation & maintenance.

A-05. POWER PANELS

The Power panels shall be fabricated from MS sheet steel 14/16 gauge and shall be of compartmental design. The main supporting framework shall be of angle iron or of heavier gauge sheet metal. The panel shall be self-supporting design, dust and vermin proof, dead front and fully inter locked with isolating switches. The panel-mounted switches shall have Interlock defeat arrangement for testing and inspection.

The panel shall be designed so as to facilitate inspection, cleaning and repairs. The clearance between phase to phase and phase to earth or metal parts shall be as per relevant IS standards. The metering instruments like volt meter, ammeter etc. shall be flush mounted and shall be of 1.0 class accuracy and of standard design size of 96 mm x 96. All indication lamps shall be of neon /LED type.

The busbars shall be air insulated and made up of high conductivity, electrolytic aluminum / copper bars complying with the requirement of IS 5082:1981 and shall have a fault withstand capacity of 50 KA/1 Sec. All busbars shall be fully screened by means of PVC heat shrinkable sleeves in their own compartment running throughout the length of the Panel. Suitable allowance should be made for bus expansion.

The panel shall have separate cable ally and a bus bar chamber. The bus bars shall be rigid hard drawn tinned electrolytic copper wherever specified & sleeved with heat shrinkable sleeves. The current density shall not exceed 1.25 amp per sq.mm and the neutral bus shall be rated for capacity of phase bus unless otherwise stated in schedule of quantities/drawings. However, the minimum size of bars shall be 25mmx3mm. Minimum electrical clearance shall be maintained between phases, neutral and body as per IS 4237:1982.All outgoing feeders shall have neutral link of appropriate capacity at cable termination end. For Incomers as MCCBs wherein cable is directly connecting at switchgear end the neutral link to be mounted adjacent to switchgear.

The panel shall be powder coated comprising of degreasing and de-scaling in sulphuric acid etc. with synthetic enamel paint for smooth finish. The color of paint shall be battleship grey or as directed. The Panel shall be tested at site before commissioning. The Panel drawings shall be got first approved from Consultants before taking up for fabrication.

All wiring inside the panel shall be done with switchboard copper conductors/cables and/or with solid copper links. The insulators for supporting the Bus-Bars shall be epoxy based cast resin. All hinged doors shall be earthed with flexible braided copper earth. An earth bus of copper shall be fixed along the length of the panel at

the lower section. Adequate ventilation for the panel shall be provided. Logic diagram of operation of switches shall be painted on the panel. The name plates for each feeder shall be of engraved design and pasted to the respective switch gear. The letters shall not be less than 10 mm size for individual feeders and not less than 18 mm for the main feeders. All switchgear to be mounted in the panel shall be as per schedule of quantities.

A-06. EARTH PITS/STATION

The Earthing station shall be done as per IS 3043 (1981) and as per drawing no. E1. The earth pit shall be at least 2.5mtrs deep with CU/GI Plate electrode. The GI plate electrode shall be hot dipped of 600x600x6 mm thick. The size for copper plate electrode shall be

600x600x3mm thick. An alternate layer of salt and charcoal shall be filled up to 200 mm above the top of the electrode. The electrode shall be connected with 32x6 mm thick GI Flat (for copper earth electrode size of flat shall be 25x3 mm) which shall be terminated with nuts and bolts into brick masonry chamber on top. The brick masonry chamber shall be of size 300x300x450mm deep which will carry the funneling arrangement for watering. A GI Flat of 32x6 mm from brick masonry chamber to the switch gear inside the switch room shall be laid underground and/or fixed to walls. The rate for laying GI/ CU strip from earth pit to switch room shall be paid under separate item.

All the main earth conductor above the ground level shall be painted with two coats of enamel paint. The following colour codes have to be followed:

(a) Main body earth bus - Green colour
(b) Main neutral earth bus - Black colour
(c) Lightning protection earth bus - Red colour or as preferred by Owner/Consultant.

Earthing system of equipment earthing, neutral earthing, Data Networking earthing and lightning protection earthing should not be mixed together above the ground. These systems/connections shall be tested in accordance with IS 3043-1987. Earth resistance of the individual system shall be measured after connecting all the electrodes to the bus and the combined value shall be less than 1 ohm (One ohm).

A-07. INSTALLATION OF ELECTRIC FITTINGS

All electrical fittings shall be fixed with down rods or on round blocks as stated in schedule of quantities. The down rods shall be of 19/20 mm dia. and with 1.6mm wall thickness of ERW black enameled MS or GI. The down rods shall be fixed with ball and socket joints, check nuts etc. Special fixtures like spot lights etc.; shall be fixed to the false ceilings as per manufacturer's recommendations. The fittings shall be connected with 3 core 0.5 sq.mm flexible copper cord/cable from ceiling rose and suitable earthed.

A-08. POWER FACTOR CORRECTION PANEL

The power factor correction panel shall be fabricated from sheet steel & powder coated. The panel shall be compartmentalized with tinned copper bus bars TP as described for power panels.

The power capacitors shall be APP type, low loss, 3 phase, delta connected & self-discharged type.

The power factor control shall be done by automatic power factor control relay for controlling the power factor within the set limits by auto switching of required capacitor Banks. The required Capacitors / PF Banks shall be as per schedule of quantities. The P.F. shall be automatically corrected to near Unity.

The C.T. ratio given in the Schedule/diagram is indicative. The same shall be matched for correct operation depending upon the operating load. The relay shall be totally microprocessor based for setting the desired target power factor band. The APFC relay shall have indications like power ON, low current etc.& shall be of required stages as per schedule of quantities. The P.F Panel shall have Auto Manual switching facility.

The general specification shall be as follows:

i) System supply voltage 415 volts.
ii) C.T. secondary rating 5A, 5VA Burden.
iii) Output switching capacity 5A at 230 V AC & 2A at 440V AC, Operating temperature 10 degree Centigrade to 50 degrees Centigrade. Accuracy better than 1%. Low current release 10% of full rated C.T.
iv) Switching time between stages 4 to 6 seconds.
v) Range of indications of PF 0.5 lag to 0.5 lead digital.
vi) Display LED indications.
vii) Range of target P.F. setting 0.7 to 0.99.
viii) Switch for auto/manual operation.
ix) Indications for selection of stages.
x) Selection of dead band.

A-09. TESTING OF ELECTRICAL INSULATION

The following tests shall be carried out during execution and after completion of the electrical installation work.

1) Insulation Resistance Test.
2) Polarity Test of Switches.
3) Earth Continuity Test.

1) Insulation Resistance Test: The insulation resistance shall be measured by applying between earth and whole system of conductors or any section thereof with all fuses in place and all switches closed (except in earthed concentric wiring) all lamps in position & both poles electrically connected together, or direct current pressure of not less than twice the working pressure, provided that it need not exceed 500 volts for medium voltage circuits, be applied. Where the supply is derived from 3 wire DC or Poly phase A.C. System, the neutral pole of which is connected to the earth either direct or through added resistance, the working pressure shall be deemed to be that which is maintained between the phase conductor and the neutral. The insulation resistance measured in mega-ohms between all conductors connected to one pole of phase conductor of the supply and all the other conductors and switches in off position it's value shall be not less than as specified below:

The insulation resistance measured in mega ohms shall not be less than 50 mega-ohms divided by the number of outlets or when PVC insulated cables are used for wiring, 12.5 mega-ohms divided by the outlet subject to a minimum value of 1 mega-ohm.

A preliminary and similar test may be made before lamps etc. are installed and in this event the insulation resistance to earth shall not be less than 100 mega ohms divided by the number of outlets or when PVC insulated cables are used 25 mega ohms divided by the number of outlets subject to a minimum of 1 mega ohm.

2) Polarity Test of Switches: In a 2-wire system a test shall be made to verify that all switches in every circuit are fitted in the same conductor throughout and such conductors shall be labeled or marked for connection to the phase conductor or to the non-earthed conductor of supply.

In a 3 wire or 4 wire insulation a test shall be made to verify that every non-linked single pole switch is fitted in a conductor which is labeled or marked to one of the phase conductors of supply.

3) Earth Continuity Test: The Earth Continuity Conductor including metal conduits and metallic envelopes of cables in all cases shall be tested for electric continuity and electrical resistance of the same along with the earthing lead but excluding any added resistance or earth leakage circuit breaker measured from connection with earth electrode to any point in the earth continuity conductor in the completed insulation shall not exceed 1 ohm.

TECHNICAL SPECIFICATION OF TESTING AND COMMISSIONING

The scope of work for testing and commissioning of the total installation shall be for the capital equipment like transformers, switchgears, cables etc., and also for the associated equipment like relays CTs, PTs, etc.

The scope of work for testing and commissioning of electrical equipment for the above shall include but not be limited to the following:

e) Providing sufficient number of experienced Engineers, Supervisors, Electricians so that the installation can be commissioned in stipulated time.
f) All the instruments, tools and tackles required for carrying out the testing and commissioning shall be provided by the bidder.
g) The testing of electrical equipment shall be carried out as per the relevant Indian Standards/Code or Practices/Manufacturer's instructions.
h) Cleaning of electrical equipment, contacts cleaning and greasing etc. All the equipment and material required for above shall be supplied by the bidder.
i) Connecting the panel/equipment wiring for proper functioning of the schemes required/called for.
j) Installation and wiring of additional equipment on panels like auxiliary contactors, timers, etc. which may be additionally required for proper functioning of the schemes.
k) Checking of equipment earthing and system earthing as a whole.
l) Testing of all the cables.
m) Co-ordination with other contractors for testing and commissioning of interface cables.

TESTS TO BE CONDUCTED

1. All tests shall be performed in the presence of the bidder and customer/consultant. For all types of visual inspections, checking, pre-commissioning, commissioning test and acceptance tests, IS Code to be followed for the tests given therein in addition to the instructions in this technical specification. The intention of

giving the few test procedures, described below, is to provide a guideline for the bidder. However, bidder shall not restrict themselves in carrying out only the tests described in this document.

2. Bidder shall submit their proposed test procedures for approval and shall not commence testing such approval is given.
3. Bidder shall check and test all electrical equipment and systems installed and supplied them, including equipment supplied by the Owner.
4. Bidder shall supply all necessary test equipment and personnel both craft and supervisory category to carry out the work without danger to personnel or damage to equipment.
5. Bidder shall ensure that no tests are applied which may stress equipment above the limits for field testing recommended by the manufacturer. Bidder shall be responsible for any damage to personnel or equipment resulting from improper test procedure.
6. All defective materials furnished by the bidder and defects due to poor workmanship revealed through field testing, shall be corrected at bidder expense without affecting the completion of the project.
7. Client/Consultant reserves the right to interpret and approve all test results prior to energization of circuits or apparatus.
8. Bidder shall visually inspect all equipment for defects immediately upon arrival at site including those supplied by the Owner.
9. Relay coordination chart and final setting before/commissioning.

MECHANICAL CHECKOUTS

After installation, but before any power supply is connected, the contractor shall make a complete mechanical check of all installed electrical equipment and systems. This shall include but not to be restricted to the following:

- Check equipment numbers against drawings/documents.

- Check name plates of transformers, switch gears etc., for conformity with the data given in the drawings and specifications.
- Check all equipment bus joints and connections for tightness.
- Check all cable and wire connections for tightness.
- Check phase sequence.
- Check all bushings/insulators to ensure they are clean and unchipped. Inspect tank cooling tubes and radiators for leaks.
- Check silica gel for dryness where breathers are supplied. If the colour of the silica gel is pink, remove from the breather and dry out following manufacturer’s recommended procedure, until a light blue colour is restored and then replace it.
- Check valve in the connecting pipe between the conservator and transformer tank to ensure that valve is in 'open' position.
- Check interlocking on access doors for mechanical and electrical safety. Check that key and electrical interlocking system functional and accomplish their purpose.
- Check all plug-in contacts for alignment and 'grip'.
- Check all contactors for free manual operation.
- Remove all locking devices installed for shipment.
- Check all the coils for their continuity and proper voltages.

- Check the arc chutes, arcing horns, main contacts of breakers are clean and undamaged. Check the carriages ride smoothly and reliably on their guide-rails. Check for proper operation of circuit breaker operation mechanism, controls and adjustments.
- Check for the fuses whether correctly rated and installed, undamaged and fit for operation.
- Check all relays and instruments are clean, correctly connected and undamaged. Check test plugs are installed in all protective relays. Check relays for free manual operation, if applicable.
- Check instrument transformer ratings against drawings. Check for proper installation and connection.
- Check interlock and auxiliary devices and the operation of the circuit breaker with the protection relay circuit.
- Clean the equipment by vacuum cleaner before energizing.

EARTHING

1. Bidder shall test the buried earth grid and shall record the values.

2. Bidder shall inspect and test all earthing work carried out by him, including all interconnections between ground loops, grounding of equipment and ensure all connections are permanent and that the earthing circuit is continuous.

3. Bidder shall megger and record earth resistance at various earth connection points.

SWITCHGEAR

- Switch gears rated 433 volts or more shall be tested with a 1000 volts megger.

- Auxiliary wiring rated less than 415 volts shall be tested with a 500 volts megger.

- All protective relays shall be tested at sufficient points to establish their proper functioning in accordance with the manufacturer's specification and curves.

- Operation checks and functional checks on all switchgear panels.

- For current transformers insulation test, polarity test, ratio test, secondary injection test, operating current check, service setting in consultation with Client / Consultant.

- For potential transformers, ratio test, insulation test, etc.

- Contact resistance for breaker contacts between male and female.

WIRES AND CABLES

- Continuity testing of all cables.

- Wires and cables rated for 433 volts or more shall be tested with a 1000 volts megger. Cables rated less than 433 volts shall be tested with a 500 volts megger.

- No wires or cable having resistance between conductors or between conductors and ground of less than 100 mega-ohm shall be accepted.

FUNCTIONAL TESTING

1. All circuit breakers, contactors, relays, remote devices, etc.,

PRECOMMISSIONING TESTS

- All pre-commissioning tests stated as per IS for respective items

TECHNICALSPECIFICATIONS

1. Main Low Voltage Switch board Enclosure

This section covers the detailed requirements of Main Low Voltage Switch board for 415 volts, 3phase, 50 Hz, 4 wire system.

STANDARDS AND CODES

The equipment proposed in this offer has been designed, manufactured, and tested according to the relevant IEC recommendations.

- IEC61439-1/2–Edition 3 Low voltage switchgear & control gear assemblies–Part 2 Power switch gear and control gear assemblies
- IEC60044-1Current transformers
- IEC60186 Voltage transformers
- IEC60529 Degrees of protection provided by enclosures
- IEC60947-2Lowvoltageswitchgear&controlgear–part2Circuitbreakers
- IEC60947-3Low voltage switchgear & controlgear–Part 3 Switches, disconnectors, switch- disconnectors & fuse combination units
- IEC61140 Protection against electric shock–Common aspects for installation and equipment–Basic safety publication
- IEC60947-4-1Contactors and motor starters

General

The LV switchboards shall be as per the standards IEC 61439-1&2. The switchboards and the associated equipment including switchgear, control gear, Busbar supports, Busbar orientation, Busbar links etc shallbe identical in construction to the assembly which has undergone the type test. The drawings of the type- tested assemblies shall be made available for inspection.

Switch boards shall have a shortcircuit level with stand as per Schedule

of Quantities and drawings.

The enclosures shall be designed to take care of normal stress as well as abnormal electro- mechanical stress due to short circuit conditions. All covers and doors provided shall offer adequate safety tooperating persons and provide ingress protection of IP 42 unless otherwise stated. Ventilating openingsand vent outlets, if provided, shall be arranged such that same ingress protection of IP 42 is retained.

Switch boards must have mechanical impact IK10 tested.

The switchboard along with ACB sand connections should have been type tested design at CPRI

/Independent international test house for shortcircuit, temperaturerise, protective earth short circuit test and dielectric tests of the ratings required.

Refer SLD for form of construction.

Switchboard Configuration

The Switch board shall be configured with Air Circuit Breakers, MCCB's, MCB'sand other equipment as called for in the schedule of quantities.

The Switchboards shall have Rated Impulse withstand voltage (Uimp) of 8kV for withstanding against transient Overvoltages, for which the values of clearances are referred applicable forACB, vertical and horizontal busbars.

The MCCBs shall be arranged in multi-tier formation whereas the Air Circuit Breakers shall be arranged in Single tier formation only to facilitate operation and maintenance.

The Switchboards shall be of adequate size with a provision of spare space to accommodate possible future additional switch gear.

Constructional Features

The Switchboards shall be metal clad totally enclosed; floor mounted free-standing type of modular extensible design suitable for indoor mounting.

Switch boards construction shall employ the principle of compart mentalized and segregation for each circuit.

Incomer and bus section panels or sections shall be separate and independent and shall not be wired with sections required for feeder. The incomer panel shall be suitable for receiving bus trunking or LV cable of size specified.

Switch boards shall be made up of requisite vertical sections, which when coupled together, shall form continuous switchboards.

Switchboard shall be readily extensible on both sides by addition of vertical sections after removal of the end covers.

The switchboards shall be designed for use in high ambient temperature and humid tropical conditions as specified. Ease of inspections, cleaning and repairs while maintaining continuity of operation shall be provided in the design.

Special care to be taken to ensure effective earthing of the frame and doors of the switchboards

Each vertical section shall be provided with a rear or side cable chamber housing the cable end connections and power/control cable terminations. There should be generous availability of space for ease of installation and maintenance with adequate safety for working in one vertical Section with out coming into contract with any live parts. The design of the switchboard shall allow standard extension chambers if required to accommodate cables.

The complete fabrication process of the sheet steel must be carried outby bidder.

Switchboard panels and cubicles shall be fabricated with CRCA Sheet Steel of thickness, same as that of tested assembly according to IEC61439-1 & 2.

Switchboard Dimensional Limitations

The overall height of the switchboard shall be limited to 2100 mm for all the Busbar ratings and type of switchboards. Panel should have integral base frame of 75/100mm,

The height of the operating handle, push buttons etc shall be restricted between 300 mm and 1800 mmfrom finished floor level.

Other dimensional limits if any are specified separately.

Switchboard Compartmentalization

Switchboard design shall be completely compartmentalised with separate compartments for horizontal busbars, vertical busbars, Cable alleys and functional units consisting of ACBs, MCCBs, & MCB's.

Earthed metal or insulated shutters shall be provided between drawout and fixed portion of the switchgear such that no lives parts are accessible with equipment drawn out. Degree of protection within compartments shall be at least IP 2X.

For all Circuit Breakers separate and adequate compartments shall be provided for accommodating instruments, indicating lamps, control contactors and controlMCBetc.These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, busbars and connections.

Each switchgear cubicles shall be fitted with label in front and back identifying the circuit, switchgear type, rating and duty. All operating device shall be in front of switchgear only.

Separate cable compartments running the height of the switchboard in the case of front access boardsshall be provided for incoming and outgoing cables.

Cable compartments shall be of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top. The construction shall include necessary and adequate and proper support shall be provided in cable compartments to support and clamping the cable in the cable alley / cable chamber.

Switchboard BusBars

Busbars shall be made of high conductivity, and high strength Aluminum E91 grade.

Busbars shall be of rectangular cross sections better suitable for full load current for phase bus bars and half/full rated current for neutral busbar or asstipulated in schedule of quantities.

Busbar shall be suitable to with stand the stresses of fault level as specified in schedule of quantities.

The bus bar system may comprise of a system of main horizontal bus bars and auxiliary vertical bus bars run in bus bar alloy on either side in which the circuit could be arranged with front access for cable entrances.

The Busbar Support and the spacing should be same as per the type

tested assembly. Clearances between phases should be in line with IEC.

Switchboard Interconnection

All connection and tap offs shall be through adequately sized connectors appropriate for fault level at location. This shall include tap off to feeders and instrument/control transformers.

For unit ratings upto 160Amps, PVC insulated copper conductor wires of adequate size to carry full load current shall be used. The terminations of such interconnections shall be crimped.

All connections, tappings, clamping, shall be made in an approved manner to ensure minimum contact resistance. All connections shall be firmly bolted and clamp with. even tension. Before assembly joint surfaces shall be filed or finished to remove burrs, dents and oxides and silveredto maintain good continuity at all joints. All screws, bolts, washers shall be zinc plated. Only 8.8 grade nuts and bolts shall be used for busbar connections.

Smart Wireless Sensors (Cable Heating Detection)

Thermal monitoring wireless sensors shall be fitted at least on LV field cable connections andACB connections (upstream and downstream) as well as bolted copper connections. The monitoring shall be done by a battery less sensor that communicates wirelessly using Zigbee Green Power protocol. The corresponding gateway and EPMS Software should be considered in offer while quoting. Equivalent to TH110, PME and PAS600 of Schneider.

Switchboards, non-forced air ventilated, shall be enabled with a DIN rail wireless sensor capableofmonitoringthesystemandgeneratethree-levelsofalertsonoverheatingwireconnections or overheating cables depending on the severity of the detected situation.

Each column of the electrical switchboard shall include one wireless sensor at the top, to help user to prevent electrical switchboards from being damaged, by analyzing gas and particles inthe air and sending alerts before any smoke or insulator browning occurs.

Sensor shall be able to analyze gases and microparticles inside the switchboard, by concentrating air into the sensor (with the help of an aspiration fan), applying a smart algorithm to sort internal cable issues from overheating, and sending alerts via email or notification to a smart phone application, enabling the switchboard's digital management.

Temperature and humidity inside the switchboard should be measured by the wireless sensor and valuesto be communicated through the network. Wireless sensor for early detection of overheating wire connections or overheating cables, should fulfill ISO 14025 PEP ecopassport® program requirements.

Sensor device should not replace any fire protection device of the installation.

ACB:

Drawout Features for ACB

Air Circuit Breakers shall be provided in fully drawout cubicles, unless otherwise stated. These cubicles shall be such that drawout is possible without disconnection of the wires and cables. The power and control circuits shall have self-aligning and self-isolating contacts. Mechanical latches shall be integrated in ACB at service, test and isolated position to ensurethat Breakeris firmly latched in respective eposition. It shall not be possible to move the breaker from the position unless latch is manually operated.

Instrument Accommodation/Meters

All voltmeter and ammeter and other instruments shall be flushed mounted type of size 96 sq. mm conforming to class 1.5 to IS1248 for accuracy. All voltmeter shall be protected with MPCBs.

Instruments and indicating lamps shall not be mounted on the Circuit Breaker Compartment door for which a separate and adequate compartment shall be provided and the instrumentation shall be accessible for testing and maintenance without danger of accidental contact with live parts of the Switchboard.

For MCCBs, instruments and indicating lamps can be provided on the compartment doors.

The current transformers for metering and for protection shall be mounted on the solid copper/aluminium busbars with proper supports.

On all the incomers of switch boards ON/OFF indicators lamps shall be provided suitable for operation on AC 230 volts supply. All lamps shall be protected by MCBs.

Wiring

All wiring for relays and meters shall be with PVC insulated copper conductor wires. The wiring shall be coded and labelled with approved ferrulesfor identification. The minimum size of copper conductor control wires shall be 1.5 sq. mm. Runs of wires shall be neatly bunched and suitably supported and clamped. Means shall be provided for easy identification of wires. Identification ferrules shall used at both end of wires. All control wires meant for external connections are to be brought out on a terminal board. The cables and control wires shall be suitable for withstanding 105 deg C.

Space Heaters

Anti-condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch suitable for electrical operation at 230 volts A.C 50Hz single phase of sufficient capacity to raise the internal ambient temperature by 5OC. The electrical apparatus So protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the switchboard is in operation. As a general rule, the heaters shall be placed at the bottom of the cubicle.

Earthing

Continuous earth bus sized for prospective fault current to be provided with arrangement for connectingto station earth at two points. Hinged doors / frames to be connected to earth through adequately sized flexible braids.

Sheet Steel Treatment andPainting

Sheet steel used in the fabrication of switchboards shall undergo a rigorous cleaning and surface treatment seven tank process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognised phosphating process after which a coat of primer paint compactively with the final paint shall be applied over the treated surface. Final paint coat of oven baked

powder coating, of minimum 50 micron thickness, of sheet approved by Engineer-in-Charge shall then be provided.

Type test reports

Switchboard configurations offered shall be CPRI /Independent international test house tested for all the 12 type tests as per IEC61439-1&2. Copies of all 12 type test reports shall be submitted with the tender.

Air Circuit Breaker

The ACB shall have following features

- ACBs shall be a sealed low voltage air circuit breaker operated as specified on the drawings with integrally mounted electronic tripunits with option to add communication port.
- Circuit breakers shall have a maximum 5-cycle closing time. The closing time shall be less than or equal to 50 milliseconds for ratings <800A;70 milliseconds for ratings <4000A; 80 milliseconds for ratings >4000A
- ACB shall be equipped with anti-pumping function: If opening and closing orders occur simultaneously, the circuit breaker shall remain in the open position. After fault tripping or intentional opening usingthemanualor electrical controls, the closing order must first be discontinued, then reactivated to close the circuit breaker.
- ACB shall not derate upto 50'C, as per testing guidelines prescribed in IEC60947-2.
- All ACBs up to 2500A shall be of same frame size to enable quick replacement in theevent of emergency and to optimize spares inventory.
- All 4 Pole ACBs shall have 100% rated neutral pole.
- All EDO type ACBs shall indicate Ready-to-Close status of breaker (mechanically on front of ACB or electrical indication lamp of panel front door), after checking all the given conditions (UV release energized, Shunt release de-energized, spring charged, Breaker is not "ON", Breaker has not tripped on fault, Breaker is not mechanically interlocked with other
- Breaker and ACB is not racked incompletely in service position)

ensuring safety for user and electrical distribution.

- All ACBs shall be fully tropicalized as standard & suitable for terminating copper or aluminum bus bars. ACBs up to 2500A shall be provided with top horizontal and bottom vertical terminal adapters on both sides for proper cable connections/bus duct connections. ACBs rated for 3200A and above, shall have both side vertical terminal adaptors for effective heat dissipation and better thermal performance.
- All ACB trip unit shall be possible to view the percentage loading of three phases at once on trip unit via LEDs or LCD display to help the user in identifying the current load balancing of the network.

ACB-Breaking Capacity

The ACB interrupting rating shall exceed the available fault current.

The ACB range will offer several level of Icu capacity upto100kA@415V to fit to the application. (for 2MVA<Traffo</=3MVA) ACB shall have the breaking performance Ics=Icu=Icw1sec=65kA) or (for </=2MVATraffo) ACB shall have the breaking performance Ics=Icu=Icw1sec=50kA).

- The ACB shall be available in 3-pole or 4-pole (neutral protection) versions. On 4-pole circuit breakers, a 3-position switch shall be provided to set neutral protection to any of the following levels: unprotected neutral (4P3D), half-protected neutral (4P3D+N/2) or fully protected neutral (4P4D).
- The trip units shall not increase overall circuit breaker dimensions
- All electronic components shall withstand temperatures upto 105°C.
- Trip units shall be adjustable for settings and fine settings without specific tool.
- Trip units shall have traceability of settings.
- Trip units shall provide native ERMS (Energy Reduction Maintenance settings) function for safety protection.
- Engaged status of ERMS shall be visible at a distance.
- Protection settings shall apply to all circuit breaker poles
- Electronic trip unit shall be fitted with thermal memory
- It shall be possible to equip ACBs with an auxiliary contact signalizing an electrical fault operatedby the trip unit
- The following monitoring functions shall be integral parts of electronic tripunits:
    - Pre Warning LED for load indication lighted above 90% of the adjusted

threshold Ir

- Warning LED for load indication lighted above 105% of the adjusted threshold Ir
  - Trip units shall have communication/test port for checks on electronic and tripping mechanism operation in compliance with market standards (USB-C) avoiding require specific Manufacturer's hardware additional tool
  - Trip units shall have native NFC wireless communication for protection reading with smartdevice. Dedicated Bluetooth communication version provides protection settings.

Trip unit protection functions

ACB shall be equipped with a trip unit that offers the appropriate level of performance to fit to the application:

Basic protection (LI) with energy measurement

These trip units shall offer

- **L**ong time protection
  - Adjustable Ir(A)threshold settings from 40% to 100% of the trip unit rating
  - Adjustable tr(sec) time delay
- **I**nstantaneous protection
  - Adjustable Isd(A) threshold

settings from 1.5xIr to10xIr **Selective**

protection (LSI) with energy

measurement

  - These trip units shall offer
- **L**ong time protection
  - Adjustable Ir(A) threshold settings from
  - 40% to100% of the trip unit rating
  - Adjustable tr(sec) time delay
- **S**hort time protection

- Adjustable Isd(A) threshold settings from 1.5xIr to10xIr
- Adjustablet sd(sec) time delay

- **I**nstantaneous protection
  - Adjustable Ii(A) threshold settings from 2xInto15xIn with an OFF position
  - Specific setting for fast breaking time:30ms
  -

Selective protection & Ground fault (LSIG) with energy measurement

The trip units shall offer

- Long time protection
- Adjustable Ir(A) threshold settings from 40% to 100% of the trip unit rating
- Adjustabletr (sec) time delay
- Short time protection
- Adjustable Isd(A) threshold settings from 1.5xIr to10xIr
- Adjustable tsd(sec) time delay
- Instantaneous protection
- Adjustable Ii(A)threshold settings from 2xInto15xIn with an OFF position
- Ground fault protection(GF)
- Adjustable Ig(A) threshold settings
- Adjustable tg(sec)time delay
- Option to set OFF the ground fault protection(GF)

Trip unit measurement function

The trip unit shall provide measurement (at least current / at most energy) without anyadditional module whatever the protection (LI, LSI, LSIG).

- Rogowski current transformers shall be used to ensure accurate measurements from low current up to high currents

- All protection functions shall be ensured by an ASIC (Application Specific Integrated Circuit), independently of measurement function.
- The measurements shall be displayed on the breaker itself, on a remote system via Modbus communication and locally by means of smart device using wireless protocol (Bluetooth). In addition to these solutions it shall be possible to connect a remote display (front panel).

ACB-Protection Type

Instantaneous settings on the trip units with LSI protection shall be adjustable from 1.5 to 15 xIn.The Instantaneous settings hall also have an OFF setting when short-time pick-up is provided. Long time over current protection threshold shall be adjustable from 0.4 to 1 x ln. Long time over current protection time delay shall be adjustable from 12.5 to 600sat1.5xlr,
0.5 to 24s at 6 x lr and 0.7 to 16.6 x lr. Short time overcurrent protection threshold shall be adjustable from
1.5 to 10 x lr and short time overcurrent protection time delay shall bead justable from 10 to 40ms of I2T.
Ground fault protection shall be adjustable.

ACBs shall have separately powered, individual fault trip indication LEDs (For overload, short circuit, earth fault and trip-unit failure) shall be available on the trip unit which shall function even in the absence of external power supply to the breaker.

All ACBs in main LT panel shall be provided with zone selective interlocking which helps in reducing the thermal and dynamic stress on installation during short circuit and ground faults. The releases shall be suitable to communicate between incomer breaker and outgoing breakers enabling zone selective interlocking.

The trip unit shall be a Micrologic6 from Schneider Electric, equal and approved.

ACB-Release Functions

ACB-Release with Metering, Protection & Communication functions. **ACB-Connectivity** The main incomer shall be with RS485MODBUS connectivity.

Standalone Metering -

Incomer Multi-function Meter

The power meter shall measure the following parameters: Energy, Active and Reactive power, Voltage, Current, Frequency, Power Factor and THD to the 31st harmonic (OverCommunication). Power Meter (PM) needs to comply to

Active energy accuracy of Class 0.5S as per IEC 62053-22. Relevant type test documents tested in third party lab to be produced. Power Quality Meter (PQM) needs to comply to Voltage, Current, Active Power, Power Factor, Frequency as per IEC 61557-12.5. Power Meter (PM) needs to be capable of storing 12am Snapshot (Time Configurable) for Voltage, Current, Power, Energy delivered and capable of retrieved during the 24 hours of the day. Power Meter (PM) needs to be capable of inbuilt 02 energy counters for KgCo2 and Energy Cost. 6. Power Meter (PM) needs to be inbuilt with Calibration Pulse LED configurable from 1 to 9999000 pulses/k_h (kWh, kVAh, or kVARh) unauthorized access and Heart beat LED for communication Status. 9. Power Meter (PM) needs to be capable of onboard data logging up to 2 parameters with option to select from Power (W,VA,VAR) Bi-directional energy (+/-Wh, +/- VAh, +/- VARh), Demand (W, VA,VAR) with configurable interval and duration (e.g. 2 parameters for 60 days at 15 minutes interval). Power Meter (PM) needs to needs to have RS 485 port Modbus RTU and disabling RS485 port through front panel keys against unauthorized access.

The meter shall be a PM2230 or equal and approved (ReferSLD).MCCBs

The MCCB shall have following features

- MCCBs shall comply with standards IS/IEC60947-1&2.
- The breaking capacity performance certificates shall be available for category A to the above- mentioned standards.
- MCCB shall have a rated operational voltage (Ue)of 415V,insulation voltage (Ui) of 690V (AC 50/60 Hz) & impulse voltage (Uimp) of not less than 8kV.
- MCCB shall not have any line load bias. MCCB shall comply with the environmental directives like RoHS and WEEE.
- MCCBs shall be current limiting type and shall have an encapsulated double break roto design having two fixed contacts, one moving contacts and two arc chutes per pole.The design is required to minimize the effects of short circuit currents i.e. to limit the let through energy and improve the life of cables. It shall be possible to fit lead seals to prevent unauthorised access to the settings.
- MCCB'sshallhavepushtotripfunctionforcheckingthetrippingmechanism healthiness. Also this checking shall be possible with or without rotary handle.
- MCCBs up to 200A shall be thermal magnetic type, above 200A shall be microprocessor based type.

- MCCBs accessories (Shunt Coil, Auxilary Contacts, UV Coils,etc.,) shall be considered asper SLD.

MCCB s-Type

MCCBs shall be fixed type.

MCCB s-Breaking Capacity

The MCCBs shall have a rated service breaking capacity (Ics) equal to the ultimate breaking capacity (Icu) at 415V and as per system fault levels (refer SLD). Switchgear Manufactures can optimize breaking capacity of outgoing breakers(MCCBs,MCBs)by using cascading technique as defined in IEC 60947-2 Annx. A. Switchgear manufacturer shall submit necessary backup documents and Cascading reports along with techno-commercial offer.

MCCBs-Protection Type

Adjustable thermal protection from 0.7 to 1.0x the current rating. Fixed magnetic protection for current ratings up to 200 A. Adjustable (from 5 to 10 x the current rating) for current ratings greater than 200A.

Electronic Long-time protection will have a selectable Ir threshold rating. Short time protection Isd will have a threshold which shall be adjustable from 1.5 to 10 x the thermal setting Ir. Instantaneous protection will have a threshold that shall be adjustable starting from 1.5 x In and up to a value between 12 and 15 x In, depending on the rating. It shall be possible to adjust earth leackage setting min 30mA with adjustable time delay.

CODES AND STANDARD

The following codes and standards shall be applicable for continuous performance of all electrical equipment to be supplied delivered at site erected, tested and commissioned. The electrical Equipment offered shall comply relevant Indian Standard Specifications, Fire Insurance Regulations Tariff Advisory committee's Regulations and to Indian Electricity Rules in all respects with all its latest amendments up-to-date.

For guidelines to the Bidder few of the Indian

Standards are indicated below: - IS 3043 - Code of

practice for Earthing
IS 10118 - Code of practice for Installation of Switchgear.
IS 3106 - Code of practice for selection installation and maintenance of fuse (up to 650 Volts) IS 3427 - Metal Enclosed Switchgear and control gear.
IS 4064 - Switch fuse units for Industries etc.
IS 4237 - General requirement for Switchgears not exceeding 1000 volts. IS 4615 - Switch Socket Outlets.
IS 5133 - (Part I) Sheet Steel Boxes.
IS 5216 - Guide for safety procedures and practice in electric work. IS 5578 - Guide for making of insulated conductors.
IS 5908 - Method of measurements of electrical installation in building. BS 162 - Electric power switch gear for indoor and outdoor Installations.
IS 374 - Ceiling Fans
IS 415 - Tungsten Filament Lamps.
IS 694 - PVC insulated cable and cords for Power/Lighting. IS 732 - Electrical wiring installation (up to 650 V)
IS 1087 - Single pole Tumbler switch 5 amps.
IS 1293 - 3 Pin Plugs and Socket outlets.
IS 1554 - PVC insulated Cables - heavy duty. IS 1567 - Metal clad switches up to 100 Amps.
IS 1771 - Industrial Light fittings with accessories.
IS 6381 - Specification for constructions and testing of Electrical Apparatus. IS 2268 - Call Bells / Buzzers.

IS 2274 - Code of practice for wiring installations (exceeding 650 Volts). IS 3854 - Switches for Domestic and similar Purpose.
IS 2312 - Exhaust Fans.
IS 2509 - PVC Electrical conduits.
IS 2675 - Enclosed Distribution Fuse Boards and cutouts for voltage up to 1000 Volts. IS 2834 - L.T. Capacitors.
IS 3043 - Code of Practice for Earthing.
IS 1646 - Code of Practice for Fire Safety in Electrical Installation.

The entire electrical installation work shall be strictly complied with the codes and Standards. Rules and Regulations framed under the Indian Electricity Act 1910 and Indian Electricity Rules 1956. Further it shall be carried out as per the Regulations and Rules setout by "Tariff Advisory Committee and or / Fire Insurance Regulations.

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SCOPE

1. This specification covers the design fabrication testing packing and supply of 415/230 volt, 3 phase 4 wire Indoor Fixed type compartmentalized cubicle type. Floor mounting switchboards.

2. The switchboard and mounted equipment shall comply with following Indian Standards:

1. IS 2516 - AC Circuit breaker requirements voltage not exceeding 1000V.

2. IS 2147 - Degrees of protection provided by enclosures for low voltage switchgears and control gear.

3. IS 4237 - General requirements for switchgears and control gear for voltages not exceeding 1000V.

4. IS 4047 - Heavy-duty air break switches and fuses for voltages not exceeding in 1000V.

5. IS 2208 - HRC cartridge fuse links up to 650V.

6. IS 2705 - Current transformers.

7. IS 1248 - Electrical indicating instruments.

8. IS 375 - Marking and arrangement for switchgears busbars main connections and auxiliary wiring.

9. IS 159 - Busbars and Busbar connections.

10. IS 8623 - Factories Built Assemblies Switchgears and Control gear.

11. IS 1897 - Copper strip for electrical purpose.

12. IS 3618 & IS 6005 Phosphate treatment of iron and steel.

13. IS 2032 - Graphical symbol.

SPECIFICATION

A) The assembly shall be metal clad compartmentalized and shall comprise standard prefabricated sheet steel units. Assembled to form a rigid freestanding dead front structure Frame shall be made out of 14 gauge M. S. sheet steak and covers out of 16 gauge M. S. cold rolled sheet steel. Vertical units shall be assembled to form a continuous line-up of uniform height & depth. Switchgears shall be extensible at both ends by the addition of vertical sections. Ends of the busbars shall be suitable drilled for this purpose.

1. The switchboard shall be totally enclosed fully tropicalised weather and vermin-proof. Opening for screens or grills made of brass wire mesh. Double lipped. Neoprene gasket shall be provided on doors removable covers gland plants and between two vertical panels all round perimeter to make switchboard dust and vermin proof. Enclosure of the switchboard shall be IP 50 for indoor type as per IS 2147 Hinges should be concealed for aesthetic appearance.

2. The switchboard shall be suitable for operation in tropical climate and under ambient conditions specified.

3. All joints and connections shall be made by galvanized or cadmium plated high tensile strength steel bolts, nuts and washers secured against loosening.

4. The switchgears shall be designed to ensure maximum safety during operation inspection connection of cable and maintenance with Bursar system energized Means shall be provided to prevent shorting of power and or control terminals due to accidental dropping of maintenance tools etc Inside the switchboard i.e.

M. S. Horizontal partition between feeder compartments between Bus bar chamber and feeder compartments vertical partition between feeder compartment sand cable alleys and between two vertical panels.

5. All equipment shall be mounted on the front side and shall be accessible from the front through hinged doors. Control and selector switches ammeters, voltmeters and lamps push buttons relays etc shall be mounted on doors Current Transformer will be mounted on bus bars.

6. It shall be possible to insert any new cable and to connect all load side wiring with the bus energized without any special safety precautions. Opening of the bursars chamber shall be permitted with special tools only.

7. Compartment doors shall be interlocked against opening when the breaker/ switch is ON position. However it shall be possible to bypass this interlock for inspection purposes.

8. The switchboard will be provided with metallic engraved labels on compartments as well as by switchboard designating Department/Section/feeder where in the said switchgears/ switchboard is used.

9. The switchboard will have removable type cable gland plate to facilitate termination/glanding of cables. The size of gland plates should be spacious and to be decided in such a way that tightening of gland is easily possible without disturbing other gland. So also distance between the cables should be sufficient to maintain clearances.

10. Sufficient space for cable alley to be provided to accommodate the number of cables. Necessary clearances between cables to be maintained. Arrangement for clamping mounting to be provided. Cable alley to be located in switchboard in such a way that after termination cables on switchgear tension will not be created on lug/terminals.

11. Base frame for switchboard will be of ISMC 100 rigidly welded to switchboard compartment.

12. Above the base frame compartments of min size of 300mm will be left vacant throughout the length of panel.

13. Formation of switchboard will be single Tier for ACB and Two/ Three tiers for Switchgears. Main Busbar chamber will be on top of these tiers and vertical Busbar chambers connected to main bus will feed to various feeders.

B) BUSBARS

1. The switchboard shall comprise high conductivity electrolytic copper 3 phase and neutral busbars, which shall be extended through all units of the switcher line - up. All phase busbars shall be of uniform cross sections throughout the length of the switchgears and shall be sized to carry continuously the current specified.

2. The busbar shall be dynamically braced and thermally sized for short circuits PVC sleeves shall be provided for the busbars.

3. Neutral bus shall be rated for half the capacity of phase bus. All connection bolts and nuts shall be accessible in such a way that they can be checked with normal tools. Minimum clearance between live parts between phase and neutral and also between phase and neutral with ground must as per IS 4237.

4. The busbar supports shall be made of high quality non-hygroscope non-

flammable high tracking index class KA3c withstanding temp up to 130° C

high impact tensile strength fiber glass reinforced polyester insulators.

5. Current density of copper Busbar shall not be more than 1000 A per square inch.

6. Final temperature of busbars at rated current shall be limited to 85° C.

C) PAINTING

1. All metal surfaces shall undergo seven-tank process and shall be thoroughly cleaned and degreased and derusting with alkali and acid to remove mill scale grease rust and dirt. Fabricated structures shall be pickled and then rinsed with water to remove any trace of alkali /acid. Then phospating coat shall be applied. Also two coats of Zinc chromate stove primer shall be applied. The surface shall be made free from all imperfections before applying the second's coat of primer. The switchboard shall be spray painted with two coats of synthetic enameled paint of light gray of shade 631 of IS-5 and egg shall white from inside.

2. All unpainted steel parts shall be cadmium plates to prevent rust corrosion. If these parts are moving elements, then they shall be greased. Suitable lifting lungs shall be provided which shall not leave any opening when removed.

D) SPACE HEATERS

Each vertical cubicle shall be provided with 40W space heaters to prevent moisture condensation and maintain cubicle temperature 5C above the ambient.

The space heaters shall be located at the bottom of the switchboards and shall be controlled through a common thermostat with an adjustable setting and a manually operating switch. The thermostat shall preferably be located in the metering/relay chamber. For space heater one common 25A DP switch and two EE HRC fuses shall be provided.SWITCHBOARD COMPONENTS

A) SWITCHES

Switches shall be air break type as per IS: 4047 and of Ac-23 duty The switch operating handle shall be front mounted and interlocked with the door such that door cannot be opened when the switch is ON. The live parts shall be shrouded with suitable insulating barriers so as to prevent accidental contact with the live parts after opening the cubicle front door. Motor control switches are suitable for reliable and safe starting and stopping of 3 phase AC motors even under heavy starting locked rotor condition.

B) FUSES

All power and control fuses shall be of link type. Screw type Dz. fuses will not be acceptable. All fuse links shall be HRC type and shall generally conform to IS 2208 Rewirable fuses will not be acceptable. All fuses shall be readily accessible for replacement. It shall not be necessary to remove any piece of equipment or to disconnect wiring before replacing fuses 20% of spare HRC fuses to be supplied along with the switchboards.

C) CONTROL SWITCHES

1. All control switches shall be rotary back-connected types having a cam operated contact mechanism Preferably phosphor bronze contacts. Unless otherwise specified circuit breaker control switches shall be 3- positions spring return to neutral from both ON and OFF positions. They shall have pistol grip handles.

2. Ammeter selector switches shall have make before break feature on its contacts. The selector switches shall generally have four positions for reading three phase currents and neutral. The voltmeter selector switch shall also have four positions Three shall be used to measure phase to phase voltages and the fourth shall be OFF position.

D) INSTRUMENT TRANSFORMER

1. Current and voltage transformer shall preferably by cast resin insulated. Primary

and secondary terminals shall be clearly labeled.

2. Current transformers shall generally conform to IS 2705.Generally they must be mounted on the stationary parts, not on the bulbar for general guidance the vendor shall note that the protective current transformers shall have an accuracy class 5p and an accuracy limit factor 10.0 low reactance CTS shall be used for protection. Current transformers for instrument shall have an accuracy class I. O. and accuracy limit factor less than 5.0. The current transformers shall be capable of withstanding the peak momentary short circuit and symmetrical short circuit current for 1.0 second. The neutral side of the current transformer shall normally be earthen through a link.

E) MEASURING INSTRUMENTS

All measuring instruments shall be square pattern moving iron 90° scale 96 * 96 mm² flush mounted type. Instrument shall be of accuracy class I.O. as per IS: 1248 Ammeters for motors feeders shall be graduated for full load current of the motor with a compressed scale at the end for at least (six) times the full load current. The kW meter and P.F. meter shall be suitable to measure unbalanced loads on 3 phase 4 wire system P.F. meter shall be of 0.5 - 1- 0.5 range.

F) INDICATING LAMPS

Panel mounting type low power consumption indicating filament lamp suitable for specified voltages shall be used. Lamps shall be provided with suitable current limiting resistors & fuses lamp shall be provided with translucent lamp coves to diffuse light. Lamps shall be provided with bayonet cap bulbs.

G) PUSH BUTTONS

Push buttons shall be suitable for panel - mounting type comprise of a contact element and an actuator. The contacts are of silver alloy of a 10 A continuos current rating. Each push button shall be provided with 1 NO + 1 NC contacts. But if required 2 NO + 2 NC contacts shall be provided at no extra cost. Colour of the knob shall be as per I.S./B.S.

H) PROTECTIVE RELAYS

1. Wherever used all protective relays shall be back-connected flush mounted draw out type and with flag indication. The relay cases shall have provision for insertion of test plug at the front for testing and calibration using and external power supply without disconnecting the permanent wiring. It shall be possible to short the CTS through the test plugs.

All relays shall preferably be mounted in front of the panel and shall be as specified on the single line diagram. The current and voltage coils shall be rated as specified on the single line diagram. The current and voltage coils shall be rated as

specified on the drawings. All relays shall generally conform to I.S. 3842 I.S. 3231 and hand reset type.

I) NAME PLATES

1. A nameplate with the switchgears designation shall be fixed at the top of the switchboard. A separate nameplate giving feeder details shall be provided for each panel.

2. Nameplate shall be provided for each piece of equipment such as lamp pushbutton switch relays etc mounted on the switchboard Special warning plates shall be provided on all removable covers or doors giving access to cables or Busbar. Identification tags shall be provided inside the panels for switches, fuse, contractors, O/L relays etc matching with those shown on the circuit diagram.

1. Rubber grommets shall be provided so that metal parts should not come in contact with any power or control wires/cables.

2. Minimum size of terminal for control wiring shall be 10 mm2. Clipon type terminal shall be provided. 20% spare terminals shall be provided on each terminal block.

3. Stranded conductor shall be provided with copper lungs at both ends before connections are made.

J) EARTHING CONNECTIONS

All cubicles shall be incorporated with a copper earth Busbar running throughout the length of the switchboard. The earth bus size shall be 25 mm x 6 mm horizontal. All doors and moveable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing Busbar to the plant earthing grid at two ends. All non current carrying metallic parts of the mounted equipment shall be earthen.

K) DANGER NOTICE PLATE

Danger Notice plate with symbol as per I.S. shall be provided on switchboard.

L) FUSE PULLER

One fuse puller to be supplied along with each switchboard.

M) TESTS AND INSPECTION

1. During fabrication switchgears shall be subject to inspection by the consultant. Manufacturer shall furnish all necessary information concerning the supply to inspectors.

2. Tests shall be carried out at manufacturer plants under his care and expense. All routine tests as specified by the applicable standard code shall be conducted. Type test certificates of a recognized testing organization shall be furnished with the bids.

3. In addition specific tests shall be conducted to check mechanical and electrical operation and switchboard wiring to the specification and schematic diagrams. These tests shall be provisionally conducted at manufacturer plant by providing temporary connection to switcher units in order to simulate the actual conditions. Tests shall be finally performed at site in presence of manufacturers specialist once the external cables connection have been completed.

4. Shop tests shall be witnessed by an agency authorized by the consultant.

5. Acceptance tests shall be as follows:

(a) A general visual check shall be carried out. This shall cover measurement of overall dimensions locations number and type of devices terminal boxes and connections of terminals etc.

(b) Manual and electrical operation or CB/relays/contractors etc shall be checked under the worst conditions of supply voltage. Also continuity test shall be taken.

(c) Insulation resistance of the main and auxiliary circuits shall be checked before and after high voltage test.

(d) High voltage test.

(e) Operation check shall be carried out for every control function as per the schematic diagrams by manually simulating fault conditions and operation of control switches/relays etc.

(f) Relays shall be tested with secondary injection test equipment.

(g) For equipment purchased from other sub suppliers certificate test reports of test carried out at the manufacturer's works shall be submitted.

N) DRAWINGS

1. The consultant's schematic diagrams are intended as a guide and contractor shall develop his own general arrangement and schematic drawing adding necessary auxiliary devices, accessories, components peculiar to supplied equipment ferrules number terminal number etc which are required for safe convenient efficient & proper operation of the 415V power center.

2. Manufacturer shall submit single line general arrangement drawings including material list, foundation drawings and control wiring drawings to the consultant. Approval of general arrangement shown in the drawings is required before the fabrication of cubicles is started. Approval of schematic drawings single line

and control wiring drawings shall be obtained before the manufacturer proceeds with the cubicle wiring. The approval of manufacturer's drawings shall not relieve the manufacturer of his responsibility of supplying equipment conforming to the relevant specifications and standards or for any mistakes errors or omissions in the manufacturers drawings.

3. Once manufacturers schematic diagrams have been finally approved the manufacturer shall prepare wiring connection diagrams for each cubicle. This diagram shall show all wiring inside the cubicle starting from the cubicle terminal strips. These diagrams small be used for trouble shooting and shall show every device terminal and wire number.

4. Manufacturer shall submit the ten- (10) copies of final prints and one (1) reproducible tracing of each and every drawing.

O) PACKING AND TRANSPORT

The switchboard shall be shipped to site packed in wooden crates. They shall be wrappers with polythene sheets before being placed in crates to prevent damages to the finish crates shall have skid bottoms for handling.

AUTOMATIC POWER FACTOR CORRECTION PANELS

1.0 GENERAL:

The specification covers the Design, Manufacture, Testing at works, supply of 415 V Automatic Power Factor Correction Capacitor control panel.

2.0 STANDARDS:

The equipment shall conform to the following Indian

Standards. IS : 9244 - HRC Cartridge fuse links

or MCB
IS : 2147 - Degree of protection provided by enclosures for low voltage

switchgear. IS : 2516 - AC Circuit Breakers (MCCB)

IS : 8828 - MCCB's

IS : 2705 - Current Transformers (Part I

to IV) IS :1248 - Direct acting electrical

IS : 2834 - Capacitors.

3.0 CONSTRUCTION:

The Panels shall be floor mounting, fixed type, single front, self standing, totally enclosed to make it dust and vermin proof.

The Panels shall be fabricated with 14 SWG cold-rolled

sheet metal. The Panels shall be fully compartmentalised

with all doors in front only.

The number of steps and the KVAR rating of the Panels shall be as per

BOQ. Adequate lifting facilities shall be provided and the lifting eye

bolts are removable.

The panel consists of 3 nos. of bus-bars for Phases and 1 no. for neutral. The bus-bars are of high conductivity aluminium and are of sufficient cross section to carry fault current without any damage. The bus-bars shall be supported on epoxy cast resin insulators and covered by heat shrinkable PVC tapes. The main bus bars shall be adequately supported to withstand stresses developed due to short circuit current. Tapping points shall be treated against oxidation. Appropriate identification markings/labels shall be provided on the bus-bars and trappings for distinguishing the various phase and neutral.

The cable alleys shall be provided with hinged doors for each access to cables inside. The cable alley door shall be provided with bolts, which can be opened with special keys by authorized persons.

The compartment doors shall open away from the cable alley and shall be provided with special locks, which will ensure tight closing of doors making the compartment effectively dust proof.

The fabricated panel shall undergo a treatment of degreasing, picking and 2 coats of primer, before inside and outside powder coating.

The equipment inside the compartment shall be arranged in a logical manner for ease of reference at site.

Undrilled gland plates shall be provided at top and bottom of the panel and shall be removable type with nuts and bolts for proper fixing.

The control supply shall be tapped after the mains incomer MCCB. Control circuit shall have protection fuses / MCB's.

Indicating lamps shall be provided on each rack. Capacitors "ON" & "OFF" indications shall be provided on APFC relay.

Panels shall be provided with cooling fan, if required for containing the excessive temperature with suitable mesh doors for natural ventilation as required by the Electrical Inspectorate.

Capacitor should be mounted in side the panel and proper ventilation to be provided.

4.0 HRC FUSES:

HRC fuses shall be link of reputed make and shall have rupturing capacity of 80 KA.

5.0 CONTACTORS:

Contactor shall be of electromagnetic type rated for uninterrupted duty as defined in IS-2959 unless otherwise specified and also suitable for capacitor duty.

The Main Contactor shall be of silver or silver alloy. The insulation class for the

coil shall be class E. Each contactor shall be provided with 2 N/O and N/C

auxiliary contacts.

Contactor coil rating shall be minimum of pick up 85% of rated voltage and minimum drop out of 75% rated voltage.

6.0 PUSH BUTTONS

Push buttons shall be generally shrouded. Each push button shall be provided with 1 N/O and 1 N/C auxiliary contacts. “Stop” push button shall have, ‘stay-put’ feature. Colour code shall be as per IS-6875.

7.0 INDICATING LAMPS

2 Nos. indicating lamps shall be provided in each capacitor feeder with red and green colour to indicate ‘ON’ or ‘OFF’.

8.0 CURRENT TRANSFORMER:

Current transformer shall be double wound, dry type and shall have good regulation (5% or less) to cope with inrush current of contactor coils with sufficient rating of HRC fuses for primary and secondary.

9.0 SPACE HEATERS:

Anti-condensation space heaters, with thermostat suitable for 230 V, 1 Ph supply along with a switch fuse shall be provided in each panel.

10.0 CONTROL SWITCHES:

A general purpose control switch shall be provided for selection of “Auto” & “Manual”. The switch shall be provided with engraving plate in the front with “Auto”, “Manual” & “Off” inscription. This switch shall be normally of the fixed control bar type heavy duty unit.

11.0 APFC RELAY:

The Panels shall be provided with APFC relay having 4/6/ 8/10/12 steps with facility for setting target P.F. range in the form of high and low, step indication, low current indication, auto manual selection. A 7-segment LED display is provided to indicate existing power factor. The relay also provides over voltage protection up to 10% of rated voltage. Lead power factors are completely eliminated and the switching takes place on FIFO arrangement.

12.0 CAPACITORS:

The capacitor banks shall be designed as per IS: 2834 & IEC 831-1-2.

Capacitor design shall be intended for high power industrial application with extreme demand for service life, constant capacitance and high inrush current withstand capability.
The capacitor shall be compact, self healing, MPP, gas filled capacitor. The current carrying metal layer (electrode) to be vapour deposited on to one side of film.
The capacitor shall be composed of three single face element stacks, connected in delta.
The winding elements to be housed in a cylindrical aluminium case and hermetically sealed by a press rolled metal lid.

The capacitor shall be of dry technology. Instead of liquid impregnated agent the capacitor is filled with nitrogen house. So there is no risk of fire caused by leakage oil. The capacitor shall be self healing type and shall have an over pressure disconnector. This over pressure disconnector prevents the capacitor from bursting at the end of its service life or caused through electrical or thermal over load. The SIGUT termination shall ensure no loose screws and shall protect against electric shock hazards.

Capacitor banks shall comprise of identical delta connected three phase units. Capacitor banks shall be dry type metalised polypropylene type & shall be self healing and filled with non toxic & non flammable material.

Capacitor shall be compact in size and hermetically sealed. Internal silver fuses shall be provided for protection of each capacitor element. The capacitor bank to be complete with fixing channel suitable for floor mounting.

Incomer circuit breakers: MCCB as specified in the Schedule of Quantities

13.0 .EARTHING:

The Panels shall be provided with 2 earthing terminals of minimum M8 size on both sides of the Panel.

14.0 TESTS & INSPECTION:

The Panel shall be completely assembled, wired and tested as per IS-8623 at the factory in the presence of the Consultant/Purchaser's Engineer at no extra cost.
The test shall include wiring continuity tests, insulation resistance tests, high voltage tests (2.5 KV AC for 1 min) and functional tests to ensure operation of control scheme and individual equipment.
Manufacturer's Test Certificates in respect of all meters, contactors, switch fuse, capacitors, MCCB, ACB etc shall be forwarded to Owner prior to inspection, by Bidder

15.0 BUSBARS AND INSULATING MATERIALS

The control panel shall have single bush bar pattern with air insulated Busbars housed in a separate compartment, segregated from all other compartments, with the sheet steel barriers. Busbars shall be of high conductivity electrolytic copper suitable for carrying the rated and short time current without over heating. Busbars shall be adequately supported on insulated to withstand dynamic stresses due to short circuits.

Busbars shall be designed for the specified fault level, time and continuos current rating and shall have the same rating throughout the length of the control panel and shall be insulated and sleeved throughout. The neutral busbar when specified shall be of not less than half the current carrying capacity of the phase busbars.

Arc propagation barriers shall be provided to prevent arcs from flashing to the main busbars. Similarly the control panel shall be designed to prevent arcs flashing across bus-tie units.

All busbar connections and bus taps to individual feeders shall be either by means of 1100 / 650 V grade PVC insulated wires or links insulated with shrunk PVC sleeves. Busbars shall be colour coded for ready identification of three phases.

All insulating materials used in manufacture shall be non-hygroscopic, aging proof, non-fire propagating and shall be treated for preventing fungus growth. Surface of insulators shall be highly glazed and treated with silicone compound to minimise accumulation of dust, condensation of moisture and tracking. The insulating materials shall preferably be non-carbonising type. The insulating material shall have resistant to superficial discharge.

The temperature rise, above the design ambient temperature, permitted under normal working conditions with rated current flowing is as follows :

Insulated & non insulated busbars	**- 50 C**
Conductors with PVC sheath	**- 30 C**
Conductors with both side insulated	**- 65 C**
Other Contacts	**- 50 C**
Metallic parts without voltage	**- 40 C**
Exterior surfaces	**- 15 C**

16.0 ISOLATORS

Isolators shall be two position (ON / OFF) type, heavy duty, load break quick make and break type complying with the requirements of BS EN 60947-3 and suitable for front of board operation & capacitor switching.

Isolators to be interlocked with compartment door to prevent opening or closing of the door in the closed (ON) position of the isolator, in case of compartmentalised switchboard. Provision for padlocking the isolators in open or closed position also to be made.

All live terminals on the isolators to be adequately shrouded to prevent accidental contact and danger to the personnel.

The isolators shall be provided with 2# NO+NC contact for

'Status Indication'. SWITCH DISCONNETOR FUSE AND

MOULDED CASE CIRCUIT BREAKERS.

All fuses shall be non-deteriorating high rupturing capacity, link type mounted in suitable fuse carriers or fuse bases, conforming to BS 88.

Fuses shall be provided with operation indicators and it shall be possible to change fuses

with the circuit live. All fuses in control, indication and metering circuit shall be HRC, link

type.

Insulating fuse pulling handles shall be supplied for each size of fuse with the

control panel. The switch disconnector fuse units shall be provided.

MCCB's shall be short time fault rated to comply with 'service' category of performance to BS EN 60947-2 and shall be of "Utilisation: Category 'B' to give adequate fault discrimination. The MCCB shall be suitable for capacitive current switching.

The MCCB units shall be provided with with 1# NO+NC contact for 'Status Indication' & 1# NO+NC contact for 'TRIP' indication.

17.0 CONTACTORS

Contactors shall comply with IEC 158-1 and 1A and shall be air break, electromagnetically operated and electrically held unless otherwise specified in the data sheets.

All power contactors shall be rated for capacitor current switching. Minimum rating shall be not less than 9 Amps. The contactors shall be provided with inrush limiting resistors, especially designed for capacitor switching.

Coils shall be continuously rated and capable of withstanding 106% voltage continuously and 110% voltage infrequently. Coils shall have a minimum pick up voltage of 85% rated volts and a maximum drop off voltage of 60% rated volts. The trip coil of latched contactors shall operate correctly at 75% of rated voltage, unless specified otherwise on the datasheets.

Contactor breaking capacity shall be compatible with the protection afforded by the overload relay in conjunction with the fuses. Faults in excess of the contactor rating shall be cleared by the fuses.

All power contactors shall be provided with minimum 1 nos. Normally open (NO) and 1 nos. Normally Closed (NC) auxiliary contacts; preferably, convertible from NO to NC and vice versa.

All contactor coils to be suitable for climatic conditions specified in Data Sheets. Insulation Class for Coils – Class ‘E’ or higher.

18.0 INDICATING LAMPS & PUSHBUTTONS

18.1 INDICATING LAMPS

Indicating lamps shall be LED type with Low Voltage Glow Protection Cluster type LED (min-8) 300 lux. Lamp covers shall be provided with interchangeable coloured lenses of Perspex or equivalent unbreakable material. It should be noted that lenses should not get discoloured in course of time, due to the heat generated by the lamps. Requirement of indicating lamps will be indicated in Data Sheets / wiring diagrams. Lamp holder provided shall be suitable for easy removal / insertion of lamps.

The colour of indicating lamps shall be as follows:

Red	-	Feeder 'ON'
Green	-	Feeder 'OFF'
Amber	-	Auto Trip
RYB	-	Potential indication for 3Ph AC supply.

18.2 PUSH BUTTONS

Push buttons to be provided on front door.

Stop Push Button – with stay put feature, (preferably lockable) with

mushroom head. Reset Push Button – for hand resetting of BMR (to be

provided only if called for).

Start Push Button – Shrouded type spring return (to be provided only if called for). Colours of the push buttons:

Stop	-	red (stay put type)
Start	-	green
Reset	-	black or yellow

18.0 CURRENT TRANSFORMERS – CAST RESIN

Current transformers shall be bracket mounted & conform to BS 7626. The design and construction shall be sufficiently robust to withstand thermal and dynamic stresses due to maximum short circuit current, available at the point of installation of current transformer.

Secondary terminals of the CT shall be brought out suitable to a terminal block that will be easily accessible for testing and external connections.

Terminals shall be marked in accordance with BS 7626. A rating plate as per BS 7626 shall be provided on each current transformers.

Current transformers associated with circuit breakers shall be mounted in the stationary portion of the control panel to permit complete interchangeability of similar breakers.

Current transformers shall have short time current ratings not less than that of the switchgear or, in the case of fuse protected units shall be capable of withstanding the let through current of the maximum size of fuse link that can be fitted.
Where current transformers are connected in star, the star point shall be earthed through a removable link.

Shorting links shall be provided at the outgoing terminals, where protective circuit wiring leaves the control panel.

The Supplier shall be responsible for ensuring that the current ratio and volt-ampere rating of the current transformers are suitable for the functions, loads and duties they are required to supply.

The accuracy class shall be as specified in the datasheet.

The supplier shall supply magnetisation curves for each protective current transformer.

Current transformers used to power remote equipment shall be rated at not less than 10 VA and shall have 1 amp secondary.

19.0 INTERNAL WIRING

Control panel shall be complete with all internal wiring and ready for Purchaser's external cable connections at the outgoing terminals. All inter-modular wiring within the control panel for control and interlock looping shall be carried out by the control panel supplier.

All wiring inside the control panel shall be carried out with 1000/600 V grade PVC insulated wires having fire & moisture resistant properties.

All control wiring except CT secondary wiring shall be carried out with minimum 1.5 sq. mm copper conductor. CT secondary wiring shall be carried out with 2.5 sq. mm. Copper conductor.

All terminal blocks and wires shall be tagged for identification in accordance with BS EN 60439.

All wiring for external connections shall be brought out to the individual terminals on a readily accessible terminal block. All terminal blocks shall be shrouded or provided with transparent covers.

Clamp type control terminal blocks shall be provided for outgoing control cables. Minimum 10% or 4 nos. spare terminals shall be provided for future use. Control terminal block shall be separated from power terminal blocks by means of an insulating barrier.

Flexible cables shall be used for wiring to equipment on doors and shall be so arranged that it does not get trapped during door movement.

19.0 SPACE HEATERS

Adequately rated anti-condensation space heaters shall be provided in each breaker panel and in cable alleys of the control panel to maintain control panel inside temperature 10□ C above outside ambient temperature.

Space heater shall be strip type, rated for operation of 240 V, single phase, and 50 Hz. AC supply unless otherwise specified.

Each heater shall be complete with a rotary type ON/OFF switch, HRC fuse in the phase, neutral link in neutral and a control thermostat.

Isolator and link type HRC fuses for control of space heater for motor controlled by the motor starter / circuit breakers wired through auxiliary contact of the contractor / circuit breaker shall be provided wherever specified.

20.0 CABLE TERMINATIONS

Cable entry to control panel shall be bottom of the control panel as specified in the Data Sheets.

Ample space shall be provided in the cable compartment to accommodate XLPE insulated copper conductor cables as specified in the Data Sheets / Single Line Diagrams.
Removable undrilled gland plate shall be provided for termination of cables. Attention shall be given to the space and bending radii required for copper and larger copper cables.

Gland plates shall be located at the bottom of switchgear (where bottom cable entry specified) and shall be of sheet steel material unless they accommodate single core cables in which case the material shall be non- ferrous.

Cable supports shall be provided, to hold in position, cables running for a greater part of the way up or down the height of the control panel, or where the weight of the cable will create an undue strain on the cable gland plate.

The supplier shall specifically state if the cable termination cannot be accommodated within the normal height of the control panel.
Power terminals shall be provided with an approved means of locking the connections and space shall be allowed for crimping lug termination.

21.0 PAINTING AND FINISHING

All metal works and metal parts of the control panels shall undergo a process of degreasing, pickling in acid, cold rinsing, phosphatising, passivating and then sprayed with a high corrosion resistant primer. The primer shall be baked in an oven. The external finishing treatment shall be by application of two coats of epoxy based powder coated paint (anti-acid) of shade RAL 7032. The inside of the board shall be painted with anticondensate paint of same shade.

Both inside & outside paint shall be fireproof or with a low heating power value.

22.0 NAMEPLATES AND LABELS

One nameplate giving designation of the control panel shall be affixed prominently on top of the control panel. Details of designation shall be as follows:

I Year of Manufacture

II Supplier's name

III Purchaser's name and order number

IV Control panel designation

V System voltage, phases, wire

VI System frequency

VII System fault level

VIII Busbar rating

IX Site International Standard

Labels giving following details shall be affixed on each

feeder panel :- I Feeder No

II Equipment Reference Number and Description

III Rating (kVAR)

All components whether mounted inside the control panel or on the door shall be permanently and clearly labelled with reference number and / or letter of their function. (Rating of fuse shall form a part of the fuse designation).

Labels are to be secured with mechanical fasteners, not adhesives and shall comprise engraved plastic with black letters on a white background except for 'Danger' labels which shall have black letters on a yellow

background. 'Danger' labels shall comply with BS 5378 Part 1 or IEC 417.

Labels for feeder panel designation shall be fixed on the front & rear side of respective panels. For with drawable units, identification labels shall be duplicated on both the with drawable and the fixed parts. These labels shall be identical size to permit interchange.

23.0 DRAWINGS AND INFORMATION

The Supplier shall furnish drawings in accordance with "Supplier's Data Requirements", enclosed with the Data Sheet.

Generally following drawings shall be furnished:-

1. General Arrangement Drawing showing front view, plan, foundation plan, floor cutouts and trenches for external cables, elevations, transport sections with weights;

2. Schematic and control wiring diagrams for each type of feeder and protection, including indicating devices, metering instruments, alarms, space heaters etc.

3. Terminal plans showing terminal numbers, ferrules markings, device terminal numbers, function etc.,

24.0 TESTS AND TEST CERTIFICATES

Supplier to carryout all routine tests and 'Loss Angle' test on each bank and to furnish test certificates as given in 'supplier's Data Requirements' & 'Vendor Quality Plan' attached.

25.0 INSPECTION

Owner reserves the right to inspect the Capacitor Banks and witness the tests as Supplier's works, before dispatch

26.0 TOOLS

Where special tools or other equipment are required for maintenance, adjustment or other servicing the supplier shall include for all such equipment in his scope of supply. He shall also include for a circuit breaker handling trunk if applicable, and a truck for removal of with drawable starters if over 25 kg.

24.0 SPARES

The supplier shall provide with his quotation separate priced list of recommended commissioning and operating spares. Commissioning spares (list of which shall be approved) shall be purchased with the main LV control panel.

25.0 QUALITY ASSURANCE

Quality Assurance shall follow the requirements as specified in the enquiry / purchase order. Q.A. involvement will commence at enquiry and follow through to completion and acceptance, thus ensuring total conformity to Purchaser's requirements.

26.0 DEVIATIONS

Deviations from the Specifications must be stated in writing at the quotation stage. In absence of such a statement, it will be assumed that the requirements of the

Specifications are met without exception.

CABLES

1. GENERAL

MV Cables shall be supplied, inspected, laid, tested and commissioned in accordance with drawing specification and cable manufacturer's instructions. The cable shall be delivered at site in original drums with manufacturer's name clearly written on the drum.

2. MATERIAL

The MV Cables shall be XLPE insulated aluminum / copper conductor armored cable conforming to IS 1554 of 1972 (part -1) laid in trenches ducts and underground as shown on drawings.

Specification of cables will be as follows:

Cables with Aluminium and Copper conductor and polymer insulation will be manufactured at Cable Works. Essentially cables comprise of conductors, insulation, innersheath, armour and outersheath.

CONDUCTOR

Cables will be available with both aluminum and copper conductors manufactured with solid/Stranded Circular/Shaped Aluminium / Copper Conductor.

Compaction is provided to all stranded conductor constructions as under:

1. Circular Conductor :
   With one wire in the centre conductor will contains 6, 12, 18, 24, 30. wire layers in either unilay or
   opposite helical directions. The conductor will be sized upto 92% compaction.
2. Shaped Conductors :
   In all multicore cables from 16 Sq. mm size, conductors will be "shaped". Compaction degree in multicore power cables is upto 92%.
3. Segmental Conductor :
   Cables of 16 sq. mm will be made up of segmental conductors. The conductor is to be manufactured in equal segments and compacted,

then laid together. This will reduce A.C. losses in the large sized conductor, which are due to skin and proximity effects.
Copper conductor cables are to be of the same construction that of cables with Aluminium conductor except for high tensile strength, superior conductivity, better flexibility and ease of jointing, Copper cables are used in control, instrumentation, winding, submarine, mining and ship wiring etc. etc applications.
All Conductors are to be manufactured strictly in accordance with National and International specifications. National specifications IS:8130
International specification IEC:60228 / BS:6360

DIELECTRIC INSULATION
Insulation for cables is to be strictly as per National and International specifications
Cables are to be designed and manufactured with polymer dielectrics to bear thermal and thermomechanical stresses safely at continuous normal and short circuit temperature conditions.
Cables are to be with both thermoplastic & thermo setting insulations.
- PVC Cables Thermoplastic dielectric
- XLPE Cables Thermo setting dielectric

PVC cables to use PVC compounds that take care of over load and short circuit current with both coarse & fine protection systems.
XLPE cables to use XLPE compound with anti oxidant stabilizers and traces of aromatic polynuclear hydrocarbon. Thus improving electrical treeing characteristics and mechanical strength of insulation.
Cables are to be friendly during continuous, emergency and short circuit conditions.
The latest manufacturing process is to be used , to gives improved reliability and compactness to cables. The relative thermal expansion during short circuit between dielectric and conductor is therefore limited to minimum both in PVC & XLPE, thus limiting displacement of cores in cables during short circuit.
Insulation for Cables are to be strictly manufactured and applied over conductor in accordance with National and International specifications:
National Specification IS:5831/IS:7098
International Specifications BS:6746/BS:5467/IEC:60502

SCREENING

XLPE Cables with rated voltage over 3300V shall be provided with conductor and insulation screening as follows:

Conductor Conductor shall be screened with extruded Screen semiconducting compound as per is:7098 part 2. Insulation Insulation screening shall consist of non-metalic Screen part in combination with metalic part. Non metalic part shall consist of either semi conducting compound tape applied hellically or extruded layer of semi conducting compound, applied directly over insulation. Over this, metalic part (copper tape) shall be applied hellically with overlap as per IS:7098 part 2.

To avoid the cavities and voids formation in dielectric particularly on bending operation of cable, perfect bonding of insulation and screening is required. To ensure this,apply conductor screen, insulation and insulation screen (non-metalic part) in one operation through tripple extrusion.

LAYING UP

Cores are to be tested on line during production both for physcial and electrical characteristics. Control is to be observed within tight tolerance limits for dimensions in case pf PVC/XLPE insulation. For multicore cables cores are to be laid up on our latest laying up machine equipped with sector correction equipment.

In case of XLPE insulated cores the same are to be cured so as to impart the requisite characteristics both electrical and mechanical and then are to be laid up.

INNERSHEATH

Laid up cables are to be provided with innersheath with high quality of PVC which will act as bedding for steel wire / strip armouring.

Wherever required, f iller cords are to be provided to maintain the circularity to laid up cables.

Cable-polymers used for innersheath are to be softer than insulation or outersheath & are to be compatible with temperature ratings of cables & do not have deleteriocus effect on any other component of cable.

Innersheath is to be applied either with extrusion or by wrapping. Though the innersheath is to be closely applied on the laid up cores, same could be stripped with ease without damaging
insulation.
The innersheath dimensions are to be maintained strictly in accordance with laid down specification .
Specification For PVC Cables IS:1554
(Part-I & II) For XLPE Cables IS:7098
(Part-I & II) MANUFACTURING PROCESS

MANUFACTURING OF

CABLES ARMOURING
Mechanical protection to the cable is to be provided with armouring.
Single core cables are to be armoured with Aluminium or Aluminium alloy wire/strips, thus avoiding magnetic hysteresis losses on A.C.system.
Multicore cables are to be provided with galvanised steel wire/strips. Cables are to be provided with galvanised wire armouring, where cables are to run vertically and are subjected to stresses.
Mining cables are to be armoured with steel wire and tinned copper wires, so as to provide conductivity of armour more than 75% of main conductor of cable.
Cables armour wires/strips are to be of low resistivity material and meet the requirements of IS:3975.
Armoured cables are to be with almost 95% armour coverage.

OUTERSHEATH
All Cables are to be provided with PVC/polymer outersheath. Cables are to be manufactured with various characteristics of sheathing compounds.
General purpose sheathing Compound
ST1 Heat resistant Compound ST2
for sheath (H.R.)
Fire Retardant Low IEC 754 Part
I Smoke Compound IEC 60332
Part I& III (FRLS) IEEE-383
ASTM-
2843
ASTM-
2863
Flame Retartant Compound (FR) to EIL Specn.

Ultra Voilet Radiations Resistance Compound to ASTM G-53. Anti Rodent and Anti Termite Compound.
PVC compounds used for Cables are to be of various grades to meet specifications IS: 5831.
In order to be identified, Cables to have their name embossed/printed/indented on outersheath at regular intervals. On the outersheath of Cables, Voltage Grade, cable size,
trade name & year of manufacture are to be embossed, as desired. Cables are to be sequentially marked for length at every metre throughout its length.

FINAL TESTING
Each Cable is to be tested for all applicable Routine Tests.
From a lot of Cable one cable of each type is to be tested for Type tests, as per relevant specifications.
Testing of Cables are to be carried out as per applicable Standards for testing.

3. INSPECTION
All cable shall be inspected upon receipt at site and checked for any damage during transit.

4. JOINTS IN CABLES
The contractor shall take care to see that all the cables received at site are apportioned to various location in such a manner as to ensure maximum utilization and joints in the cable will not be acceptable.

5. LAYING CABLES
Cables shall be laid by skilled and experienced workmen using adequate rollers to minimize stretching of the cable.
The cable drums shall be laid placed on jacks before unwinding the cable. Great care shall be exercised in laying cables to avoid forming kinks the drums shall be unrolled and cables run over wooden rollers in

trenches .Underground Cables shall be first be laid in excavated trench on 80mm layer of sand. The second layer of 80mm sand shall then be sprayed over the cable. Bricks on the top layer of sand protect the cables. Distinguishing marks shall be made on the cable. Rate shall be inclusive of excavation in available strata of soil, Supply and laying of sand bricks, Supply and laying of cables, Backfilling of earth, Removal of excess earth etc. While erecting the cable on wall, m.s. Spacers are to be erected on wall by means of philplug/ wood screw/cement screw ,then cable is dressed properly and GI saddles to be fixed on spacers by machine screw. GI saddles shall be having minimum 20 G. The fixing of cable shall be minimum 400 apart for horizontal runs and 800 mm apart for vertical runs. Any civil work like breaking, digging and making good is deemed to be included the rate.

6. Cable Terminations of MV Cables and joints

a) Cables terminations shall be done with suitable brass cable gland and tinned copper cables lugs only.
b) The cable lugs shall generally fixed to the cable cores by crimping processes.
c) Irrespective of the cable and method of termination the core and shall be cleaned and immediately be covered with an oxide inhibiting / corrosion inhibiting compound before terminating.
d) The tail end wires shall be finished in an appropriate colour by using PVC insulating tapes.

LIGHTING FIXTURES

1. SCOPE.

Manufacturer at works will test the light fitting specified in the tender. The same fittings will be purchased, transported, delivered to site. Necessary manufacturer's test certificate will be submitted to Consultants.

2. STANDARDS

Lighting fittings covered against these specifications shall comply with the relevant latest Indian Standards and codes.

3. CONSTRUCTION

(a) The fitting shall be suitable for 240 volts single phase AC supply +/- 5% and frequency 50 Hs. +/- 3%.

(b) Industrial and decorative fittings shall comprise of mounting rails and other accessories. The decorative fitting shall be provided with louvers as specified .The decorative fittings should be suitable for recessed mounting in the false ceiling fully wired up to terminal block. Fittings will be with electromagnetic or high frequency electronic ballast as specified.

(c) Where conductors are required to be drawn through tube or channel leading to the fitting, the tube or channel must be free from sharp angles or projecting edge, and of such size as will enable them to be wired with the conductors used for the final circuit without removing the braiding or sheathing. As far as possible all such tubes or channels should be of sufficient size to permit looping back.

(d) Wires used within prewired fittings shall be flexible with PVC insulation and 14/0.193 mm (minimum) copper conductors. The leads shall be terminated on built-in terminal block, ceiling rose or connector.

(e) All Fittings will have power factor correct capacitors mounted integrally. An earth terminal with suitable marking shall be provided for each fitting.

Fittings shall be installed such that the lamp is at a height of 2.5m above floor level, unless directed otherwise.

LIGHTING FITTING COMPONENTS/ACCESORIES

(a) BALLASTS/CHOKES

These shall be compact in design copper wound, low power loss, good heat dissipation. With no humming sand and filled with polyesterand energy saving ballast shall be used

(b) STARTERS

The starters shall have hermetically sealed glow switch and radio suppression capacitors suitably designed to withstand striking voltage of tube and to ensure long lamp life starter holder shall molded type either made up of phenol-formaldehyde.

(c) CAPACITORS

These shall be low loss types to improve power factor up to 0.91 to 0.95 lag. Capacitor housing made up of corrosion resistant material and shall be hermetically sealed type.

(d) LAMP HOLDERS

These shall rotary spring-loaded resilient type either brass or moulded from unre-Fromaldehyde.

The holder shall be rigid enough to maintain shape on application of a nominal external pressure. There should be sufficient threading for fixing the base to the lamp holder part so that they do not open out during attention to the lamp or shade.

Lamp holders for use on brackets and the like shall have not less than 1.3 cm nipple, and all those for use with flexible pendant shall be provided with cord grips.

(e) LAMP FLUORESCENT

These shall be cool day light as per the stated wattage of 36W.
Colour of Tube will be 86 in office area And 82 in Reception and Canteen area.

LIGHTING AND POWER PANEL

Power and lighting panel shall be made out of 14-gauge sheet steel, vermin and dust proof, compartmentalized vermin and dust proof construction to provide general-purpose indoor/outdoor type of enclosures as per IP-42/IP52 respectively. These shall be suitable for surface or flush mounting as specified outdoor lighting panel shall be weather protected and shall also has necessary canopy. Panels shall be equipped with phase and neutral bus bars of adequate capacity and miniature circuit breakers/RCCB of 10 kA capacities for the incoming and outgoing circuits as specified in panel schedule.

Miniature circuit breakers shall be mounted in such a way that operating levers project outside the top Bakelite cover plates. A hinged lockable door to cover the operating knobs shall be provided. In addition panels shall be provided with grounding studs and an engraved

name plates etc as per the panel schedule. An earth bus shall be provided. Each circuit phase neutral shall be given ferrule numbers.
Complete wiring inside the panel shall be neatly bunched with PVC tape and button. For the outgoing circuits of these panels cable glands, plates, knock outs or conduit entry shall be provided as specified on panel schedule.
All metal surfaces shall be cleaned free of rust and given two coats of approved paints by powder coated point.
Panels shall be walls mounting type having arrangement of mounting frame.

SWITCHES

Switches, manufactured in accordance with IS; 3854 shall be used. Switches in are as where concealed wiring has been adopted shall be flush mounting piano plate type unless otherwise specified. In other areas, the switches shall be toggle types.

CEILING ROSE & LAMP HOLDERS

All ceiling Rose and holders shall be ISI marked. Ceiling Rose shall be plate type and lamp holders shall be suitable for BC.
A ceiling rose shall be used on a circuit, the voltage of which normally not exceeding 250V. Only one flexible cord shall be connected to a ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.
A ceiling rose shall not embody fuse terminal as an integral part of it.

RECEPTACLES

Only three-pin type receptacles manufactured in accordance with IS; 1293 shall be used with the third terminal connected to the earth. All receptacles shall be provided with a switch mounted on the same enclosure but shall be a separate unit to facilitate replacement by part. Flush mounting type receptacles adopted and surface type shall be used in other areas.

OUTLET BOXES

Outlet boxes for sockets, switches, fixtures and fan regulators etc shall be for minimum 16 gauge. M.S. sheet 3” deep with necessary modular plate for mounting switch, sockets etc.

WIRES

Wires shall be ZHFR PVC insulated 660/1100 Volts grade as per IS; 1554 Conductor shall be of stranded copper and size shall be (min.1.5mm^2) for lighting and (min 2.5mm^2) for power socket circuits. Red/Yellow/Blue wires for Phases, Black wire for Neutral and Green wire for Earth shall be used. Wiring in conduits without colour coding is not acceptable. The lighting layouts furnished by consultant shall indicate approx. locations of lighting fixtures. The electrical contractor shall determine, with approval of the consultant or his authorized representative. The exact locations of each fixture in order to avoid interference with mechanical equipment & also with a view to obtain as uniform illumination as

practicable, & to avoid objectionable shadows. Conduit run shown on drawing is only indicative. These shall be laid out by the contractor to suit field conditions.
The cost for cable clamps, metal spacers, anchor bolts etc. shall be deemed to have been included in the installation.

HALOGEN FREE FLAME RETERDANT Single Core Flexible Copper Cables, having high Current Rating for Voltages up to 1100 Volts A.C. shall be used having the following features:

Conductor: Many thin strands of Electrolytic Copper are to be fine -drawn simultaneously for uniformity of characteristics, such as Resistance, Dimensions, flexibility etc. The drawn strands are to be collected and closely twisted in high precision machines and further compacted. This will not only impart circularity to the bunched conductors, but also prevents the tendency for the strands to separate and exert internal pressure on the insulation when the cable is bent during installation and usage.
Insulation : Specially formulated high temperature grade of Flame Redraft Low Smoke compound restricts the spread of flame in the fire situation. The smoke emitted by the burning cable is also less as compared to traditional cables. This offers improved visibility for evacuation of trapped victims and facilitates fire fighting operation.
Marking: The cables are to be printed with generic marking .
Colours: Entire cable shall have white base and a double strip of Red, Yellow, Blue, Black, Green running along the length of the Cable.

Properties	Test Method	Value
Limited Oxygen Index	ASTM – D2863	31%
Temperature Index	ASTM – D2863	>250^{O} C
Smoke Density (Light absorption)	ASTM – D2843	<55%

Specifications generally confirm to : IS 694, IEC 60332-1, IEEE 383, IEC 754-1, BS 4066-1, DIN VDE 0281-3 Size, Dimensions and Ratings:

Conductor Area Sq. MM	Insulation Thickness mm	Configuration	Max Overall Diameter mm	Conductor Resistance Ohm/km @20^{O}C (Max)	Current Rating Amps	
					Casing	Concealed
1.00	0.6	14/0.3	3.2	18.1	14	13
1.50	0.7	22/0.3	3.4	12.1	18	16
2.50	0.8	36/0.3	4.2	7.41	24	20
4.00	0.8	56/0.3	4.8	4.95	32	26

SURFACE CONDUIT SYSTEM

Surface conduit 25mm 16SWG ms conduit /25 mm medium thickness M.S conduit system of wiring shall be adopted, wherever specified in the drawings, Suitable pull boxes or inspection type fittings will be used be used to facilitate drawing wires.

Confirming to IS 3419 & IS 9537(Part –

3). CONCEALED CONDUITING &

WIRING

1. Concealed conduiting shall be carried out by medium thick min 25mm diameter rigid M.S conduit embedded in RCC/brick work with normal accessories like junction boxes, shall also be of same material that of conduit. Only deep junction boxes shall be used for concealed conduit installation. All junction boxes shall be of ample size to permit the wires to be drawn in and out.

2. Concealed conduits shall be securely fixed to prevent movement during building operation viz. casting of concrete fixing shall be by means of clips or other approved manner so as to ensure that there will no damage or deformation to conduits.

3. Conduits installed in chases of wall shall be firmly secured by `U' nails and such fixing shall be adequate to hold the pipes by themselves with chicken mesh covering.

4. Recessed conduits buried in plaster shall permit a full 6mm depth of cover over its entire length.

5. When conduits are laid in slabs or shuttered walls, the contractor shall arrange a competent person to be in attendance while the concrete pouring operation is being carried out in order to avoid damage being caused to conduits and also to ensure that the conduit work is in sound condition and properly and efficiently maintained during installation period.

6. To prevent water dirt or rubbish entering the conduit system during erection plugs shall be utilized.

7. All bends shall be made utilizing bending spring with the help of heater. The bends shall be

long bends to avoid deformation of conduits with necessary couplers where conduits cross

expansion joints of the building structure special expansion couplings shall be used or

other approved methods adopted.

8. The minimum diameter of otherwise specified with medium thickness.

9. Wiring shall be carried out with stranded copper conductor PVC insulated colour coded

wires conforming to IS 694

10. No joints shall be permitted and wires shall be looped from point to point. Wiring shall maintain colour code for phases neutral (R, Y, B and black) and green for earthing. The earth wire also shall be drawn inside the conduit and shall be continuous.

11. At all terminations of wires, the insulation shall be neatly stripped without damaging the conductor. In no case shall bear conductors are allowed to project beyond any insulated shrouding or molding of live terminals.

12. Installation of terminal blocks will be permitted only where wires can't be terminated directly on terminals in appliances. Connectors should be properly fixed inside box. Unfixed connectors will not be permitted.

13. The preferred conduit size and capacity of wires shall be as detailed below.

	SIZE OF WIRE FR		
Size of Conduit	1.5 mm²	2.5 mm²	4 mm²
25 mm	10	7	6
32 mm	15	12	8
38 mm	17	15	10

14. The size of wires for different circuits will be as per BOQ, but generally as follows.

Lighting points and 5A sockets - 1.5 mm².
Circuit wiring/primary point/two or three 5A sockets
- 2.5 mm². AC /
Geyser - 4 mm².
Earthing wire shall be min 1.5 mm² or half of the size of phase wire.

15. Switch socket boxes. The switch socket boxes shall be of sheet steel. The min thickness of the sheet shall be 2mm. The box shall be thoroughly cleaned of grease and rust. The paintings shall be two coats of primer followed by two coats of enamel paint. All boxes shall be provided with earthing terminal. The boxes shall be provided adequate knock out for connection conduits. Proper grouting in the wall / partition will be carried out as directed by consultant/ architect. All boxes shall be provided with accessories like plates, mounting arrangements.

16. Switches and Sockets

Local switches shall be provided for controlling lighting equipment connected to sockets. All sockets shall be 2-pin and earth type unless otherwise stated. Sockets for AC unit geysers shall be metal clad types unless other wise stated.

17. In case of false ceiling employing minimum tee grid system, fixtures shall be supported from true ceiling. Exact locations of fixtures shall be finalized in consolation with air conditioning contractors and as indicated on architectural drawings. Wiring above false ceilings shall be left loose in flexible pipe and shall be supported along structures/ceiling. Wiring above false ceiling shall be on surface and below false ceiling it shall be concealed. To facilitate easy maintenance looping back system of wiring shall be followed throughout. Accordingly supply tapings and other interconnections are made only at fixture connector blocks or at switchboards. Intermediate junction boxes shall be used for wire pulling as inspection boxes. All wires in conduit shall be colour as specified. Each circuit shall have independent phase neutral and earth wire. Unless otherwise specified, insulated conductors of ac supply and dc supply shall be bunched in separate conduits.

EARTHING

1. The earthing installation shall be done in accordance with the earthing drawings, Specifications and the standard drawings of reference attached with this document. The entire earthing system shall fully comply with the Indian Electricity Act and Rules framed thereunder. Typical plate type earthing comprises of excavation up to depth of 3.2mtr, Earthing Plate along with earthing risers installation, , charcoal. Salt treatment, watering pipe, Iron funnel with wire mesh, brick masonry chamber, cast iron lockable manhole cover, earthing link etc.

The contractor shall carryout any changes desired by the electrical Inspector or the owner, in order to make the installation conform to the Indian Electricity Rules at no extra cost. The exact location of earth conductor s, earth electrodes and earthing points on the equipment shall be determined in field, the consultation with the consultant or his authorized representative. Any changes in the methods, routing, size of conductor etc shall be subject to approval of the consultants. Earthing pit shall be preferably 2mtr. away from building and other earth pit.

2. Excavation and backfilling of earth, necessary for laying underground earth bus loops shall be the responsibility of the contractor and at no extra cost.

3. The earth loop impedance to any point in the electrical system shall have a value, which will ensure satisfactory operation of protective devices.

4. The main earth loops shall be laid at depth of 500mm below grade level. In cable trenches shall be firmly cleated to the walls of concrete lined trenches. The earthing strip shall be protected against mechanical damage.

5. Joint and tapings in the main earth loop shall be made in such a way that reliable and good electrical grade shall be welded and suitably protected by giving two coats of bitumen and covering with Hussein tape. All joints above ground shall be by means of connectors/ lugs as far as practicable. Tee connectors shall be used for tapping, earth leads from the main earth loops wherever it is installed above ground. Earthing plates as shown shall be provided for earthing of two or more equipment at a place from earth grid. This GI Riser shall be protected applying two coats of bituminous painting/bitumen on the exposed portion.

DEDICATED EARTHING

For UPS, V-Sat antenna earthing is taken from Dedicated Earthing Pit. Earthing Pit shall be same as mentioned above. Only the earth conductor shall be 8 SWG single strand insulated copper wire or as mentioned, taken through conduit up to earth busbars. Earthing for computer, UPS and Antenna shall be done through this earth bus.

CONNECTION

All electrical equipment is to be doubly earthen by connecting two points on equipment to earthing several earth electrodes. The earth grid formed shall be a closed loop as shown in the drawing with earth electrodes connected to the grid with double strip connection. Panels, D.B.s, Conduit trays/steel structured in which cable has been installed, shall be effectively bonded and earthen. Cable armors shall be earthen at both ends.

TESTING

1. Measure the insulation resistance of each circuit without the lamps (load) being in place and it should be more than one M-ohms to earth. The insulation resistance measured as above shall not be less than 50 divided by the number of points on the circuit provided on the circuit provided that the whole installation shall not be required to have an insulation greater than one megohms.

2. Check the earth continuity for all socket outlets. A fixed relative position of the phase and neutral connections inside the socket shall be established for all sockets.

3. The insulation resistance between the case of framework of housing and power appliances and all live parts of each appliance shall not be less than that specified in the relevant Indian Standard Specifications.

4. On completion of cable laying work the Insulation Resistance (Sectional and overall), Continuity Resistance test, Sheathing continuity test, Earth Test., shall be conducted.

5. Checking the operation of all devices, as ACBs, MCCBs Emergency stops, etc.
6. Voltage, Current, Wattage, Power factor parameter checking at each Panel and DB level to ensure no overloading.

1. Neutral to earth voltage at all UPS DB and socket level.

2. Polarity test at UPS socket level.

3. Earth testing and Earth continuity.

4. Integrated testing of entire facility.

COMMISSIONING

1. The contractor shall obtain the written permission and sanction of commissioning the equipment from Electrical Inspector of I. E. & L. Department of State Government and Supply authority. If required under the specific rules of the Government.
2. Current and voltage of all the phases shall be measured at the lighting panel busbars with all the circuits switched on with lamps, if required load shall be balance on the three phases.
3. After inserting all the lamps and switching on all the circuits minimum and maximum illumination level should be measured in the area.

ENGINEERING SPECIFICATION – INTELLIGENT FIRE ALARM SYSTEM

PART 1.0 – GENERAL

1.1 DESCRIPTION:

A. This section of the specifications includes the furnishing, installation, and connection of the microprocessor controlled, addressable reporting fire alarm equipment required to form a complete coordinated system ready for operation. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, fire alarm control panel, auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.

B. The fire alarm system shall comply with requirements of NFPA standard No. 72 for protected premises signaling systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.

1.2 SCOPE:

A. A new addressable reporting, microprocessor controlled fire detection system shall be installed in accordance with the specifications and drawings.

B. Basic Performance:

1. Alarm, trouble and supervisory signals from all intelligent addressable reporting devices shall be encoded onto a Class B (NFPA Style 4), or Class A (NFPA Style 6, 7) Signaling Line Circuit (SLC).
2. Initiation Device Circuits (IDCs) shall be wired Class B (NFPA Style B) or Class A (NFPA Style D).
3. Notification Appliance Circuits shall be wired Class B (NFPA Style Y) or Class A (NFPA Style Z).
4. Built-in Horn Strobe Synchronization w/ selective silence.
5. Digitized electronic signals shall employ check digits or multiple polling.
6. A single ground or open on the system Signaling Line Circuit (SLC) shall not cause system malfunction, loss of operating power or the ability to report an alarm.
7. Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.

C. Basic System Functional Operation

When a fire alarm condition is detected and reported by one of the system initiating devices the following functions shall immediately occur:

1. The System Alarm LED shall flash.
2. A local piezo electric signal in the control panel shall sound.
3. A 80-character, backlit LCD display shall indicate all information associated with the Fire Alarm condition, including the type of alarm point and its location within the protected premises.
4. Printing and history storage equipment shall log the information associated with each new Fire Alarm Control Panel condition, along with time and date of occurrence.
5. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated System Outputs (alarm Notification Appliances and/or Relays) shall be activated.

1.3 SUBMITTALS

A. General:
   1. Two copies of all submittals shall be submitted to the Architect/Engineer for review.
   2. All references to manufacturer's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality. Equivalent equipment (compatible UL- Listed) from other manufacturers may be substituted for the specified equipment as long as the minimum standards are met.
   3. For equipment other than that specified, the contractor shall supply proof that such substitute equipment equals or exceeds the features, functions, performance, and quality of the specified equipment.

B. Shop Drawings:
   1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
   2. Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.
   3. Show remote annunciator(s) layout, configurations, and terminations.

C. Manuals:
   1. Submit simultaneously with the shop drawings, complete operating and maintenance manual listing the manufacturer's name(s) including technical data sheets.
   2. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnections between the items of equipment.
   3. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system.

D. Certifications:
   Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.

1.4 GUARANTEE:

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one-year period shall be included in the submittal bid.

1.5 MAINTENANCE:

Maintenance and testing shall be on a semi-annual basis or as required by the local AHJ. A preventive maintenance schedule shall be provided by the Contractor that shall describe the protocol for preventive maintenance. The schedule shall include:

1. Systematic examination, adjustment and cleaning of all detectors, manual fire alarm stations, control panels, power supplies, relays, water flow switches and all accessories of the fire alarm system.
2. Each circuit in the fire alarm system shall be tested semi-annually.
3. Each smoke detector shall be tested in accordance with the requirements of NFPA 72 Chapter 7.

1.6 POST CONTRACT EXPANSIONS:

A. The contractor shall provide parts and labor to expand the system specified, if so requested, for a period of one (1) year from the date of acceptance.
B. As part of the submittal include a quotation for all parts and material, and all installation and test labor as needed to increase the number of addressable devices by ten percent (10%). This quotation shall include addressable smoke detectors, addressable heat detectors, addressable duct detectors, addressable manual stations, addressable monitor modules and addressable control modules equal in number to one tenth of the number required to meet this specification (list actual quantity of each type).
C. Quotation shall include installation and test labor and labor to reprogram the system for this 10% expansion. If additional FACP hardware would be required, include the material and labor necessary to install this hardware.
D. Submittals that do not include this estimate of post contract expansion cost will not be accepted.

1.7 APPLICABLE SPECIFICATIONS:

The specifications and standards listed below form a part of this specification. The system shall fully comply with these standards.

A. National Fire Protection Association
(NFPA) - USA: No. 70 National
Electrical Code (NEC)
No. 72 Central Station Signaling
Systems No. 72 Protective
Signaling Systems
No. 72 Automatic Fire Detectors
No. 72 Notification Appliances for Protective
Signaling Systems. No. 72 Testing Procedures for
Signaling Systems.
No. 101 Life Safety Code
B. Underwriters Laboratories Inc. (UL) - USA:
No. 268 Smoke Detectors for Fire Protective Signaling Systems
No. 864 Control Units for Fire Protective
Signaling Systems No. 268ASmoke Detectors for
Duct Applications.
No. 521 Heat Detectors for Fire Protective
Signaling Systems No. 464 Audible Signaling
Appliances.
No. 38 Manually Actuated Signaling Boxes.
No. 346 Waterflow Indicators for Fire Protective
Signaling Systems. No. 1971Visual Notification
Appliances for the hearing impaired.
C. Local and State Building Codes
D. All requirements of the Authority Having Jurisdiction (AHJ).

1.8 APPROVALS:

The system shall have proper listing and/or approval from the following nationally recognized agencies:

- UL Underwriters Laboratories Inc.
- FM Factory Mutual Systems

- CSFM California State Fire Marshal
- MEA NYC Materials and Equipment Acceptance
- ULC Underwriters Laboratories of Canada

PART 2.0 PRODUCTS

2.1 EQUIPMENT AND MATERIAL, GENERAL:

A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system.

B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.

C. All Equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

D. Equipment should be manufactured by an ISO 9001 Certified Company.

2.2 CONDUIT AND WIRE:

A. Conduit:

1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.
2. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.
3. Cable must be separated from any open conductors of Power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, as per NEC Article 760-29.
4. Wiring for 24 volt control, alarm notification, emergency communication and similar power limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
5. Conduit shall not enter the Fire Alarm Control Panel, or any other remotely mounted Control Panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
6. Conduit shall be 3/4-inch (19.1 mm) minimum.

B. Wire:

1. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG (1.02 mm) for Initiating Device Circuits and Signaling Line Circuits, and 14 AWG (1.63 mm) for Notification Appliance Circuits.
2. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
3. Wire and cable not installed in conduit shall have a fire resistance rating suitable for

the installation as indicated in NFPA 70 (e.g., FPLR).

4. Wiring used for the multiplex communication loop shall be twisted and shielded and installed in conduit unless specifically excepted by the fire alarm equipment manufacturer. The system shall permit use of IDC and NAC wiring in the same conduit with the communication loop.
5. All field wiring shall be completely supervised.

C. Terminal Boxes, Junction Boxes and Cabinets:
D. All boxes and cabinets shall be UL listed for their use and purpose.
E. The Fire Alarm Control Panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the Main Power Distribution Panel as FIRE ALARM. Fire Alarm Control Panel Primary Power wiring shall be 12 AWG. The Control Panel Cabinet shall be grounded securely to either a cold water pipe or grounding rod.

2.3 MAIN FIRE ALARM CONTROL PANEL:

A. The FACP shall be a Fire-Lite Alarms model MS-9600 and shall contain a microprocessor based Central Processing Unit (CPU). The CPU shall communicate with and control the following types of equipment used to make up the system: addressable detectors, addressable modules, printer, annunciators, and other system controlled devices.

B. System Capacity and General Operation
1. The control panel shall provide, or be capable of expansion to 318 addressable detectors and 318 monitor or control modules (636 addressable devices).
2. The Fire Alarm Control Panel shall include a full featured operator interface control and annunciation panel that shall include a backlit, 80-character Liquid Crystal Display, individual, color coded system status LEDs, and an alphanumeric keypad for the Field Programming and control of the Fire Alarm System.
3. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the Fire Alarm Control Panel.
4. The FACP shall provide the following features: Maintenance Alert to warn of excessive detector dirt or dust. Detector sensitivity read/test information and System Status Reports to display or print. Smoke Detector Alarm Verification. Pre-signal, meeting NFPA 72 requirements. Rapid manual station reporting (under 3 seconds). Periodic Detector Test, conducted automatically by the control panel every two hours. March time, temporal (ANSI Cadence) and California Code coding options. Walk Test will check for two detectors set to same address.
5. The main CPU shall contain Form-C relay contacts rated at 2.0 amps/30VDC for the following: Alarm, Trouble, Supervisory.
6. The CPU shall contain two Class B or A (NFPA Style Y or Z) programmable Notification Appliance Circuits.

C. Central Microprocessor

1. The Microprocessor shall communicate with, monitor, and control all external interfaces with the control panel. It shall include EPROM for system program storage; non-volatile memory for building-specific program storage; and a "watch dog" timer circuit to detect and report microprocessor failure.
2. The Microprocessor shall contain and execute all programming for specific action to be taken if an alarm condition is detected by the system. Such programming shall be held in non-volatile programmable memory and shall not be lost if both the system primary and secondary power failure occurs.
3. he Microprocessor Unit shall also provide a Real- Time Clock for time annotation of system displays, printer, and history file.
4. The Microprocessor Unit shall contain flash memory capabilities for easy upload/download for upgrades of software.
5. All clock, date and history files shall be maintained during power loss.

D. Display

1. The Display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.
2. The Display shall include status information and custom alphanumeric labels for all Addressable Detectors, Addressable Modules and Software zones.
3. The Display shall provide a 80-character backlit alphanumeric Liquid Crystal Display (LCD). It shall also provide 9 Light-Emitting-Diodes (LEDs), consisting of and not limited to the following: AC POWER, FIRE

   ALARM, SUPERVISORY, SYSTEM TROUBLE, MAINTENANCE, ALARM SILENCED, DISABLED, BATTERY, and GROUND.
4. The Display shall provide a 25-key touch key-pad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels shall be provided to prevent unauthorized system control or programming.
5. The Display shall include the following operator switches: ACKNOWLEDGE/STEP ALARM SILENCE, DRILL, and SYSTEM RESET (also serving as a lamp test switch).

E. Signaling Line Circuit Interface

1. The SLC Interface shall provide power to, and communicate with, all of the Addressable Detectors and Addressable Modules over a single pair of wires. This SLC Loop shall be capable of NFPA Style 4, Style 6, or Style 7 operation.
2. The SLC interface shall receive information from all Addressable Devices. This information shall be processed to determine whether normal, alarm, or trouble conditions exist for each detector. This information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
3. The Signaling Line Circuit shall be capable of distances of 10,000 feet (@ 12 AWG, twisted). For retrofit applications, the system shall support up to 3,000 feet of untwisted, unshielded wire. (Loop 1 only)

F. Serial Interfaces
   1. An EIA-232 interface between the Fire Alarm Control Panel and UL Listed Electronic Data Processing (EDP) peripherals shall be provided. The EIA-232 interface shall allow the use of printers, or for an interface to an off-line PC programmer.
   2. An EIA-485 port shall be available for the serial connection of optional remote led-type annunciators. EIA- 485 in terminal mode shall allow serial connection of optional LCD, English language remote system displays. LED (per zone or point) annunciators shall also be provided. The maximum distance to the furthest annunciator shall be 3,000 feet. The system shall support a maximum of 32, remote annunciators on a single twisted, shielded pair. The maximum distance to the furthest annunciator shall be 6,000 feet.
   3. A PS2/PC keyboard connection shall be provided to support the connection of a PC keyboard for local programming of the fire alarm system.

G. Enclosures:
   1. The control panel shall be housed in a UL listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected.
   2. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.
   3. An optional semi-flush trim ring shall be available for a neat cabinet dress.

H. All interfaces and associated equipment are to be protected so that they will not be affected by voltage surges or line transients consistent with UL standard 864.

I. Optional plug-in modules shall be provided for NFPA 72 auxiliary and remote station fire alarm systems as well as a Digital Alarm Communicator Transmitter for NFPA 72 Central Station systems. The DACT (Fire-Lite Alarms model UDACT) shall meet all current UL requirements for delayed AC fail reporting and shall be capable of reporting individual signals for all 636 points.

J. Optional modules (FireLite Alarms model ACM-8RF) shall provide eight Form-C relays rated at 5.0 amps (Relays shall track programmable software zones) and (Fire-Lite Alarms model 4XTMF) Municipal box connection and reverse polarity connection.

K. Power Supply:
   1. The Power Supply shall operate on 120 VAC, 60 Hz, and shall provide all necessary power for the FACP.
      a. 240 VAC, 50 Hz version shall be available where required.
   2. It shall provide a minimum of 6.0 amps of usable Notification Appliance power.
   3. It shall provide a battery charger for 24 or 60 hours of standby using dual-rate charging techniques for fast battery recharge.
   4. It shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults on sensitive addressable modules.
   5. It shall be power-limited using fuse-less, quick-acting electronic circuitry meeting the latest UL requirements.

L. Operators Controls
   1. Acknowledge Switch:
      a. Activation of the control panel Acknowledge switch in response to new Alarms and/or Troubles shall silence the local panel piezo electric signal and change the Alarm and Trouble LEDs from flashing mode to steady-ON mode. If multiple Alarm or Trouble conditions exist, depression of this switch shall advance the 80-character LCD display to the next Alarm or Trouble condition.
      b. Depression of the Acknowledge switch shall also silence all remote annunciator piezo sounders.
   2. Signal Silence Switch: Activation of the Signal Silence Switch shall cause all programmed Notification Appliances and relays to return to the normal condition after an alarm condition. The selection of Notification circuits and relays that are silenceable by this switch shall be fully field programmable within the confines of all applicable standards. The FACP software shall include silence inhibit, auto-silence timers, and an option to silence horns and keep strobes flashing.
   3. System Reset Switch: Activation of the System Reset Switch shall cause all electronicallylatched initiating devices, appliances or software zones, as well as all associated output devices and circuits, to return to their normal condition. Holding the RESET switch shall perform a Lamp Test function.
   4. Drill (Evacuate) Switch: Press and hold of the Drill switch shall activate all Silenceable Notification Appliance circuits. The Drill function shall latch until press of Signal Silence or Reset.

M. Printer
   A printer may be connected to provide hard-copy printout of all changes in status of the system and shall time-stamp such printouts with the current time-of-day and date. The printer shall communicate with the control panel using an interface complying with Electrical Industries Association standard EIA-232D.

N. Field Programming
   1. The system and its respective devices (i.e. smoke detectors and modules) shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits.
   2. All programming may be accomplished through the standard FACP built-in keypad. As well through using a PC keyboard (connection provided on UNIMODE-9600 main circuit board.)
   3. All field-defined programs shall be stored in non-volatile memory and shall not be lost if AC mains and/or battery is lost.
   4. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level is used for status level changes such as zone disable or manual on/off commands. A second (higher-level) is used for actual change of program information.
   5. Program edit shall not interfere with normal operation and fire protection. If a fire condition is detected during programming operation, the system shall exit programming

and perform fire protection functions as programmed.

6. A special program check function shall be provided to detect common operator errors.
7. An Auto-Program (self-learn) function shall be provided to quickly program initial functions within several seconds. During this operation, smoke detectors connected to the Signaling Line Circuit shall be automatically installed without labor intensive operator key commands and the using additional electronic equipment to program each individual detector.
8. For flexibility, an optional off-line programming function, with batch upload/download, shall also be available.

O. Specific System Operations
1. Alarm Verification: The Fire alarm control panel shall have the ability to alarm verify addressable smoke detectors.
2. Point Disable: Any device in the system may be Enabled or Disabled through the system keypad.
3. Point Read: The system shall be able to display or print the following point status diagnostic functions: a. Device Status, b. Device Type, c. Device Label, d. Device Zone Assignments and e. Program Parameters
4. System Status Reports: Upon command from an operator of the system, a status report will be generated and printed, listing all system status.
5. Device Sensitivity Reports: Upon command from the operator, the detectors sensitivity can be read and results printed
6. System History Recording and Reporting: The Fire Alarm Control Panel shall contain a History Buffer that will be capable of storing up to 1,000 system alarms, troubles, or operator actions.
7. Automatic Detector Maintenance Alert: The Fire Alarm Control Panel shall automatically interrogate each Addressable Smoke Detector and shall analyze the detector responses over a period of time. If any addressable Smoke Detector in the system responds with a reading that is below or above normal limits, then the system will enter the Trouble Mode, and the particular detector will be annunciated on the system display, and printed on the optional printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
8. Software Zones: The FACP shall provide 99 software zones. All addressable devices may be field programmed, to be grouped into these zones for control activation and annunciation purposes. Systems that utilize limited programmability, such as general alarm operation, are unacceptable.

2.4 SYSTEM COMPONENTS:

A. Programmable Electronic Sounders
1. Electronic sounders shall operate on 24 VDC nominal.
2. Electronic sounders shall be field programmable without the use of special tools, to provide slow whoop, continuous, or interrupted tones (Temporal Pattern) with an output sound level of at least 90 dBA measured at 10 feet from the device.
3. Shall be flush or surface mounted as shown on plans.

B. Strobe Lights:
1. Shall operate on 24 VDC nominal.

2. Shall meet the requirements of the ADA (Americans with Disabilities Act) as well as UL Standard 1971.

C. Audible/Visual Combination Devices:
   1. Shall meet the applicable requirements of Section A listed above for audibility.
   2. Shall meet the requirements of Section B listed above for visibility.

D. Addressable Manual Pull Box (Fire-Lite Alarms model BG-12LX)
   1. Addressable Manual Stations shall be provided to connect to the Fire Alarm Control Panel Signaling Line Circuit (SLC) Loops. Up to 159 addressable manual stations may be connected to each SLC loop.
   2. The Manual Pull Box shall, on command from the Control Panel, send data to the panel representing the state of the manual switch. Manual Fire Alarm Stations shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
   3. All operated stations shall have a positive, visual indication of operation that cannot be reset without the use of a key.
   4. Manual Stations shall be constructed of LEXAN (or polycarbonate equivalent) with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters,
      1.75 inches or larger.
   5. Stations shall be suitable for surface mounting, or semiflush mounting as shown on the plans, and shall be installed in accordance with ADA and local codes.
   6. The Manual Station shall provide address-setting means using decimal switches. Addressable manual stations that use binary address setting methods, such as a dip switch, are much more difficult to install and are subject to installation error, and are not allowable substitutes.

E. Addressable Photoelectric Detectors (Fire-Lite Alarms model SD350)
   1. Smoke detectors shall be addressable and shall connect with two wires to the Fire Alarm Control Panel Signaling Line Circuit. Up to 318 addressable detectors may connect to two seperate SLC loops.
   2. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density.
   3. The detectors shall be low profile ceiling-mount and shall include a twist-lock base.
   4. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a switch) or initiated remotely on command from the control panel.
   5. The detectors shall provide address-setting means on the detector head using decimal switches. Because of the possibility of installation error, systems that use binary jumpers on dipswitches to set the detector address are not acceptable. The detectors shall also store an internal identifying code that the control panel shall use to identify the type of detector.
   6. The detectors shall provide an alarm and power LED. The LED shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. The LED is placed into steady illumination by the control panel indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect an external remote alarm LED (Fire-Lite Alarms model RA400Z).

F. Addressable Photoelectric Detectors with Fixed Thermal Sensor (Fire-Lite Alarms model SD350T)
   1. Smoke detectors shall be addressable and shall connect with two wires to the Fire Alarm Control Panel Signaling Line Circuit. Up to 318 addressable detectors with fixed thermal sensors (135 degree F) connect to two SLC loops.
   2. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density.
   3. The detectors with fixed thermal sensors shall alarm at a fixed temperature of 135 degree F.
   4. The detectors shall be ceiling-mount and shall include a twist-lock base.
   5. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a switch) or initiated remotely on command from the control panel.
   6. The detectors shall provide address-setting means on the detector head using decimal switches. Because of the possibility of installation error, systems that use binary jumpers on dipswitches to set the detector address are not acceptable. Systems that require a special programmer to set the detector address (including temporary connection at the panel) are labor intensive and not acceptable. The detectors shall also store an internal identifying code that the control panel shall use to identify the type of detector.
   7. The detectors shall provide an alarm and power LED. The LED shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. The LED is placed into steady illumination by the control panel indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect an external remote alarm LED (Fire-Lite Alarms model RA400Z).

G. Addressable Ionization Smoke Detectors (Fire-Lite Alarms model CP350)
   1. Smoke Detectors shall be low profile addressable and connect with two wires to the Fire Alarm Control Panel Signaling Line Circuit. Up to 318 addressable detectors may connect to two SLC loops.
   2. The detectors shall use the dual-chamber ionization principal to measure products of combustion.
   3. The detectors shall be low profile ceiling-mount and shall include a twist-lock base.
   4. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself, by activating a switch, or may be activated remotely on command from the control panel.
   5. The detectors shall provide address-setting means on the detector head using decimal switches. Because of the possibility of installation error, systems that use binary jumpers or dipswitches to set the address are not acceptable. They shall also store an internal identifying code that the control panel shall use to identify the type of detector.
   6. The detectors shall provide an alarm and power LED. The LED shall flash under normal conditions. The LED is placed into steady illumination by the control panel, indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect a remote alarm LED (Fire-Lite Alarms model RA400Z).

H. Addressable Monitor Module (Fire-Lite Alarms model MMF-300)
   1. Addressable Monitor modules shall be provided to connect one supervised IDC (zone) of conventional Alarm Initiating Devices (any N.O. dry contact device) to the Fire Alarm

Control Panel Signaling Line Circuit (SLC) Loop.

2. The monitor module shall mount in a 4-inch square, 2-1/8" deep electrical box.
3. The IDC (zone) may be wired for Style D (Class A) or Style B (Class B) operation. The Monitor module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the Fire Alarm Control Panel shall use to identify the type of device. Modules that use binary jumpers or dip-switches are subject to installation errors and are not acceptable. An LED shall be provided that shall flash under normal conditions, indicating that the Monitor module is operational and in regular communication with the control panel.
4. For difficult to reach areas, the Monitor Module shall be available in a miniature package and shall be no larger than 2-3/4"W x 1-1/4"H x 1/2"D (Fire-Lite Alarms model MMF-301). This version does not support Style D operation or include an LED.

I. Addressable 2-Wire Smoke Detector Monitor Module (Fire-Lite Alarms model MMF-302)
   1. Addressable 2-Wire Smoke Detector Monitor Modules shall be provided to connect one supervised IDC (zone) of two-wire conventional smoke detectors to the Fire Alarm Control Panel Signaling Line Circuit (SLC) Loop.
   2. The monitor module shall mount in a 4-inch square, 2-1/8" deep electrical box.
   3. The monitor module shall provide terminal connections for a resettable external supply voltage to provide power to the IDC (zone) of two-wire smoke detectors.
   4. The IDC (zone) may be wired for Style D (Class A) or Style B (Class B) operation. The monitor module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the Fire Alarm Control Panel shall use to identify the type of device. Modules that use binary jumpers or dip-switches are subject to installation errors and are not acceptable. An LED shall be provided that shall flash under normal conditions, indicating that the Monitor module is operational and in regular communication with the control panel.

J. Addressable Dual-Circuit Monitor Module (Fire-Lite Alarms model MDF-300)
   1. Addressable Dual-Circuit Monitor Modules shall be provided to connect two supervised IDCs (zones) of conventional Alarm Initiating Devices (any N.O. dry contact device) to the Fire Alarm Control Panel Signaling Line Circuit (SLC) Loop.
   2. The-monitor module shall mount in a 4-inch square, 2-1/8" deep electrical box.
   3. The IDCs (zones) may be wired for Style B (Class B) operation only. The Monitor module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the Fire Alarm Control Panel shall use to identify the type of device. Modules that use binary jumpers or dip- switches are subject to installation errors and are not acceptable. An LED shall be provided that shall flash under normal conditions, indicating that the Monitor module is operational and in regular communication with the control panel.

K. Addressable Control Module (Fire-Lite Alarms Model CMF-300)
   1. Addressable Control Modules shall be provided to supervise and control the operation of one conventional Notification Appliance Circuit (NAC) of compatible, 24 VDC powered, polarized Audio/Visual appliances or audio speakers.
   2. The Control Module shall mount in a standard 4-inch square, 2-1/8" deep electrical

box or to a surface mounted backbox.

3. The NAC shall wire in a Class B (Style Y) or Class A (Style Z) fashion. Each control module shall support up to 1 Amp of Inductive or 2 Amps of Resistive Audible/Visual signals.
4. Audio/Visual power shall be provided by a separate supervised power Loop from the main Fire Alarm Control Panel or from a supervised, UL listed Remote Power Supply.
5. The Control Module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the Control Panel shall use to identify the type of device. Modules that use binary jumpers or dip-switches are subject to installation errors and are not acceptable. An LED shall be provided that shall flash under normal conditions, indicating that the Control Module is operational and is in regular communication with the control panel.
6. A magnetic test switch shall be provided to test the module without opening or shorting its NAC circuit wiring.

M. Addressable Relay Module (Fire-Lite Alarms model CRF-300)

1. Addressable Relay Modules shall be provided to allow a compatible control panel to switch discrete contacts by code command.
2. The Relay Module shall mount in a standard 4-inch square, 2-1/8" deep electrical box or to a surface mounted backbox.
3. The Relay Module shall provide two isolated sets of Form-C contacts for fan shutdown and other auxiliary control functions.
4. The Relay Module contact ratings shall support up to 1 Amp/30 VDC of Inductive load or 2 Amps/30VDC (coded) of Resistive load (up to 3 Amps in non-coded applications). The relay coil shall be magnetically latched to reduce wiring connection requirements and to insure that 100% of all auxiliary relays or may be energized at the same time on the same pair of wires.
5. The Control Module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the Control Panel shall use to identify the type of device. Modules that use binary jumpers or dip-switches are subject to installation errors and are not acceptable. An LED shall be provided that shall flash under normal conditions, indicating that the Control Module is operational and is in regular communication with the control panel.
6. A magnetic test switch shall be provided to test the module without opening or shorting its NAC circuit wiring.

N. Isolator Module (Fire-Lite Alarms model I300).

1. Isolator Modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.
2. If a wire-to-wire short occurs, the Isolator Module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section of the SLC loop.
3. The Isolator Module shall not require any address setting, and its operations shall be

totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.

4. The Isolator Module shall mount in a standard 4-inch deep electrical box or in a surface mounted backbox. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

O. Waterflow Switches (System Sensor WFD Series)
   1. Flow switches shall be integral, mechanical, non-coded, non-accumulative retard type.
   2. Flow switches shall have an alarm transmission delay time that is conveniently adjustable from 0 to 60 seconds.
   3. Flow switches shall be located a minimum of one (1) foot from a fitting that changes the direction of the flow and a minimum of three (3) feet from a valve.

P. Sprinkler and Standpipe Valve Supervisory Switches:
   1. Each sprinkler system water supply control valve riser or zone control valve, and each standpipe system riser control valve shall be equipped with a supervisory switch. Standpipe hose valves, and test and drain valves shall not be equipped with supervisory switches.
   2. Each Post Indicator Valve (PIV) or main gate valve shall be equipped with a supervisory switch.
   3. Mount switch so as not to interfere with the normal operation of the valve and adjust to operate within two revolutions toward the closed position of the valve control, or when the stem has moved no more than one-fifth of the distance from its normal position.
   4. The mechanism shall be contained in a weatherproof aluminum housing, that shall provide a 3/4-inch tapped conduit entrance and incorporate the necessary facilities for attachment to the valves.
   5. Switch housing to be finished in red baked enamel.
   6. The entire installed assembly shall be tamper proof and arranged to cause a switch operation if the housing cover is removed, or if the unit is removed from its mounting.
   7. Valve supervisory switches shall be provided and connected under this section and installed by mechanical contractor.

Q. Serial, LED-Type, Remote Annunciation (Fire-Lite Alarms AFM Series)
   1. The annunciator shall communicate with the fire alarm control panel via an EIA 485 (ACS mode) communications loop and shall annunciate all zones in the system. Up to 32 annunciators may be connected to the EIA 485 communications loop.
   2. The annunciator shall need no more than four wires to connect to the FACP.
   3. The annunciator shall provide a red Alarm LED per zone, and a yellow Trouble LED per zone. The annunciator will also have an "ON-LINE" LED, local piezo sounder, local acknowledge/lamp test switch, and custom zone/function identification labels.
   4. The annunciator switches may be used for System control such as, Global Acknowledge, Global Signal Silence, and Global System Reset.

R. Serial, LCD-Type, Remote System Display (Fire-Lite Alarms LCD-80 Series)

1. The annunciator shall communicate with the fire alarm control panel via an EIA-485 (Terminal Mode) communications loop and shall include a 80-character, backlit, LCD display which mimics the integral fire alarm control panel LCD display. Up to 32 annunciators may be connected to the EIA-485 communications loop.
2. The annunciator shall require no more than four wires on the communication loop (two for communication, two for supervision) and two additional wires for power.
3. In addition to the LCD, English language display, the annunciator shall also include a Power LED, Alarm LED, Trouble LED and Supervisory LED.
4. A local piezo sounder shall also be included on the annunciator.
5. Switches for Acknowledge/Lamp Test, Silence, Drill and Reset shall be included on the annunciator protected from unauthorized usage by a key switch (keyed alike to the host FACP).

2.5 BATTERIES:

A. Shall be 12 volt, Gell-Cell type (two required).
B. Batteries (two required) shall have sufficient capacity to power the fire alarm system for not less than twenty- four hours plus 5 minutes of alarm upon a normal AC power failure.
C. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks refilling, spills and leakage shall not be required.

PART 3.0 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer.
B. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.
C. All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.

3.2 TEST:

Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system.

1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
2. Close each sprinkler system flow valve and verify proper supervisory alarm at the FACP.
3. Verify activation of all flow switches.
4. Open initiating device circuits and verify that the trouble signal actuates.
5. Open and short signaling line circuits and verify that the trouble signal actuates.
6. Open and short Notification Appliance Circuits and verify that trouble signal actuates.
7. Ground all circuits and verify response of trouble signals.

8. Check presence and audibility of tone at all alarm notification devices.
9. Check installation, supervision, and operation of all addressable smoke detectors using the Walk Test.
10. Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.
11. When the system is equipped with optional features, the manufacturer's manual should be consulted to determine the proper testing procedures. This is intended to address such items as verifying the controls performance by individually addressed or grouped devices, sensitivity monitoring, verification functionality and similar.

3.3 FINAL INSPECTION:

At the final inspection, a manufacturer-trained representative shall demonstrate that the system functions properly in every respect.

3.4 INSTRUCTION:

Provide instruction as required for operating the system. "Hands-on" demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided. The Contractor and/or the Systems Manufacturer's representatives shall provide a typewritten "Sequence of Operation" to the Owner if required.

A Public Address (PA) system amplifies and distributes sound to a large audience. Key technical specifications
include power output, frequency response, signal-to-noise ratio, and output impedance. The system comprises input sources (microphones, etc.), amplifiers, control & monitoring equipment, and loudspeakers. Specific requirements, like those for railway systems, can be found in documents like RDSO specification.

Detailed Specifications:

- **Power Output:**

  Measured in watts (e.g., 120W, 240W, 500W) per channel, with a specified total harmonic distortion (THD).

- **Frequency Response:**

  The range of frequencies the system can reproduce, typically 40 to 20,000 Hz +1 dB, ensuring clarity for speech and music.

- **Signal-to-Noise Ratio (SNR):**

  The ratio of the desired signal (voice, music) to background noise, expressed in decibels (dB). A higher SNR (e.g., 100dB) indicates a cleaner signal.

- **Output Impedance:**

  The electrical resistance of the output circuit, often 100V or 70V for PA systems, influencing how the amplifier interacts with the loudspeakers.

- **Channel Separation:**

  In multi-channel systems, the degree to which one channel's signal is isolated from others, measured in dB (e.g., 90dB at 1 kHz).

- **Controls and Indicators:**

  Volume controls, power switches, LED indicators, and VU meters for monitoring and adjusting the system.

- **Grounding:**

  Separate protective and operational grounding to minimize electrical interference, with a recommended grounding resistance not exceeding 1Ω, according to SPON Communications.

- **Software:**

  PC control software with features for programming audio routing, amplifier levels, zone management, and monitoring system status.

- **Call Stations:**

  Equipped with microphones and "push-to-talk" buttons for making announcements, with zoning capabilities for targeted messaging.

- **Intercom Functionality:**

  Larger systems may include intercom features, like those found in railway applications, for communication between different personnel or areas.

- **Compliance:**

  PA systems may need to comply with standards like IEC 60065 (for paging microphones) and IEC 60268 (for sound system equipment).

  Additional considerations:

  - **Zoning:** PA systems often divide the coverage area into zones for targeted announcements.
  - **Background Music (BGM):** Some systems integrate background music playback.
  - **Emergency Features:** PA systems may be integrated with fire alarm systems for voice

evacuation, and they should be designed for reliability and self-recovery in case of failure.

- **Server:** In IP-based systems, the server must support protocols like SIP or equivalent, along with security features like firewalls.
- **Installation:** The system should be installed according to design specifications, with proper cabling and wiring.
- **Maintenance:** Regular maintenance and testing are essential for optimal performance.

NETWORKING SYSTEM (FOR DETAILING REFER BOQ) A network system's technical specifications define its architecture, components, and operational parameters. It details the hardware, software, protocols, and configurations necessary for devices to communicate and share resources effectively. Key aspects include network topology, communication protocols, transmission media, and security measures.
Here's a more detailed breakdown:

1. Network Topology:

- **Definition:** Describes the physical or logical arrangement of devices and connections within the network.
- **Examples:** Bus, star, ring, mesh, and tree topologies.
- **Specifications:** May include the number of nodes, connection types (wired/wireless), and the overall layout.

2. Communication Protocols:

- **Definition:** Rules and standards that govern how devices communicate and exchange data.
- **Examples:** TCP/IP, HTTP, FTP, SMTP, etc.
- **Specifications:** Details the protocols used for various functionalities, such as data transmission, routing, and application-level communication.

3. Transmission Media:

- **Definition:** The physical or wireless medium used to carry data between devices.
- **Examples:** Ethernet cables, fiber optic cables, Wi-Fi, Bluetooth.
- **Specifications:** Specifies the type of cables used, their lengths, and the wireless frequencies used.

4. Hardware Components:

- **Definition:** Physical devices that enable network functionality.
- **Examples:** Routers, switches, hubs, network interface cards (NICs), servers, and client devices.
- **Specifications:** Includes details about hardware specifications, such as port capacity, processing

power, and storage capacity.

5. Software Components:

- **Definition:** Software that enables network operations and applications.
- **Examples:** Operating systems, network management software, security software.
- **Specifications:** Details the software versions, configurations, and required resources.

6. Security Measures:

- **Definition:** Mechanisms to protect network resources and data from unauthorized access.
- **Examples:** Firewalls, intrusion detection systems, encryption protocols.
- **Specifications:** Includes security policies, access control methods, and encryption algorithms.

7. Network Services:

- **Definition:** Services offered by the network, such as DHCP, DNS, and file sharing.
- **Specifications:** Details how these services are implemented, configured, and managed.

8. Performance Metrics:

- **Definition:** Measures that indicate the efficiency and effectiveness of the network.
- **Examples:** Throughput, latency, packet loss, and jitter.
- **Specifications:** Defines acceptable performance thresholds and monitoring procedures.

9. Scalability:

- **Definition:** The ability of the network to accommodate growth and changes in demand.
- **Specifications:** Includes provisions for expanding network capacity, adding new devices, and upgrading infrastructure.

By clearly defining these technical specifications, a network system can be designed, implemented, and maintained effectively, ensuring reliable and efficient communication and resource sharing.

DRAWINGS

Set of as built drawing shall be submitted to consultant after completion of job including drawings for the panels, Distribution Boards, Circuit diagrams, single line diagrams, Electrical layout, Raceway layout, Junction Boxes used in Raceways, Conduit Layout, Cable layout, Location of Fire Detectors, Speakers, Emergency Circuits, etc..

SECTION–VI

LIST OF APPROVED BRANDS /MAKES OF EQUIPMENT REQUIRED UNDER THIS TENDER

The following are list of approved brands/makes of equipment required under this tender. Please note that wherever there is a multiple choice of brands/makes approved, only nominated brands/makes by consultant shall have to be supplied.

SR.NO	DISCRIPTION	MAKESOFMATERIAL
1	Air Circuit Breaker	Legrand/ Schneider/ L&T/ ABB
2	Moulded Case Circuit Breaker	Legrand/ Schneider/ L&T/ ABB
3	Switch Fuse Unit	Legrand/ Schneider/ L&T/ ABB/Honeywell
4	Miniature Circuit Breaker	Legrand/ Schneider/ L&T/ ABB
5	RCCB/RCBO	SCHNEIDER
6	Auto Transfer Switch	ASCO7000series
7	Meters	TRINITY/SCHNEIDER/ELMEASURE
8	LOAD MANAGERS	TRINITY/SCHNEIDER/ELMEASURE
9	Indicating Lamps LED	TEKNIC/L&T/SCHNIDER/SIEMENS
10	Selector Switches	L&T/SIEMENS
11	Terminal Block	ELMEX/CLIPON
12	Metal Clad Sockets/ IEC Sockets	GERALD/RRPACE/LEGRAND
14	Distribution Boards	Legrand/ Schneider/ L&T/ ABB/Honeywell
15	APFCR Relay	TRINITY/L&T/Rudrashakti
16	Heavy Duty Capacitor	TRINITY/SCHNEIDER
17	Cables	POLYCAB/ KEI/RR
18	Lugs	DOWELL'S/BRACO/JAINSONS
19	GLANDS	SIEMENSTYPEBRACO/COMET
20	FRLSPVC conduits ISI MARK	PRECISION/NATIONAL
21	MS Conduits & accessories	BEC/BI
22	Wires1100VGradeFRLSISIMARK	POLYCAB/KEI/RR
23	PANEL MANUFACTURE	1) Arrow Electricals India Limited 2) VDHIK PANELS 3) Plasma Engineering India Limited
24	CO2 FLOODING SYSTEM	Kanex / Supremex
25	AHF	INSTASINE/TRINITY
26	Modular Switches ,Sockets ISI MARK	MK-Honeywell/ Legrand/ OBO OR AS PER APPROVAL OF SWAMI CONSULTANT
27	Screws	Any ISI Mark
28	Light Fittings	WIPRO/HAVELLS/PHILIPS

29	CABLETRAY/RACEWAYS/RACEWAYS JB	PRAKASH FABCOM / ENJAY INDUSTRIES
30	BUSDUCT	SCHNEIDER / GODREJ
31	CEILING FAN	CROMPTON/GEC
32	WALLMOUNTED FAN	CROMPTON/ALMONARD/GEC
33	NETWORKING	LEGRAND / SYSTIMAX / PANDUIT
34	FIRE ALARM SYSTEM	HONEYWELL (AS MENTION IN BOQ) / EDWARD / GST
35	PA SYSTEM	BOSCH /AHUJA /SONY
36	CCTV	Dvtel / Pelco / Bosch
37	NOVAC	SIEMENS / HONEYWELL / CYRPTO / STAR ELECTRONICS
38	WLD	SIEMENS / STAR ELECTRONICS
39	RODENT REPELLER	STAR ELECTRONICS / RSCAT / MASER

TECHNICAL SPECIFICATIONS FOR HVAC WORK

SCOPE OF WORK :

The Scope of Work will include (but not limited to) the following:

A. CHILLED WATER SYSTEM :

A.1 WATER COOLED CHILLED WATER SYSTEM COMPRISES OF :

1. 300 TR x 1 Nos. Water Cooled Screw Chillers.
2. 1 Nos. Primary Chilled Water Pumps
3. 2 Nos. Secondary Chilled Water Pumps
4. 1 Nos. Condenser Water Pumps

B. PIPING :

B.1 CHILLED WATER PIPING :

1. Complete Primary Chilled Water Piping in the Plant Room.
2. Complete Secondary Chilled Water Piping in the Plant Room.
3. Complete Condenser Water Piping in the Plant Room.

B.2 DRAIN PIPING :

1. Complete Drain Piping as per Drawing.
2. Complete Drain Piping as per Drawing for DX / VRF System.

B.3 PIPE COATING & INSULATION :

1. Entire Condenser Piping to be with FRP Coating.
2. Entire Chilled Water Piping to be with Nitrile Rubber Insulation.
3. Entire Condensate Drain Piping to be with Nitrile Rubber Insulation.

C. Drain piping with Insulation for entire Chilled Water System including Low side AHU's.**VALVES & ACCESSORIES :**

D.1 CHILLED WATER :

1. Motorized ON/OFF Butterfly Valves.
2. Butterfly Valves.
3. Ball Valve for Drain.
4. Energy Valves.
5. Manual Balancing Valves.
6. 2-way Modulating cum Automatic Balancing Flow Control Valves.
7. 2-way ON / OFF Valves.
8. Y-Strainers.
9. Suction Guide for Pumps.
10. Wafer Swing Check Valves.
11. Cartridge type side stream filter for closed loop.
12. Pressure Gauges.
13. Thermometer.
14. Automatic Air vents.
15. Flow Switch.

16. Sockets / Ball Valves for BMS sensors.
17. Flanges.
18. Accessories such as bends, elbows, tees, reducers, rubber gaskets, companion flanges etc.

D.2 CONDENSER WATER PIPING :

1. Butterfly Valves.
2. Motorized Butterfly Valves.
3. Suction Guide for pumps.
4. POT Strainers.
5. Ball Valve for Drain.
6. Wafer Swing Check Valves.
7. Sand Media type side stream filter for open loop system.
8. Pressure Gauges.
9. Thermometer.
10. Automatic Air vents.
11. Flow Switch.
12. Sockets / Ball Valves for BMS sensors.
13. Flanges.

D. FANS :

D.1 TOILET & PANTRY VENTILATION SYSTEM :

1. Toilet / Pantry Exhaust Fans for each Shaft.
2. PIR Ducting
3. Grilles
4. Diffusers
5. Dampers
6. Canvas Connections
7. Panels
8. Cabling
9. Earthing

E. COMMON AREA UPS ROOM AIR-CONDITIONING & VENTILATION SYSTEM.

F. DOCUMENTS REQUIRED (AS PER IGBC, CLIENT & PMC REQUIREMENT) :

F.1 Submission of Technical Data Sheets for all Materials / Equipment specified above.

F.2 Complete Final Design Basis Report

F.3 Equipment Selection & Calculation Sheets.

F.4 Technical Data Sheets for following :

1. Chillers for Conventional System
2. Primary Pumps for Conventional System
3. Secondary Pumps for Conventional System
4. Condenser Pumps for Conventional System
5. Motorized Valves for Conventional System
6. Toilet & Pantry Ventilation Fans

F.5 Shop Drawings for entire HVAC Systems

F.6 Factory Testing :

1. 4 Point (100%, 75%, 50%, 25%) Testing report for 1 Chiller.
2. Consider 4 PAX from Client Side for Factory Testing Visit.

F.7 Factory Test Reports of all equipment/material

F.8 Site Testing & Commissioning Reports of entire HVAC equipment

F.9 Power Tap off to each AHU Room with Earthing.

F.10 Documentation required for Green Building Certification.

F.11 Handing over documents along with As-built drawings, Test Reports, List of spare parts, Escalation matrix, Operation Schedule & Maintenance Schedule.

1.0 WATER COOLED SCREW CHILLER

CHILLED WATER SYSTEM

The air-conditioning system shall be chilled water type in which water is cooled up to 7°C in the evaporator of refrigeration machine. This water is circulated to fan coil of the terminal units / AHUs with VFD located in the areas to be air-conditioned. The water at 7°C flows through the coil and air is blown from the coil, which means heat transfer takes place and will give ultimate effect in the area. The water temperature is increased to 12°C in the above action and the same is cooled again in the evaporator of the machine.

PERFORMANCE PARAMETERS

A. WATER COOLED SCREW CHILLER WITH VFD FOR CONVENTIONAL SYSTEM

1. Cooling capacity at design conditions: 300TR
2. Chilled Water O/I Temp - 7 / 12°C
3. Cooling Water I/O Temp – 32.0 / 38.0°C
4. Chiller Fouling Factor - 0.0001 $ft^2*°F$ / Btu. hr.
5. Condenser Fouling Factor - 0.00025 $ft^2*°F$ / Btu. hr.
6. Part load energy efficiency (AHRI IPLV) ≥ 9.50
7. Minimum COP at AHRI Relief ≥ 6.20
8. Sound Pressure Level @ 3m should not exceed 75 db(A)
9. Maximum ΔP across Evaporator ≤ 3.0 mwc
10. Maximum ΔP across Condenser ≤ 8.0 mwc
11. **GENERAL**

SYSTEM DESCRIPTION

Microprocessor-controlled water-cooled chiller utilizing a mono / twin rotor, 2960 rpm (50 HZ), direct drive, hermetic / semi-hermetic / open, multiple screw compressor using refrigerant 134A.

QUALITY ASSURANCE

Unit shall be rated in accordance with ARI / Eurovent standard.

Unit construction shall comply with European directives-

- Machinery directive 98/37/EC, modified.
- Low voltage directive 73/23/EEC, modified.
- Electromagnetic compatibility directive 89/336/EEC, modified, and the applicable recommendation of European standards-
- Machine safety-electrical equipment in machines, general regulations, EN 60204-1.
- Electromagnetic emission EN 50081-2.
- Electromagnetic immunity EN 50082-2.

Unit shall be designed, manufactured and tested in a facility with a quality assurance system certified ISO 9001.

Unit shall be manufactured in a facility with an environment management system certified ISO 14001. Unit shall be tested at the factory.

DELIVERY, STORAGE AND HANDLING-

Unit controls shall be capable of withstanding 55°C storage temperatures in the control compartment.

PRODUCTS & EQUIPMENT-

GENERAL-

Factory assembled, single-piece, air-cooled liquid chiller contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (HFC – 134a), required prior to field start-up.

UNIT CABINET-

- Frame shall be made of U steel beam and protected by three layers of paint.
- The control box plates shall be steel with an oven-baked polyester-paint finish, and be capable of withstanding a 500-hour salt spray test in accordance with the ASTM B-117 standard (USA).

COMPRESSORS-

- Unit shall have semi-hermetic mono / twin-screw, gear-driven compressors with internal muffler and check valve.
- Each compressor shall be equipped with a discharge shut-off valve.
- Capacity control shall be provided by pilot-operated solenoid valve, capable of reducing unit capacity to 20% of full load. Compressor shall start in unloaded condition.
- Motor cooling shall be provided by direct liquid injection and protected by internal overload thermistor.
- Lube oil system shall include pre-filter and internal filter capable of filtration to 3 microns.

EVAPORATOR-

Unit shall be equipped with a single evaporator.

- Evaporator shall be tested and stamped in accordance with applicable European pressure code for a refrigerant side operating pressure of 1700 kPa (service des Mines units) and for a maximum water-side pressure of 1000 kPa.
- Shall be mechanically cleanable shell-and-tube type with removable heads.
- Tubes shall be internally-enhanced, seamless-copper type, and shall be rolled into tube sheets.
- Shall be equipped with Victaulic water connections (accessory flanges on request).
- Shell shall be insulated with 19 mm closed-cell, polyvinyl-chloride foam with a maximum K factor of 0.28.
- Shall incorporate two independent refrigerant circuits.
- Shall have an evaporator drain and vent.
- Shall incorporate a refrigerant level control system.

CONDENSER-

- Coil shall be Water-cooled with integral sub cooler and shall be constructed of aluminium fins mechanically bonded to internally finned copper tubes. The tubes are then cleaned, dehydrated and sealed.
- Condenser tubes shall be leak tested and shall be pressure tested at 3400 kPa.

REFRIGERATION CIRCUITS-

Refrigeration circuit components shall include oil separators, high and low side pressure relief devices (according to applicable standards), discharge and liquid line shutoff valves, filter driers, moisture indicating sight glasses, electronic expansion devices, refrigerant

economizers and complete operating charges of both refrigerant and compressor oil.

CONTROLS, SAFETIES AND DIAGNOSTICS-

1. CONTROLS-

a. Unit controls shall include as a minimum; the microprocessor board, and a 6-digit diagnostic display with keypad.

b. Shall be capable of performing the following functions -

- Automatic changeover between compressors.
- Capacity control based on leaving chilled fluid temperature with return fluid temperature sensing.
- Limiting the chilled fluid temperature pull-down rate at start-up an adjustable range of 0.1°C to 1.1°C per minute to prevent excessive demand spikes at start-up.
- Enable adjustment of leaving chilled water temperature according to the return water temperature or by means of a 0 – 10 V signal to the outdoor temperature.
- Provide a dual set point for the leaving chilled water temperature activated by a remote contact closure signal.
- Enable a 2-level demand limit control (between 0 and 100%), activated by a remote contact closure signal.
- Control water pump(s) operation.
- Enable automatic lead-lag of two chillers in a single system.

2. DIAGNOSTICS-

a. Display module shall be capable of displaying set points, system status (including temperatures, pressures, run time and percent loading), and any alarm or alert conditions.

b. Control Module, in conjunction with the microprocessor, shall be capable of displaying the output of a full load run test to verify operation of every switch, sensor, fan and compressor before the chiller is started, and carrying out a diagnosis and preventive maintenance (incorrect water loop, oil filter dirty etc.)

3. SAFETIES-

a. Unit shall be equipped with all necessary components and in conjunction with the control system shall provide the unit with protection against the following

- Loss of refrigerant charge.
- Reverse rotation.
- Low chilled water temperature.
- Low oil pressure (per compressor).
- Current imbalance.
- Thermal overload.
- High pressure.
- Electrical overload.
- Loss of phase.

b. Fan motors shall be individually protected by a circuit breaker.
Control shall provide general alarm remote indication for each refrigerant circuit. Control system shall have a RS485 serial output port (option and accessory).

OPERATING CHARACTERISTICS-

- Unit shall be capable of starting and running at full load at outdoor ambient temperatures from 0°C to 46°C.
- Unit shall be capable of starting up with 25°C entering fluid temperature to the evaporator.

ELECTRICAL CHARACTERISTICS-

- Unit electrical power supply shall enter the unit at one or two locations.
- Unit shall operate on 3-phase power supply without neutral.
- Unit with two compressors shall have a factory-installed, star-delta starter to limit electrical inrush current.
- Control voltage shall be supplied by a factory-installed transformer.
- Unit shall be supplied with factory-installed electrical disconnect switch / circuit breaker.

FINISHING-

Electrical cabinet colour – as per manufacturer. Compressor / heat exchanger colour – as per manufacturer

LOW-VOLTAGE UNIT MOUNTED STARTER

A reducer voltage wye-delta or double / solid-state starter shall be supplied. The compressor motor starter shall be factory mounted, wired, and tested prior to shipment by the chiller manufacturer. Customer electrical connection for compressor motor power shall be limited to main starter power connection only. Solid-state starter shall provide stepless compressor motor accelerating and limit motor in rush current to 150-300% of compressor motor RLA. The starter shall include 6 Silicon Control Rectifiers (SCR) with integrally mounted bypass contactors to provide SCR by pass once the motor has achieved full voltage and speed. The starter shall also include automatic acceleration kick circuitry which monitors motor current subsides and automatically ramps voltage up at a faster rate to eliminate the instability that occurs at the break away torque point.

Starter shall be UL and CSA approved and shall include-

- NEMA 1 enclosure with integral fan cooling and lockable hinged doors.
- Main power disconnects (non-fused type)
- Solid-state 3-phase over load relay with manual reset.
- 2 KVA control / oil heater transformer
- Branch circuit breaker for control power and oil heater
- 5 pilot relays for control of chilled water pump.
- Condenser water pump, tower fan, customer remote alarm, shunt trip, and main power disconnect. The shunt trip shall be energized by the SMM during unauthorized operation (such as loss of communication) between the SSM (Starter Management Module) and PSIO (Processor Sensor Input / Output Module).

Solid-state starters also include the following standard features-

- Current imbalance detector which monitors 3 phase motor current to provide the following protection-
- Phase loss
- Phase reversal
- Phase imbalance
- Ground fault
- Shorted SCR
- Current flow while stopped protection

- Diagnostic LED's shall be provided to indicate:

- Starter on
- Run (up to voltage)
- Phase corrects
- Over temperature fault
- SCR gates energized
- Ground fault
- Current imbalance fault
- Shorted SCR.

I²T fuses the solid-state circuitry at 200,000 amp interrupting capacity.

ELECTRICAL REQUIREMENTS

The contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, electrical protection devices per local code requirements and as indicated necessary by the chiller manufacturer. The contractor shall wire the water flow switches to the chiller control circuit to ensure that chiller will not operate until flows are established & maintained as per contractors / consultant's specifications. The contractor shall supply and install electrical wiring and devices required to interface the chiller controls.

PIPING REQUIREMENTS – INSTRUMENTATION AND SAFETIES

The contractor shall supply and install pressure gages in readily accessible locations in piping adjacent to the chiller such that they can be easily read from a standing position on the floor. Gages shall be very accurate. Scale range shall be such that design valves shall be indicated at approximately mid-scale. Gauges shall be installed in the entering and leaving water lines of the cooler and condenser. HVAC contractor shall supply & install flow detection devices in chilled water and condenser water piping. Switches shall make contact when flow is established. Flow switches shall be installed in horizontal runs at least 5 pipe diameters down-stream from any bend or tee.

INSULATION

1. Chilled water piping and cooler water boxes shall be installed by the HVAC contractor.
2. Chiller shall be insulated at factory. Final layer of insulation shall be installed at the job site by the HVAC contractor along with cladding.
3. Chiller insulation shall confirm to UL standard 94, classification 94 HBF and should be suitable for positive temperature operation.

VIBRATION ISOLATION

Chiller manufacturer shall furnish neoprene isolator pads for mounting equipment on a level concrete surface.

START-UP

1. The manufacturer shall provide a factory trained representative, employed by the chiller manufacturer, to perform the start-up, operation and maintenance manual provided by the chiller manufacturer.
2. After the above services have been performed, the same factory trained, representative shall be available for a period of class room instruction (not to exceed 4 hours) to instruct the chiller owner's personnel in the proper operation and maintenance of the chiller.
3. Manufacturer shall supply the following literature-
   a. Start-up, operation and Maintenance Instructions.
   b. Installation Instructions
   c. Field Wiring Diagrams
   d. Maintenance manual showing maintenance based on calendar basis and hourly basis.

QUALITY ASSURANCE

i. Chiller performance shall be rated in accordance with AHRI Standard 550/590, latest edition.

ii. Equipment and installation shall be in compliance with ANSI/ASHRAE 15 (latest edition).

iii. Cooler and condenser shall be in compliance with ASME OR equivalent code for unfired pressure vessels.

iv. Centrifugal compressor impellers shall be dynamically balanced and over-speed tested by the manufacturer at a minimum of 120% design operating speed.

Each compressor assembly shall undergo a mechanical run-in test to verify vibration levels, oil pressures, and temperatures are within acceptable limits. Each compressor assembly shall be proof tested at a minimum 204 psig (1406 kPa) and leak tested at 185 psig (1276 kPa) with a tracer gas mixture.

v. Entire chiller assembly shall be proof tested at 204 psig (1406 kPa) and leak tested at 185 psig (1276 kPa) with a tracer gas mixture on the refrigerant side. The water side of each heat exchanger shall be hydrostatically tested at 1.5 times maximum working pressure.

vi. Prior to shipment, the chiller automated controls test shall be executed to check for proper wiring and ensure correct controls operation.

vii. 4-point Factory testing for ONE Chiller of each type 5 PAX from client's side.

A) CAPACITY & EFFICIENCY:

One Chiller shall be tested for performance at Manufacturer works at 100% & 25% at AHRI condition and at 75% and 50% at Design condition (at constant condenser entering temperature) for verification of IKW/TR & Capacity as per submission of AHRI selection data sheet. If the inspection is outside India, the contractor shall visit and witness the test and shall submit photographs/proof to ascertain his witnessing the testing. The Client (MCGM / consultant) representative may also witness the test. The cost of their visit shall be borne by the Client. However, necessary coordination shall be arranged by the Contractor for their visit. In case of failure of any equipment during testing, the Contractor shall be bound to arrange for subsequent inspections. All the expenses (including travel, boarding etc.) for such inspections shall be borne entirely by the Contractor.

1) Casing: The casing should be of GRP.

2) Access: 1 no. Portable Aluminium Ladder per Cooling Tower shall be supplied.

3) Civil Work, Electrical Work, Piping, Pumps, etc.: All excluded from Vendors' scope.

Enclosed herewith is the water quality chart.

2.0 PUMPS

A. Pumps shall be of Horizontal split-case type and suitable for the given duty points and parallel operation -

i.	Type	-	Inline / End Suction
ii.	Impeller	-	Bronze confirming to BS - 1400
iii.	Shaft	-	High Tensile Steel
iv.	Bearings	-	Ball/Roller
v.	Pump/Motor Body	-	CI confirming to IS -210
vi.	Seal	-	Mechanical
vii.	Motor	-	Sq. cage T.E.F.C.
viii.	Starter	-	Star Delta
IX.	Shaft Sleeve	-	Bronze LG2

Pumps shall be selected for the rated conditions indicated. Efficiency of the pump proposed to be used shall be high. Peak efficiency shall be obtained at or near rated conditions. Impellers shall be statically and dynamically balanced.

B. Motor rating shown are only tentative and tenderer shall select their drives atlas 5% in excess of the max. BHP of the pumps. Motor shall be TEFC weatherproof design in IP-55 enclosure IE-3 rating, Class-F Insulation

The following accessories shall be provided where required with each pump besides other standard accessories -

i. Lubrication fittings and seal packing.
ii. Test and air vent cock.
iii. Drain Cock.
iv. Adequately sealed Terminal box for Aluminium conductor armored cable termination.

C. The following fittings shall be provided with each pump besides other standard fittings (to be measured and paid for separately) -

i. Suction and discharge shut-off valve, discharge check valve as specified under respective items.
ii. Suction and discharge pressure gauge not less than 150 mm diameter & of the appropriate rating with gauge cocks etc.
iii. 25mm GI drain piping up-to the nearest drain point.

D. The pump casing should be of closed grain with smooth finishing ensuring minimum frictional losses and having sufficient strength to withstand the forces due to water flow at all working conditions.

E. The impeller should be of Bronze and statically and dynamically balanced to ensure smooth working without vibration and noise.

F. Pumps shall be installed as per the manufacturer's recommendation. Pump shall be mounted on floating foundations, which in turn are mounted on vibration isolators. The Contractor shall supply the floating frame and vibration isolators & concrete foundation.

G. After complete installation, original paint of the pump shall be retouched and accessories, fittings and floating foundations frame shall be given two coats of synthetic enamel paints of color specified in specifications for paining Works / Approved color over a coat of primer.

2.1.1 TESTS & INSPECTION

A standard hydrostatic test shall be conducted on the pump casing with water at 1.5 times the maximum discharge head or twice the rated discharge head., whichever is higher. While arriving at the above pressure, the maximum suction head shall be taken into account. The hydrostatic tests on the casing shall be conducted for a minimum duration of 30 minutes.

2.1.2 PERFORMANCE TEST

(a) Standard Running Test

The pumps shall be tested as per IS 5120, at rated speed at SUB-CONTRACTOR's works to measure capacity, total head, efficiency and power. The negative tolerance on efficiency shall be limited to 2.5% (not 5 % as indicated in IS 5120. These tests shall form the basis for acceptance of pumps except for vibration and noise.The pumps shall be tested over the range covering from shut-off head to the maximum flow. The duration of the test shall be minimum one hour. Minimum five readings approximately equidistant shall be taken for plotting the performance curves.

(b) NPSH TESTS

NPSH tests shall be conducted with water as the medium.

2.1.3 MECHANICAL BALANCING

In addition to static balancing, impeller and balancing drum shall be balanced dynamically at or near the operating speed.

2.1.4 FIELD TESTING

After installation, the pumps shall be subjected to testing at site also. If the field performance is found not to meet the requirements regarding vibration and noise as specified, the equipment shall be rectified or replaced by the CONTRACTOR, at no extra cost to the EMPLOYER.

2.1. CONDENSER PUMPS

2.2.1 GENERAL

The variable pumping system should allow for the operation of multiple pumps of the same size in parallel at the same output frequency. It shall stage the pumps on and off as required to meet the system demand to provide increased performance, precision control and maximum energy savings.The pump controller software package should determine the settings for the controller to help in optimizing the control system by predicting the best staging on and off frequencies.

2.2.2 CONFIGURATION

The pump controller shall form an integral part of the VFD itself and shallnot besupplied as a standalone basis.

It shall have a 4-line alphanumeric display which is capable of displaying all the operating parameters. It shall be possible to program the VFD and the pump controller through the same local display panel. It shall be possible to supply the VFD and pump controller in IP 20 and IP 54 protection. Display key pad should be detachable and can be mounted on the panel door (up to 3 meter distance)The pump controller shall be capable of running up to five equally sized pumps in parallel in the best efficiency pattern.The VFD-cum-pump

controller shall be suitable for adapting itself to any locally available standard sized pumps and shall be capable of maintaining its best efficiency operating pattern throughout its operating speed. No de-rating of the pump motor shall be applicable to the offered VFDS.

2.2.3 AUTO / OFF/ MANUAL CONTROL

It shall be possible to set the Auto / Manual control for the pumps from the control panel of the VFD. During normal operation on the VFD shall be in the AUTO mode and the pump controller should start and stop the pumps as necessary.

The HAND position should allow for the manual start of each pump as necessary e.g. at manual operation, commissioning etc. It shall be possible to permanently disable a pump by setting the switch to OFF. If a pump is disabled for service, the pump controller shall enable the next pump to be switched ON to meet the system demand.

2.2.4 OPERATING MODE

The VPS shall follow a master / slave systems set up, where all pumps and are speed controlled with Variable Frequency Drives. The pumps shall be of the equal size and should be run at the same speed. One of the VFD shall act as a master and the other VFDS shall act as slaves which follow the speed of the master pump. It shall be possible to stage ON and OFF the slave pumps as necessary by the master to match the system requirement.

The in built pump controller shall calculate the best efficiency operation which optimizes the number of pumps to achieve the highest system efficiency based on the number of pumps operating in parallel, the system design head and set point head and the pump curves.

2.2.5 STAGING / DESTAGING DELAY

It shall be possible to program a staging and de-staging delay time to prevent fast cycling of the salve pumps.

2.2.6 PUMP CYCLING

In order to achieve equal operation of the slave pumps, the pumps should be cycled. Whenever a pump has to be started, the pump with the least hours is switched on. In case pump has to be switched off, the pump with the most hours is switched off.

STAGING FREQUENCIES

It shall be possible to program the staging ON / OFF frequencies in the display panel of the VFD which will determine the frequencies at which the slave pumps should be switched ON & OFF to maintain the best efficiency operation.

2.2.7 DRY RUNNING PROTECTION

The pump controller shall have a provision to wire a flow switch to the interlock terminals to avoid dry running of the pumps.

2.2.8 PID CONTROLLER

The system shall be controlled through a fully programmable PID controller which has the capability to accept the set points in process units (e.g. GPM or m3/h). The PID controller shall have the provision to accept two remote feedback signals from differential pressure transmitters, giving an output of 4-20 mA, located in the chilled water pipe line from the field.

It shall be possible to select the most deviated signal as feedback for controlling the speed of each pump. Each input signal shall be capable of accepting a different set point. The controller shall be capable of controlling up to 5 pumps in parallel in the master / salve control mode. It shall be possible to program the proportional, integral and derivative value inputs to the controller for fine tuning of the PID controller.

2.2.9 DISPLAY

The pump controller VFD shall have a 4-line, back lit, alpha numeric display capable of displaying all messages in English in text form. It shall have a quick programming menu for faster commissioning and a detailed menu for fine tuning of the system parameters.

The display panel shall have LED pilot lights for RUN, TRIP and WARNING conditions. The key pad switches shall be of soft touch type.

The following parameters shall be displayed on the display panel-

RPM of the pumps
Differential pressure in kg/cm^2
Motor Current in Amperes
Motor voltage in Volts
Energy consumed by individual pump in kWh
Run time of each pump in hours
No of pumps working (on the master drive)
KW consumed by the pump in kW

DATA SHEET – A

TECHNICAL REQUIREMENTS

1	**DESIGN FEATURES**		
1.1	Pump designation		
1.2	Minimum design capacity	LPS	
1.3	Total head	M	
1.4	Location		
1.5	Maximum rated speed (at 50 Hz.)	RPM	
1.6	Liquid handled		
1.7	Number required		
2.0	FEATURES OF CONSTRUCTION		
2.1	Type of pump		
2.2	Impeller		
2.3	Volute		
2.4	Shaft		
2.5	Drive Transmission		
2.6	Seal		
2.7	Coupling		
2.9	Prime Mover		
3.0	**MATERIALS OF CONSTRUCTION**		
3.1	Impeller		
3.2	Casing		
3.3	Shaft		
3.4	Shaft Sleeve		
3.5	Impeller Ring		
3.6	Casing Ring		
3.7	Stuffing Box Packing		
3.8	Base Plate		
	Note: For components marked * material test certificates shall be furnished		
4.0	**ACCESSORIES**		
4.1	Companion Flanges		
4.2	Foundation Bolts		
4.3	Base Plate		
4.4	Flexible connections at inlet / outlet		
5.0	**TESTING**		
5.1	Hydrostatic Test Casing Jackets / Cooling Passage		
5.2	Performance Test Std. Running Test NPSH Test		

DATA SHEET - B

DATA TO BE FURNISHED BY TENDERER ALONG WITH OFFER

Sr.	DESCRIPTION	TENDERER TO FURNISH
1	Pump tag number	
2	Number working stand by	
3	Make	
4	Model	
5	Design Capacity	LPS
6	Differential Head	MLC
7	Shut off head	MLC
8	Hydrostatic test pressure	Kg / cm^2(g)
9	Pump efficiency	%
10	Motor efficiency at duty point	%
11	Power input to motor at duty point	KW
11.1	Motor rating –BKW / KW	KW
12	Rated speed	Rpm
13	NPSH required	MLC
14	Materials of construction as per specification indicate deviations	
15	Suction Nozzle	
15.1	Orientation	
15.2	Size	Mm
16	Discharge Nozzle	
17	Impeller type	
18	Pump weight	Kg
19	Pump set weight	Kg
20	Moment of inertia of pump rotor	Kg – m^2

DATA SHEET - C

DATA TO BE FURNISHED BY THE CONTRACTOR AFTER AWARD OF CONTRACT AND `BEFORE' INSTALLATION

1. Quality Assurance Plan (QAP)
2. Detailed dimensioned general arrangement drawing of pump and driver.
3. Foundation drawing of pump and driver with static and dynamic loads, details of fixing, grouting and all relevant data required for design of foundation.
4. Cross-section drawing of the pump with complete part list, materials of construction and relevant standards for each part.
5. Pump performance curves flow rate Vs head, BKW, efficiency, NPSHR from zero flow to maximum flow and torque-speed curve.
6. Scheme for pump sealing, lubrication and cooling.
7. Driver dimensional drawing.
8. Surface preparation and painting procedures.
9. Catalogues, data sheets and drawings for instruments.
10. Installation, operation and maintenance manual.
11. Isolation pads and SS or Hot dip galvanized foundation bolts provided by the Contractor.
12. Cori-rubber make metallic bellows shall be provided at suction and discharge.
13. Pressure gauges with needle valve provided at suction and discharge lines.
14. All accessories provided to complete the pump installation.

DATA SHEET - D

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

N	Description	Unit	Time			Date			Remarks
			10.00	12.00	14.00	16.00	18.00	20.00	
1.	Suction pressure	Kg/cm^2							
2.	Discharge pressure	Kg/cm^2							
3.	Water flow rate	LPS							
4.	Current	Amps							
5.	Bed plate levels and alignment checks								
6.	Hydraulic test for casing at 1.5 times design pressure								
7.	Noise level from pump	1.8m dB							
8.	Discharge Vs head	Mtr							
9.	Discharge Vs efficiency								
10.	Discharge Vs BkW								

MODE OF MEASUREMENT:

1.0 Representatives from the Contractor and Engineer shall conduct a joint inspection of the Equipment's. All the discrepancies observed either incomplete works or defective work shall be clearly indicated in the joint inspection report. The mode of measurements given below is for the purpose of measurement and payment and the scope of works shall be as specified elsewhere in the specification.

2.0 CENTRIFUGAL PUMPS

Each pump set including motors, flexible connection at inlet and outlet, vibration isolators and accessories as specified in tender document shall be regarded as one unit for the purpose of measurement and payment.

3.0 VARIABLE FREQUENCY DRIVES

3.1. VFD FOR AHU'S

1) The VFD shall be of the type suitable for operation on a 3 phase, 415 V, 50 Hz input power supply at the following conditions:

Input supply voltage variations	: ± 10 %
Input supply frequency variations	: 48 – 52 Hz ± 1%
Ambient temperature	: 0 - 45° C, without derating.
Maximum relative humidity	: 95% non-condensing
Vibration	: 0.7 G RMS in 3 directions
Minimum efficiency at full load	: **97%**

2) The VFD's will be mounted in the open near the AHU's / Pumps in the AHU / Plant room. Hence the VFD's shall have integrated; factory built metallic enclosures of IP 55 rating, without any de-rating. VFD's of IP 00 / IP 20 / IP 21 / IP 42 rating enclosures with additional sheet metal enclosures to achieve IP 55 ratings are not permitted.

3) VFD's shall conform to the recognized international standards like IEC and manufactured according to ISO 9001, BS 5750 part 1 & 2 and shall be UL listed. It shall carry the CE mark on EMC compliance.

4) The VFD shall be capable of providing a starting torque of 160% for 0.5 sec and an overload torque of 110% torque for 1 minute.

5) The VFD shall maintain full output voltage during main's variations of ±10% to prevent loss of torque and speed variations occurring during motor operation.

6) The VFD shall comply with Electro Magnetic Compatibility (EMC) document **IEC/EN 61800 -3** for Radio Frequency Interference (RFI) control (emission) as an integral part of its design by incorporating RFI filters to meet **C1 -50 Mts, Unrestricted distribution for conducted emission.**

7) For AHU application, VFD should be able to give "Clog Filter" (by potential free contact) indication as per the set pressure requirement.

8) If a temperature / pressure / flow feedback signal is given to the VFD, it shall use its PID controller to modulate the speed in such a way that the set point of temperature or pressure is accurately maintained. This should eliminate the requirement of PID loop of BMS or external PID controller.

9) Additional PIDs (3 Nos.) are required to control chilled water valves and fresh air damper. This should be an integral part of the VFD.

10) The VFD shall be capable of accepting three such feedback signals simultaneously and be able to do a speed control based on average / sum / difference / minimum / maximum / 3 zone control of the above 2 signals. This should work in absence of BMS or should not use PID loop of BMS, in case of presence of BMS.

11) The PID controller shall be capable of programming the set points and incoming signals in any of the flowing units: RPM, l/s, l/m, l/h, m3/h, m3/s, bar, Pa, kPa, GPM, lb/s, lb/h, CFM, in3/h, in wg, ft wg, PSI, kW, HP, °C, °F, as required by the application, and be able to display the same while in operation. This should eliminate the requirement of PID loop of BMS or external PID controller.

12) In case the VFD detects a broken belt (AHU etc.) or coupling (pumps etc.), it shall display a warning signal to that effect. There shall be provision to export this warning signal to the BMS system through RS 485, without any need of I/Os of BMS.

13) For easier maintenance and to reduce inventory, the VFD shall allow connection of motors one frame size larger and 4 sizes smaller than its nominal rating.

14) The VFD shall have the following protective functions: Electronic motor overload, Protection to motor and VFD against input transients, phase loss, short circuit, under voltage, over voltage, phase imbalance, motor over temp., phase to phase short circuit or earth fault at motor terminals.

15) The VFD's shall have internal harmonic filters on the DC bus **(on both positive & negative limbs)** to reduce THVD to below 5% as per IEEE standard 519-1992. AC line chokes on the input side are not allowed for harmonic current control as it will cause voltage drop to the VFD and motor.

16) The Upeak of the VFD shall be below 1000 Volts (when measured with a cable length of 50 meters) to prevent damage to motor insulation.

17) Manufacturer of the VFD shall submit data sheet to verify this requirement in order to permit the usage of standard motors for the applications specified.

18) The VFD shall be capable of having an output motor cable length of at least 150 meters (armored cabling) without any need of additional equipment like output chokes.

This is essential for applications like chilled water pumps where the motors are located far away from the control center.

19) The VFD's shall incorporate a surge protection circuit as standard to protect the VFD from transients and spikes in the incoming power supply.

20) The VFD shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor and switching back ON with VFD in on mode.

21) The display of the VFD shall be Alpha numeric **(Graphical)** type.

LED displays are not acceptable, as it is not user friendly. Display of all messages and faults shall be in English text format. Codes are not acceptable.

The display shall show the following operating parameters:

- Energy consumed in kWh
- Power consumed by motor in kW
- Run time of motor in Hours
- Current drawn by motor in Amps.
- Output frequency in Hz.
- Motor speed in RPM
- Set point in process units
- Feedback in process units

22) It shall be possible to see at least 4 of the above operating parameters in the VFD display, simultaneously.

23) The VFD's shall have internal galvanic isolation (PELV) to avoid damage to BMS / PLC / DDC system when interconnected. If PELV is not available, the VFD vendor should offer opto-isolators for all the inputs and outputs in the VFD.

24) The VFD shall automatically operate at high switching frequency at low speeds and low switching frequency at high speeds to maintain silent operation of the AHU's at all speeds. The switching frequency range shall be from 4-14 kHz for VFD's to be installed on AHU's.

25) The VFD shall optimize the magnetizing current on a real time basis based on actual torque

requirement (energy optimization function) to minimize the power consumption compared to standard variable torque VFD's. VFD's offering fixed settings of V/f ratios are not permitted.

26) The VFD shall have Auto / OFF / Manual switch on the key pad itself. It shall be possible to manually change the speed of the AHU's from the key pad of the VFD, if required, without the need of an external potentiometer. In manual mode the speed reference signal shall be from keypad of VFD and in auto mode, the reference shall be from the remote – either BMS or transmitter.

27) The VFD shall have self adjustable ramp times to prevent tripping / VFD damage in case in appropriate ramp times is set with respect to application requirement.

28) The VFD's shall have the provision to program a minimum and maximum speed of operations, through the VFD programming itself.

29) In case of a power failure, the VFD shall be capable of automatically restarting after a programmable time delay, without need of an operator having switch on unit.

30) To prevent damage to the VFD's due to pre-rotating fans, the VFD shall have the capability to detect such spinning fans and adjust its frequency to its spinning speed before it starts controlling the fan. If the fan is running in the opposite direction, the VFD should brake the fan by sending a DC current, before starting the fan in the right direction.

31) If the transmitter feedback signal goes below a particular low limit value or goes above a particular high limit value, the VFD shall give an alarm signal. It shall be possible to transfer this signal to the BMS system as well.

32) The VFD shall be provided with at least 4 by-pass frequencies with adjustable band width in order to eliminate resonance in duct work and pipe lines occurring within the motor's operating frequency range.

33) The VFD shall have an auto de-rating facility by operating at a lower capacity in case of a phase loss or higher ambient temperature so that minimum air conditioning can be maintained. VFD's that trip on a phase loss or high ambient temperatures are not suitable for this application and hence not permitted.

34) The VFD's shall have the provision of 4 parameter set ups, which can be activated by the BMS or by digital inputs.

35) The variable frequency drives (VFD) shall have the provision to integrate into a BMS system, utilizing a serial communication protocol – open protocol or BMS specific protocol - that enables a full "read & write" seamless interface between VFD & BMS. The VFD manufacturer shall be responsible for technical support to the BMS Vendor in the implementation of a serial interface to the BMS System. The BMS Vendor shall be responsible for the complete "integration and interoperability" of the VFD through the BMS via the serial interface.

36) The VFD shall provide to BMS, via serial communication (by RS-485, 2 wire), access to the following VFD parameters as a minimum:

- Motor current
- Motor kW
- AHU KWh
- AHU Running hours
- Auto / Off / Manual status feedback
- PID controller programming
- Set point programming
- Alarms
- Run & Trip status

- Air flow status / alarm
- Dirty filter status / alarm
- Fault log history

37) The VFD shall also be able to provide the following selectable & programmable physical I/Os to the BMS system

- 6 Digital inputs (for start, stop, interlock, auto, manual, setup selection etc).
- 2 Relay outputs (for reading Auto / Manual status & VFD On / Off indication)
- 2 Analog input, 4 – 20 mA (for single feedback signal to VFD)
- 3 Analog inputs 0-10V (for feedbacks, if two feedbacks are taken)
- 1 Analog Outputs, 4-20 mA (for speed & kW feedback to BMS)
- 2 Analog Outputs, 0-10V for any other feedback required.

38) VFD shall have inbuilt real time clock for scheduling purpose.

39) If the VFD loses the feedback signal or reference signal in auto mode, the VFD shall be capable of maintaining the speed at which it is running.

40) If the VFD operates at the minimum speed for a set time, it shall be able to program the VFD to automatically switch off to save power.

A parameter lock shall be available in the VFD local display panel to prevent unauthorized resetting of parameters.

4.0 AIR-CONDITIONING UNIT/S

4.1 DOUBLE SKIN INTEGRATED AIR HANDLING UNIT/S

4.1.1 SCOPE

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

4.1.2 TYPE

The air handling units shall be floor mounted type with horizontal / vertical airflow arrangement with cabinet casing of double skin construction consisting of aluminium profile structure and insulated sandwich panels, draw-thru or blow through type comprising of various sections like –single or double stage filter section, coil and hydraulics section , starter panel and controller section, Direct drive EC fan section etc. as shown in the schematic layout arrangement drawings and included in schedule of quantities. Customized sections to include components like Hot water coil, mixing box, adiabatic pads, heat recovery wheels, automatic damper modules, heater and humidifiers etc. must be possible to integrate in modules as per requirements.

4.1.3 CAPACITY

The air handling capacities, maximum motor horse power and static pressure shall be as shown on Drawings and in Schedule of Quantities. The AHU design must be based on airflow velocities, pressure drops and static requirements as specified.

4.1.4 UNIT HOUSING / CASING

The unit casing shall be made of double skin design comprising of the chassis structure made of extruded aluminum framework with thermal / non thermal break profile of 48mm / 25mm as specified in Bill of Quantities. The panels shall be double skin sandwich type with minimum 1.0 mm thick powder coated/pre coated steel sheet on the outer side and minimum 0.8 mm thick galvanized sheet on inner side with 45mm ± 2 / 25± 1 mm thick rockwool insulation material of density 60 kg/cum between both inner and outer skin. Considering fire safety norms injected PU foam insulation is not acceptable.

The base frame of the AHU shall be made of 100mm high steel profile structure for rigidity.

All sections/panels shall be bolted to each other with Neoprene rubber gasket in between and fixed with steel screws for perfectly aligned and airtight joints. The gaskets shall be held in place by inserting them in the integrated channels in the framework. All panels shall be detachable or hinged. Hinges shall be made of die cast aluminum with stainless steel pivots. Door handles and locks shall be made of self-extinguishing thermoplastic nylon filled with glass wool and minerals. Marine lights can be provided in fan & coil sections, if required, to see the inside and shall be interlocked with door opening.

Condensate drain pan shall be provided with multiple slopes towards drain outlet. Condensate drain pan shall be fabricated from SS 304/GI powder coated, insulated with 19 mm thick closed cell elastomeric insulation.

4.1.5 EC - FAN SECTION (ELECTRONICALLY COMMUTATED)

Unit must be provided with direct drive backward curved EC fans each running with DC drive electronically communicated motors, the fans should be aligned and balance statically and dynamically. The fan speed must be controlled based on the room return air temperatures and also must have automatic step-less speed control without manual intervention.

The fans can be in multiple numbers as per the manufacturer's standard. Units shall be factory balanced. Fan curves must be provided to confirm selection as and when required. The motor and fan must be from approved manufacturers as one assembly.

Noise Level: Less than 73 db from 2 Mtr. of unit in free filed conditions.

Only direct drive fans to be provided in offered units and centrifugal fans with belt drive is strictly not acceptable.

4.1.6 COOLING COIL / EVAPORATOR COIL SECTION

The cooling section shall be of Chilled Water Coil, DX Coil, Dual Fluid or Dual Chilled Water as specified in the Bill of Quantities.

Coil shall be shall be made from seamless copper tubes with aluminum anti-corrosive corrugated fins/Hydrophilic coated blue fins. The tubes shall be solid drawn copper of not less than 9.5 or 12.5 mm dia. and minimum 0.4 mm wall thickness.

Aluminum fins shall be continuous and equally spaced by collars forming integral part of the fins. The number of fins shall not be more than 12 FPI and the thickness of fins shall be minimum 0.11mm. The fins shall be uniformly bonded to copper tubes by mechanical/hydraulic expansion for minimum thermal contact resistance with fins. The fins shall be assembled in a GI or specified in BOQ. Coils shall be sliding track mounted inside the Unit for easy replacement. Each section of the coil shall be fitted with supply & return header of Copper/MS to feed all passes of coil equally. U bends shall be of forged copper and shall be joined to tubes by brazing and silver soldering.

Headers shall be provided with flanged ends for pipe connections. The headers shall also be provided with vent plug at top and drain plug/valve at bottom. The coil shall be designed for a maximum working pressure of 7 Kg/Sq.cm. Each coil shall be factory-tested at 21 kg/sq.cm air pressure under water. Computerized cooling coil selection output shall be submitted.

Coil selections must ensure total water side pressure drop including header are not exceeding 50 kPa as per design standards.

4.1.7 CHILLED WATER CONTROL VALVE

The coil and hydraulic section of the air handling unit shall be provided with factory fitted required size of 2 Way Valve/Pressure Independent Dynamic Balancing Valves with actuators to stabilize the flow and to have better heat transfer resulting in Energy savings and increase in overall performance of the unit. The type of valve to be used shall be in accordance with specification in bill of quantities. Manufacturer to ensure the valve control is possible via integrated control signal based on feedback from temperature sensors of return or supply air as control logic specified.

4.1.8 PRE-FILTER SECTION

Each unit shall be provided with a factory assembled filter section containing synthetic media washable air filters with efficiency of 90% down to 10-micron particle size confirming to MERV 8. Filters shall have aluminum frame. Filter face velocity shall not exceed 500 FPM. Holding frames shall be provided for installing number of filter cells in banks. These cells shall be held within the frames by sliding the cells between guiding channels. Optionally high efficiency filters wherever required can be provided as separate sections.

4.1.9 ELECTRICAL PANEL

The air handling unit shall have inbuilt integrated electrical starter panel with AUTO/Manual over ride switch for operation. Control cabinet to be provided with Type 2 enclosure, with grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control circuit transformer. The electric panel provided for the unit must be equipped with main incoming power isolation switch, additionally the unit must be provided with under voltage / over voltage / phase reversal / single phasing protection in standard for DX systems, all three phase motors must be operated only via. 24V / 48V coil voltage contactors and MPCB's, additionally step down transformer must be provided for power supply to the unit controller. The electrical panel must also be providing with relay block for common alarm.

4.1.10 MICRO PROCESSOR CONTROLLER

The controller to be equipped with appropriate capacity processor with minimum 128 MB Flash + 128 MB DDR3 Memory. The controller should have ports for BMS Connectivity using Modbus RTU protocol. The power input to the controller shall be DC 24, with working range of DC 9V-28V, the power consumption should be less than 10W. Touch Screen Display shall be provided as standard and the controller / DDC must be compatible to connect to a laptop or display for configuring or viewing unit performance parameters.

The controller to have the following outputs:

- Temperature (Air, Water) connectivity as per devices options.
- Sensor Using Rs485 (Modbus slave) connectivity.
- CO2/VOC sensor connectivity – optional, if mentioned in the BOQ
- I/O summary upto 250 devices compatible.
- Multiple controller (Slave) connectivity.
- Modbus RTU (485/IP) compatible output to BMS.
- Wireless connectivity of devices through WLAN Adaptor/Switch.
- Memory storage through SD card (Optional).
- Downloading updates/via USB interface software utilities – optional, if mentioned in the BOQ
- Password Protection.
- The control should have an auto-restart feature which will return the unit to normal operation resumption of mains power.
- Feedback from sensor etc and regulate the fan speed/ valve opening.
- Automatic load / time and alarm sequencing function to be performed by the unit.
- Microprocessor must have output point for ON/OFF of motorized outlet damper and must be suitable to be integrated with fire point for unit shut off incase receiving signal from fire panel or fire detectors.

In normal operating mode the screen should display unit number, temperature and relative humidity set points and actual, operating status.

Instrumentation: The following sensors shall be part of AHU package for modulation of fan and control valves

a) Temperature Sensor
b) DP sensor across filter

 Signature & Seal of Contractor

4.1.11 MIXING BOX - OPTIONAL

AHU's requiring mixing boxes as specified in Schedule of Quantities shall be complete with fresh and return air dampers.

4.1.12 DAMPER WITH ACTUATOR - OPTIONAL

Dampers shall be opposed blade type. Blades shall be made GI and assembled within a GI frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in Teflon bushes. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Actuators for manual dampers can be provided as mentioned in the schedule of quantities. Damper frames shall be sectionalized to minimize blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure. Time delay settings for damper On/Off based on signal from unit controller can be provided.

4.1.13 MULTI STAGE PARTICULATE FILTERATION – OPTIONAL BOQ SPECIFICATION.

Additional filter sections comprising of fine filter (MERV 13) with efficiency of 99% down to 3-micron particle size and other super fine filter to be provided as mentioned in the schedule of quantities.

4.1.14 TESTING AT WORKS – OPTIONAL IF SPECIFIED IN BOQ

Factory performance testing to establish the cooling capacity of the unit, air flow rate, dry bulb and wet bulb temperatures of air entering and leaving the coil of the air handling unit using PLC controlled graphical display. All the results must be fully computerized and can be seen on real time basis. The testing setup shall be in accordance with DIN EN 14511. Minimum 4 hours continuous real time readings should be recorded for computation of operational parameters. Additionally, electrical safety Hi-pod testing, dry run testing for control logic, thermal bridging test and leakage testing of cabinet at works must be complied with as part of performance test of the air handling unit, if Specified in BOQ.

CASSETTE UNIT/S

4-Way Cassette Type Fan coil units complete with decorative panel and cordless remote control. Unit shall have flexible coil selection between 2 Row dia 9.52mm & 3 Rows dia 7mm, now also modulation control function, Fresh air input, ABS fan blower, cleanable fabric filters, High quality main drain tray with inbuilt condensate drain pump, casing, and copper coil headers, coil piping connections through copper pipes., AC Motor- 3 speed fan control, filter and thermostat.

Cassette units are compatible with BMS Inclusive Adaptor/ Controller/ Gateway etc.

5.0 PRECISION AIRCONDITIONING SYSTEMS

5.1 UNITS WITH ELECTRONICALLY COMMUTATED MOTORS AND VARIABLE SPEED

Scope of this section comprises the supply, installation, testing and commissioning of High Density cooling solution with horizontal throw.

5.2 CABINET CONSTRUCTION

The frame and panels shall be constructed of heavy gauge corrosion resistant sheet steel and have modular construction with aluminium based railing and hinged doors.

The cabinet shall be powder coated and have a textured finish.

The cabinet Shall be provided with acoustic / thermally insulated panels as require with panel of minimum thickness of 1.2mm

The front door shall be of removable hinged construction with provision of required perforation for supply air.

Front door to be provided with horizontal laminar airflow design or with bi-directional throws as per site requirements.

5.3 REFRIGERATION CIRCUIT

The refrigeration system shall be of the direct expansion type and each unit must incorporate independent evaporator coil circuit. Thermal expansion valve is to be provided with flare connection, sight glass and filter drier, shut off valves, shall be provided.

All refrigeration controls including connection to units shall be only with flare or quick coupling connections to ensure no hot works like brazing activity is to be carried out inside the server area. Further incase major failure like internal coil leakage the unity must be suitable to be disconnected via quick couplings and removed outside the critical server area for maintenance / repairs and can be reinstalled without requirement of any shutdown to operating servers/racks.

5.4 EVAPORATOR COIL (DIRECT EXPANSION TYPE)

The evaporator coil shall be constructed of rifled bore copper tubes and louvered aluminium fins, with the frame and drip tray fabricated from heavy gauge steel. The evaporator coil must be minimum six rows deep to handle high temperatures across the coil ranging from air inlet of 30DegC to 37DegC and maintain a leaving temperature with delta of minimum 10DegC and maximum 15DegC. Further since the application is high sensible loads the evaporator must be designed accordingly.

The coil with hydrophilic or varnish coating will be preferred to prevent any water carry if used without sensible loads only as a primary cooling solution. Drip trays are an option bust recommended to be provided as standard option and must be double angled for condensate flow and easily removable for cleaning. The construction of the drip pan must be of stainless steel/aluminum or galvanized steel as per manufacturer's recommendation. The distance between the fins should not be less than 1.8 mm and the face velocity shall not be more than 2.5 m/sec.

5.5 FAN AND MOTOR: ELECTRONICALLY COMMUTATED DRIVES

Fans: Unit must be provided with direct drive backward curved fans each running with DC drive electronically communicated motors, the fans should be aligned and balance statically and dynamically. The fan speed must be controlled based on the room return air Temperatures and also must have automatic speed control without manual intervention.

Units shall be factory balanced in accordance with Section 15071, Mechanical Sound and Vibration Control.

Only direct drive fans with electronically commutated motors are acceptable. The operational logic of the units to take into account that incase of failure of one fan the balance two fans will increase speeds to makeup to best possible extent the loss of airflow due to non-availability of one fan. All the fans to be provided with individual and independent air flow alarm pressure switches which shall shoot alarm to the unit microprocessor in case of airflow failure.

The power to the fan motor must be 24V or 48V DC, however required SMPS/Converters for conversion of main power source from 400V/50Hz/3ph to 24V/48V DC is in scope of equipment supplier. The motors to also be compatible to be powered via UPS supply to ensure ventilation provision in case of loss of power supply to the unit

5.6 SERVICE AREA

The unit shall be serviceable from the front and back via an aisle space of maximum 1 mtr.

5.7 ELECTRICAL HEATING

Considering the units are for use in high density applications, there are not heaters to be equipped with the unit.

5.8 HUMIDIFICATION

In high density applications due to the dominant sensible loads there are not humidifiers to be equipped with the unit.

5.9 AIR FILTRATION

The units shall be provided with washable synthetic air filters with metal frames which can be removed from the unit and taken out of the server area for cleaning and can be installed back into the unit without requiring any shut down of the unit.

Filtration level shall be microbe filters of 90% - 10 microns. Filter clog pressure switch is to be provided to ensure maintenance and up keep of the equipment and also to ensure no reduction in unit capacity resulting from reduced airflow.

5.10 ELECTRICAL PANEL

Control cabinet to be as per OEM design, with grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control circuit transformer.

The construction of the unit electrical panel must be such to also provide space for microprocessor controller and without opening of any panels from the front of the unit the microprocessor panel must have direct access for operation. Return air T/H sensor shall be part of standard supply of the unit.

The electric panel provided for the unit must be equipped with main incoming power isolation switch, additionally the unit must be provided with under voltage / over voltage /

phase reversal / single phasing protection, all three phase motors must be operated only via 24V coil voltage contactors and MPCB's, additionally step down transformer must be provided for power supply to the unit controller. The electrical panel must also be providing with relay block for common alarm.

5.11 MICRO PROCESSOR CONTROLLER

Each floor Mounted Evaporator unit must be equipped with individual microprocessor controls with individual display and sensors to comply with below specifications.

5.12 CONTROL TYPE

The controls shall be a microprocessor programmable logic controller. The controls shall have separate indication of operating modes (cooling, heating, humidifying and dehumidifying), alarm conditions (temperature high, loss of sensor, compressor HP & LP, wet floor, no air flow and low humidifier water). The display and indication shall be visible on the front without removing any external panels. Local and remote alarms will be triggered if an alarm condition is reached.

5.13 ALARMS:

The alarm should operate with the audible signal.

Following alarms should be available:

1. Loss of Sensor
2. Compressor 1 High / Low Pressure
3. Wet floor
4. No Air flow
5. Filter clogs
6. Temperature high / low
7. Humidity high / low

The control should have an auto-restart feature which will return the unit to normal operation resumption of mains power.The unit controller must have option of dual set point for energy saving i.e. customer must have the option to set two independent set points for the unit based on operational requirements and energy saving concepts.

5.14 DISPLAY:

In normal operating mode the screen should display unit number, temperature and relative humidity set points and actual, operating status. The unit must have a large screen LCD display on controller with user friendly menus and minimum two level password protections.

RS485 interface port for BMS with Modbus RTU protocol is required.

6.0 PIPING

6.1 CHILLED WATER PIPING

The Consultant's drawing shows the general layout of the piping. Piping herein specified is meant for Chilled Water and Drain Water Services.

Material	Chilled water	Drain water services
Pipes	M.S. pipe 'C' class as per IS code mentioned in the list	PVC pipe as per the IS Code mentioned in the list
Joining	Weld fitting	Screwed fitting

Sealing 3mm 4 ply non-hardening rubber gasket between Material flanges and Teflon type for threaded joints.

Butterfly valves/balancing valves and ball valves shall be provided as shown in the applicable drawings confirming to following specifications –

Size	Construction	Ends
15mm to 40mm	Ball Valve with forged carbon Steel body & S.S. working parts	Screwed female
50mm & above	Moulded liner cast iron body	Nylon Disc, Seat black nitrile suitable upto 80° C. wafer type confirming to IS - 1536

Check valves shall be provided as shown in the drawings and shall confirm to the following specifications,

Size	Construction	Ends
15mm to 50mm	Gun Metal	Screwed female
65mm & above	Body- Cast iron Disc. & Seat - Gun Metal	Flanged

Swing check valves shall normally be used in all water services and shall confirm to IS - 5312 or BS - 5153. Lift type check valves may be used in horizontal run. Air release and clean out plunger shall be provided and valves shall be suitable for 21 Kg/Cm2 test pressure.

6.2 STRAINERS

Strainer shall be provided at the suction side of pump and chilled water cooling coil. Strainer shall be ISI Marked and preferable of approved type and shall have fabricated steel bodies of ample strength to withstand the test pressure specified for the gate valves.

Strainer shall have flanges for connecting the piping. Strainer shall be designed so as to enable blowing out accumulated dirt & facility of removal & replacement of the screen without disconnecting from main piping. Each strainer shall be provided with equal size isolating valves so that strainer may be cleaned without draining the system.

6.3 PIPING INSTALLATIONS

The drawing indicates schematically the size and location of pipes. The Contractor, on the award of the work, shall prepare detailed working drawing. He must keep in view the specific opening in building and other structures through which the pipes are designed to pass.

Piping shall be properly supported on or suspended from stands, clamps, hangers etc., as specified & required. The Contractor shall adequately design all the brackets, saddles, clamps, hangers etc. and shall be responsible for their structural integrity. The pipe hangers shall provide vibration free installation.

Pipe support shall not exceed the following spacing -
Maximum Spacing of pipe Supports

Nominal pipe size mm.	25	50	75	100	150	200	300
Maximum span meters	2	3	3.5	4	5	6	6

Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. Metal sheet shall be provided between the insulation and clamp, saddle or roller extended at-least 150mm on both sides of the clamp, saddle or roller. High-density polyurethane saddles be used between M.S. angles & pipes.

Vertical piping shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 10mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage.

Pipe sleeve of 50 mm larger than the pipe diameter shall be provided wherever pipe pass through walls and the annular space filled with felt and finished with plaster. Moreover, pipes shall be insulated with Rockwool and fire retardant sealant wherever it crosses fire barricaded walls.

All pipes using screwed fittings shall be accurately out to the required sizes and threaded in accordance with IS - 554 and burrs removed before laying. Open ends of the piping shall be blocked while working to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely. In other locations, concentric reducers may be used.

Drains shall be provided at all low points in the piping system and shall be of the following sizes with valves.

Mains	**Drains**
Up to 150mm	25 mm
Over 150 mm	65 mm

Air vents of 15 mm with vent valves of equal size be provided at all high points in the piping system for venting.

6.4 AIR VENTS

Air Vents for Purging of Air Trapped in Piping System Shall Be Provided at the Highest Point. Globe Valves of The Size as Indicated Below Shall Be Provided & No Additional Price Shall Be Paid.

6.5 SUCTION GUIDE

Suction Guide shall be installed at the inlet of each pump. Suction Guide shall have cast iron body, outlet guide vanes, removable SS. Strainer and fine mesh brass start-up strainer.

The Contractor shall inspect the strainer prior to start-up of the pump and shall remove the fine mesh brass strainer after short running period. Space shall be provided for removal of strainer and for connection of blow down valve.

6.6 PRESSURE GAUGES & THERMOMETER

1. Pressure gauges shall be not less than 100 mm dia. & appropriate range and be complete with shut off valves, stainless steel or CP Brass stem etc.

2. Pressure gauge shall be provided to measure the pressure at the following locations:
   i. On inlet and outlet of each chiller
   ii. Suction and discharge of pumps

3. Care shall be taken to protect pressure gauges during pressure testing.

6.7 EXPANSION JOINTS

Where necessary expansion joints or expansion loops shall be provided to take care of expansion and contraction of pipes due to variation in temperature.

6.8 CENTRIFUGAL TYPE AIR SEPARATOR

An adequately sized Centrifugal type Air separator to remove air from closed chilled water pipe circuit. The unit shall have inlet & outlet connections tangential to the vessel shell. Vessel shell diameter to be three times the nominal inlet/outlet pipe diameter.

The unit shall have an internal stainless-steel air collector tube with 5/32“diameter perforations and 63% open area designed to direct accumulated air to the compression tank via an NPT connection at top of unit. The unit shall have a removable galvanized steel system strainer with 3/16” diameter perforations and a free area of not less than five times the cross-sectional area of the connecting pipe. A blow down connection shall be provided to facilitate routine cleaning of the strainer.

Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

6.9 TESTING

All water piping shall be tested to hydrostatic test pressure of at-least two times the maximum operating pressure, but not less than 10 Kg/cm2 for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Consultant. Piping repaired subsequent to the above pressure shall be retested in the same method as mentioned above.

6.10 CLEANING OF PIPING

After piping system has been tested and proved tight and leak free, the Contractor shall clean piping system for dirt, scale, oil, grease, waste & other foreign substances which may have accumulated during process of installation. Strainer, screens shall be removed, cleaned and replaced after cleaning process & cleaned after flushing process.

6.11 PASSIVATION OF WATER PIPING

The M. S. pipe line should be passivated by following method-

- Rinse the M. S. pipe line with water 4 times to remove all dust & dirt.
- Circulate mild solution (@5%) of Sulphumic acid or oxalic acid for 24 HRS.
- Rinse the M. S. pipe line with water to remove the acid content.
- Circulate mild solution (@2%) of Caustic soda for 24 HRS and rinse the line with water.
- Circulate solution of SODIUM HEXA META PHOSPHATE in ratio of 10 Gm. per Liter for 12-14 hours.
- Drain the solution and check the pipe surface. If found okay, fill the line again and drain again before final charging of fresh soft water.

A required dozing of Anti Oxidant is required to add periodically.

The sample of water which will be used for the chilled water system shall be analyzed by the successful contractor free of cost. The analysis report shall be submitted to PMC / HVAC Consultant with the recommendation as to any changes in water input is required.

6.12 PAINTING

After all piping has been installed, tested and run for at-least 2 weeks it shall be coated with primer coat and synthetic enamel paints of approved shades as per the colour code. The direction of fluid flow in the pipes shall be visibly marked with arrow.

7.0 SUPPORTING ARRANGEMENT FOR PIPES / DUCTS

8.1 SUPPORT FROM RCC SLAB

a. DUCT SUPPORTS

Description

Duct should be simply supported by Support Channel made up of cold rolled steel of quality **DX51 or greater & as per EC3 (Eurocode 3) or DIN EN 1993-1-1**.

Support channel should be **pre galvanised with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents & should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the suspension of the Duct should be made up of **partially annealed** medium carbon steel of **grade 4.8 strength class & as per DIN 976 standard.**

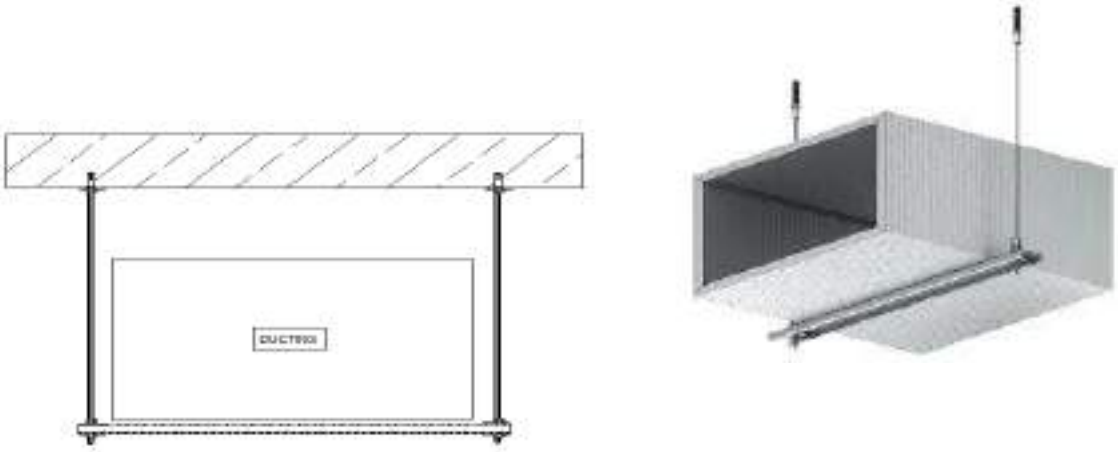
The Drop-in anchors used for the suspension of the rods should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

The load calculations should be as per Finite Element Method for the selection of the channels for suitable size of the duct and should be provided by the contractor to the consultant for verification.

Supporting DETAILS for low pressure systems are given below			
Larger Side of Duct mm	**Support Channel mm**	**Vertical Rod Día mm**	**Maximum Spacing between supports mm**
0-600	27x18x1.2	M8	2400
601-1250	38x24x2	M8	2400
1250-2100	38x40x2	M10	2400
2100 and above	40x60x2.5	M12	2400

Fig.A. Typical Arrangement for Duct Supports from RCC slab



b. CHW PIPE SUPPORTS

Description

The CHW Pipes should be simply supported by **Split Clamps with rubber support insert**.

Split Clamps should be as per **DIN 3567** pre-galvanised and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

Rubber support insert should be made from **EPDM or NR/SBR Rubber** The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB. The Clamp and rubber support insert should have the temperature capacity of -50 degree Celsius to +150 degree Celsius.

In the case of multiple pipes, the supporting arrangement should be made using support channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre galvanised with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

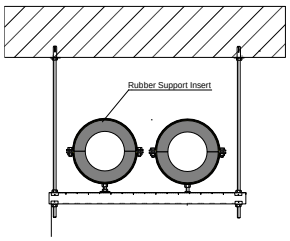
The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of grade **4.8 strength class and as per DIN 976 standard**.

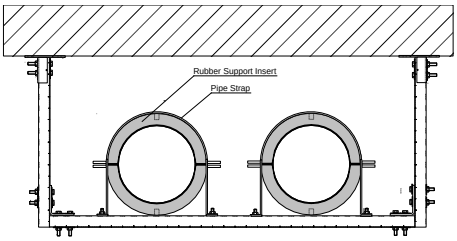
The Drop-in anchors used for the suspension of the rods should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole. The load bearing capacity for the selection of the split clamp for suitable size of the pipe should be provided by the contractor to the consultant for verification.

Maximum Support Spacing (m)					
Nominal Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	1.8	65	3.7	250	5.0
20	2.4	80	3.7	300	6.1
25	2.4	100	3.7	350	10.0
32	2.7	125	3.7	400	10.5
40	3.0	150	4.5	450	11.0
50	3.0	200	5.6	500	12.0

Typical Arrangement for Pipe Supports from slab





c. DRAIN PIPE SUPPORT

Description

The Drain Pipes should be simply supported by **Split Clamps**.

Split Clamps should be pre-galvanised and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp should have the temperature capacity of -50 degree Celsius to +150 degrees Celsius.

The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of grade 4.8 strength class and as per DIN 976 standard.

The Drop-in anchors used for the suspension of the rods should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

Maximum Support Spacing (m)					
Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	1.0	32	1.0	65	1.2
20	1.0	40	1.0	90	1.4
25	1.0	50	1,1	80	1.5

Typical Arrangement for Drain Pipe Supports from slab

8.2 SUPPORT FROM PEB STRUCTURE

a. DUCT SUPPORT

Description

The Duct should be simply supported by Support Channel made up of cold rolled steel of quality **DX51 or greater and as per EC3(Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be pre galvanised with minimum **GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes** on back of the rail.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the suspension of the Duct should be made up of partially annealed medium carbon steel of grade 4.8 strength class and as per DIN 976 standard.

For parallel to beam application.

The Girder cleat for attachment of support channel to steel girder
Girder cleat should be **Vds approved.**

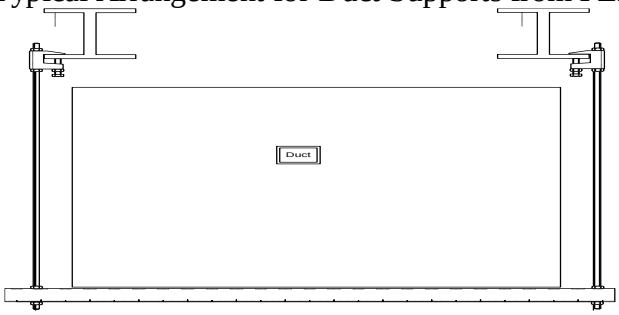
For perpendicular to beam application

The Girder clamp for suspension of threaded pins and threaded rods for support channels.
Girder clamps should be **FM and Vds Approved**.

The load calculations should be as per Finite Element Method for the selection of the channels for suitable size of the duct and should be provided by the contractor to the consultant for verification.

Supporting Details for low pressure systems are given below			
Larger Side of Duct mm	**Support Channel mm**	**Vertical Rod Dia mm**	**Maximum Spacing between supports mm**
0-600	27x18x1.2	M8	2400
601-1250	38x24x2	M8	2400
1250-2100	38x40x2	M10	2400
2100 and above	40x60x2.5	M12	2400

Typical Arrangement for Duct Supports from PEB structure



 Signature & Seal of Contractor

b. CHW PIPE SUPPORT

Description

CHW Pipes should be simply supported by **Split Clamps with rubber support insert**.

Split Clamps should be as per **DIN 3567** pre-galvanised and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

Rubber support insert should be made from **EPDM or NR/SBR Rubber**
The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp and rubber support insert should have the temperature capacity of -50 degree Celsius to +150 degree Celsius.

In the case of multiple pipes, the supporting arrangement should be made using support channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre galvanised with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of grade 4.8 strength class and as per DIN 976 standard.

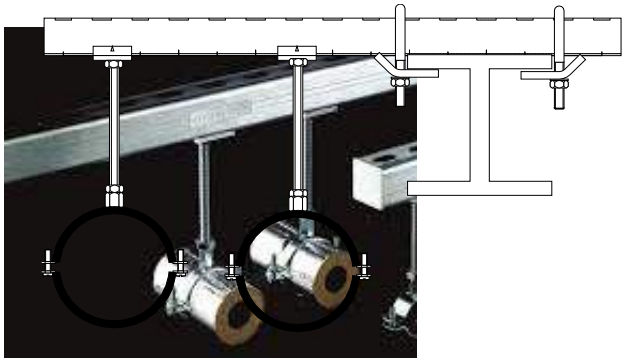
For parallel to beam application.
The Girder cleat for attachment of support channel to steel girder.
Girder cleat should be **Vds approved.**

For perpendicular to beam application
The Girder clamp for suspension of threaded pins and threaded rods for support channels.
Girder clamps should be **FM and Vds Approved.**

The load bearing capacity for the selection of the split clamp for suitable size of the pipe should be provided by the contractor to the consultant for verification.

Maximum Support Spacing (m)					
Nominal Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	2.5	65	3	250	3
20	2.5	80	3	300	3
25	2.5	100	3	350	3
32	2.5	125	3	400	3
40	2.5	150	3	450	3
50	2.5	200	3	500	3

Typical Arrangement for CHW Pipe Supports from PEB structure



c. DRAIN PIPE SUPPORT

Description

The Drain Pipes should be simply supported by **Split Clamps**.

Split Clamps should be pre-galvanised and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp should have the temperature capacity of -50 degree Celsius to +150 degrees Celsius.

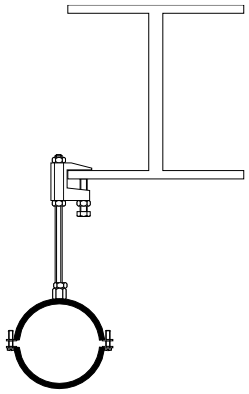
The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of grade 4.8 strength class and as per DIN 976 standard.

The Drop-in anchors used for the suspension of the rods should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

Maximum Support Spacing (m)					
Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	1.0	32	1.0	65	1.2
20	1.0	40	1.0	90	1.4
25	1.0	50	1,1	80	1.5

Typical Arrangement for Drain pipe support from PEB structure



8.3 SUPPORT FROM BUILDING SHAFT

a. DUCT SUPPORTS

Description

The Duct should be simply supported by Support Channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre galvanised with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

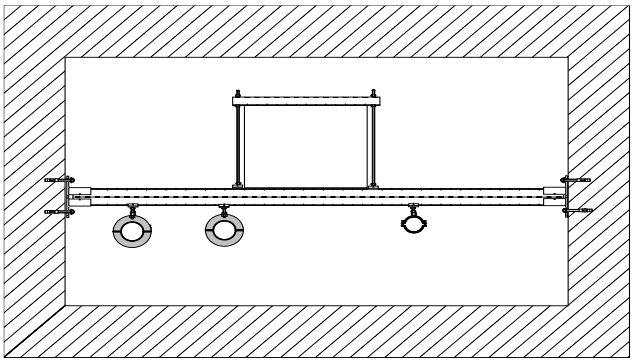
The Threaded Rods used for the suspension of the Duct should be made up of **partially annealed** medium carbon steel of **grade 4.8 strength class and as per DIN 976 standard.**

The Drop-in anchors or stud anchor used for the suspension of the rods should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete. It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

The load calculations should be as per Finite Element Method for the selection of the channels for suitable size of the duct and should be provided by the contractor to the consultant for verification.

Supporting Details for low pressure systems are given below			
Larger Side of Duct mm	**Support Channel mm**	**Vertical Rod Dia mm**	**Maximum Spacing between supports mm**
0-600	27x18x1.2	M8	2400
601-1250	38x24x2	M8	2400
1250-2100	38x40x2	M10	2400
2100 and above	40x60x2.5	M12	2400

Typical Arrangement for Duct,CHW pipe and drain pipe support from building shaft



b. CHW PIPE SUPPORT:

Description

CHW Pipes should be simply supported by **Split Clamps with rubber support insert**.

Split Clamps should be as per **DIN 3567** pre-galvanized and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

Rubber support insert should be made from **EPDM or NR/SBR Rubber** The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp and rubber support insert should have the temperature capacity of -50 degree Celsius to +150 degree Celsius.

In the case of multiple pipes, the supporting arrangement should be made using support channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre galvanized with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the fixing Pipe clamp with channel that should be made up of partially annealed medium carbon steel of grade 4.8 strength class and as per DIN 976 standard.

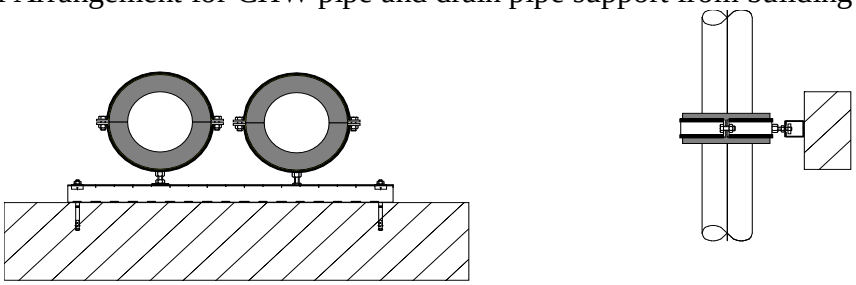
The Drop-in anchors or stud anchor used for the channel fixing with shaft that should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

The load bearing capacity for the selection of the split clamp for suitable size of the pipe should be provided by the contractor to the consultant for verification.

Maximum Support Spacing (m)					
Nominal Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	2.5	65	3	250	3
20	2.5	80	3	300	3
25	2.5	100	3	350	3
32	2.5	125	3	400	3
40	2.5	150	3	450	3
50	2.5	200	3	500	3

Typical Arrangement for CHW pipe and drain pipe support from building shaft



c. DRAIN PIPE SUPPORT

Description

The Drain Pipes should be simply supported by **Split Clamps**.

Split Clamps should be pre-galvanized and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp should have the temperature capacity of -50 degree Celsius to +150 degrees Celsius.

The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of **grade 4.8 strength class and as per DIN 976 standard.**

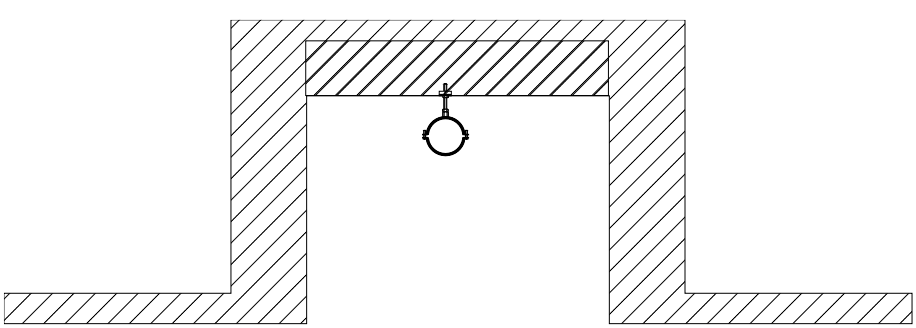
The Drop-in anchors or stud anchor used for the suspension of the rods should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

Maximum Support Spacing (m)					
Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**

Upto 15	1.0	32	1.0	65	1.2
20	1.0	40	1.0	90	1.4
25	1.0	50	1,1	80	1.5

Typical Arrangement for drain pipe support from building shaft



SUPPORT ON TERRACE

a. DUCT SUPPORTS

Description

The Duct should be simply supported by Support Channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre-galvanized with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the assembly of channel structure that should be made up of **partially annealed** medium carbon steel of **grade 4.8 strength class and as per DIN 976 standard.**

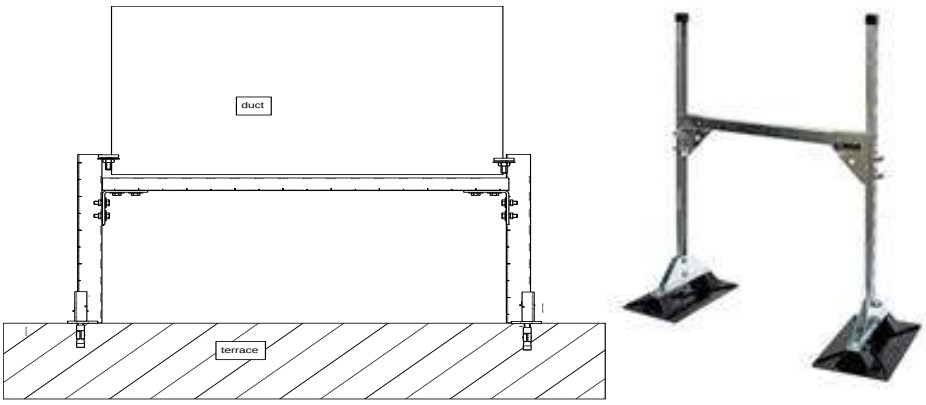
The Drop-in anchors used for the fixing channel with terrace that should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

The load calculations should be as per Finite Element Method for the selection of the channels for suitable size of the duct and should be provided by the contractor to the consultant for verification.

Supporting Details for low pressure systems are given below			
Larger Side of Duct mm	**Support Channel mm**	**Vertical Rod Dia mm**	**Maximum Spacing between supports mm**
0-600	27x18x1.2	M8	2400
601-1250	38x24x2	M8	2400
1250-2100	38x40x2	M10	2400
2100 and above	40x60x2.5	M12	2400

Typical Arrangement for drain pipe support on terrace



 Signature & Seal of Contractor

b. CHW PIPE SUPPORT:

Description

CHW Pipes should be simply supported by **Split Clamps with rubber support insert**.

Split Clamps should be as per **DIN 3567** pre-galvanized and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

Rubber support insert should be made from **EPDM or NR/SBR Rubber** The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp and rubber support insert should have the temperature capacity of -50 degree Celsius to +150 degree Celsius.

In the case of multiple pipes, the supporting arrangement should be made using support channel made up of cold rolled steel of quality **DX51 or greater and as per EC3(Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre-galvanized with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the connecting clamp and channel that should be made up of partially annealed medium carbon steel of **grade 4.8 strength class and as per DIN 976 standard**.

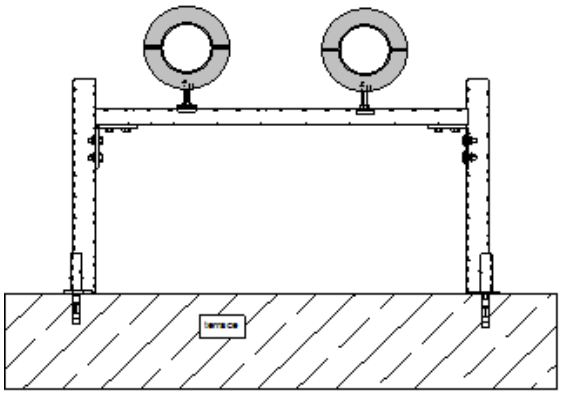
The Drop-in anchors used for the fixing channel with terrace that should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

The load bearing capacity for the selection of the split clamp for suitable size of the pipe should be provided by the contractor to the consultant for verification.

Maximum Support Spacing (m)					
Nominal Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	2.5	65	3	250	3
20	2.5	80	3	300	3
25	2.5	100	3	350	3
32	2.5	125	3	400	3
40	2.5	150	3	450	3
50	2.5	200	3	500	3

Typical Arrangement for CHW pipe support from on terrace



c. DRAIN PIPE SUPPORT

Description

The Drain Pipes should be simply supported by **Split Clamps**.

Split Clamps should be pre-galvanised and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp should have the temperature capacity of -50 degree Celsius to +150 degrees Celsius.

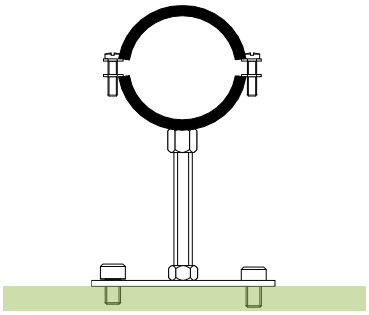
The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of **grade 4.8 strength class and as per DIN 976 standard**.

The Drop-in anchors used for the Fixing base plate, should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

Maximum Support Spacing (m)					
Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	1.0	32	1.0	65	1.2
20	1.0	40	1.0	90	1.4
25	1.0	50	1,1	80	1.5

Typical Arrangement for Drain pipe support from on terrace



8.4 SUPPORT FROM WALL

a. DUCT SUPPORTS

Description

The Duct should be simply supported by Support Channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre-galvanized with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

The Threaded Rods used for the suspension of the Duct should be made up of **partially annealed** medium carbon steel of **grade 4.8 strength class and as per DIN 976 standard.**

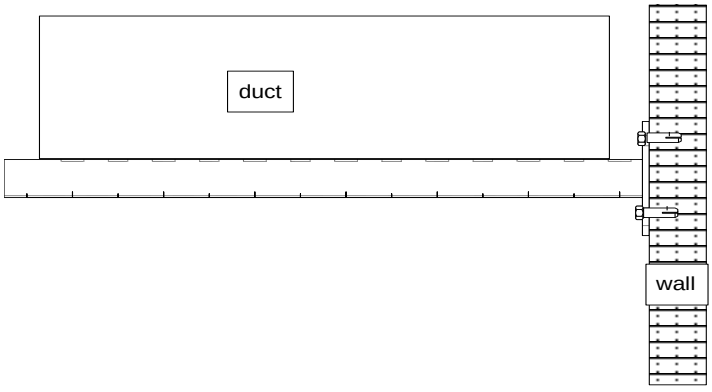
The Drop-in anchors or stud anchor used for fixing with wall that should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

The load calculations should be as per Finite Element Method for the selection of the channels for suitable size of the duct and should be provided by the contractor to the consultant for verification.

Supporting Details for low pressure systems are given below			
Larger Side of Duct mm	**Support Channel mm**	**Vertical Rod Dia mm**	**Maximum Spacing between supports mm**
0-600	27x18x1.2	M8	2400
601-1250	38x24x2	M8	2400
1250-2100	38x40x2	M10	2400
2100 and above	40x60x2.5	M12	2400

Typical Arrangement for Duct support from wall



b. CHW PIPE SUPPORT (from wall):

Description

The CHW Pipes should be simply supported by **Split Clamps with rubber support insert**.

Split Clamps should be as per **DIN 3567** pre-galvanized and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

Rubber support insert should be made from **EPDM or NR/SBR Rubber** The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp and rubber support insert should have the temperature capacity of -50 degree Celsius to +150 degree Celsius.

In the case of multiple pipes, the supporting arrangement should be made using support channel made up of cold rolled steel of quality **DX51 or greater and as per EC3 (Eurocode 3) or DIN EN 1993-1-1.**

The Support channel should be **pre-galvanized with minimum GSM of 275** and should have universal mounting slot on the front of the rail for accurate positioning of fasteners and system compatible **round and long holes on back of the rail**.

The Mounting according to static requirements should undertake into account the manufacturer's documents and should be monitored according to **RAL - GZ 655-C**.

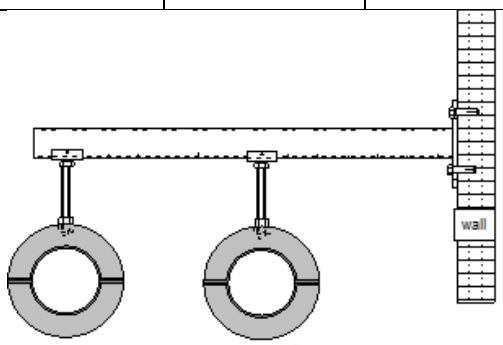
The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of **grade 4.8 strength class & as per DIN 976 standard**.

The Drop-in anchors or stud anchor used for Fixing with wall that should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided in four expansion segments of uniform pressing force in borehole.

The load bearing capacity for the selection of the split clamp for suitable size of the pipe should be provided by the contractor to the consultant for verification.

Maximum Support Spacing (m)					
Nominal Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	2.5	65	3	250	3
20	2.5	80	3	300	3
25	2.5	100	3	350	3
32	2.5	125	3	400	3
40	2.5	150	3	450	3
50	2.5	200	3	500	3



c. DRAIN PIPE SUPPORT

Description

The Drain Pipes should be simply supported by **Split Clamps**.

Split Clamps should be pre-galvanized and should have a two-piece arrangement with ribbing reinforced clamp body and two captive tightening bolts, secured with loss washers for non-slipping high load bearing capacity.

The Split clamp should have an **EPDM rubber lining** which will prevent the direct contact of Pipe with the steel. The rubber lining should have the capacity to reduce the structure borne noise vibration to up to 18 dB.

The Clamp should have temperature capacity of -50 degree Celsius to +150 degrees Celsius.

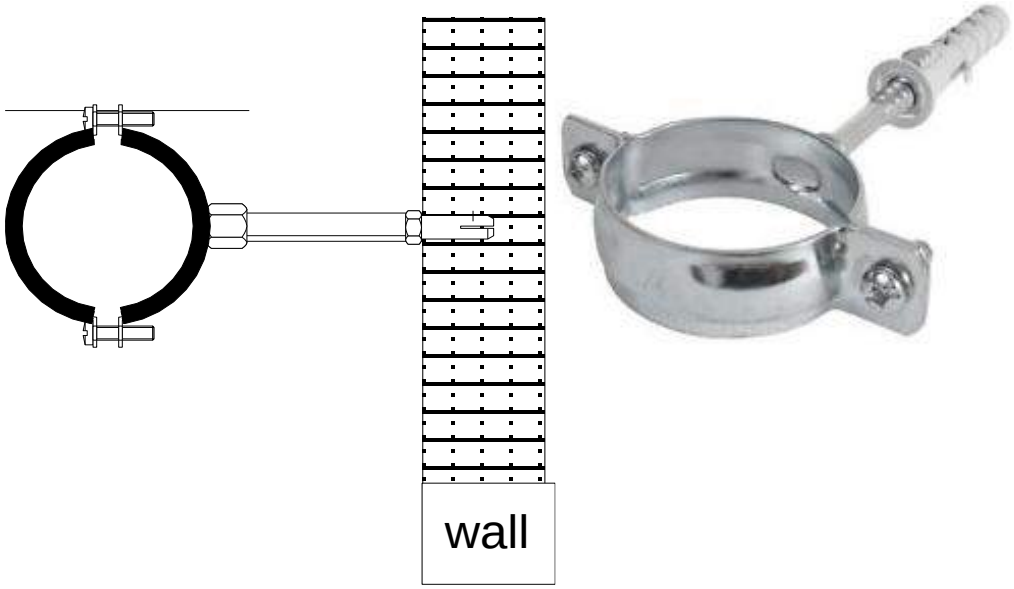
The Threaded Rods used for the suspension of the Pipe should be made up of partially annealed medium carbon steel of **grade 4.8 strength class & as per DIN 976 standard**.

The Drop-in anchors or stud anchor used for fixing with wall that should be **ETA (European Technical Approval) with CE mark** for cracked and un-cracked concrete.

It should be divided into four expansion segments for uniform pressing force distribution in the borehole.

Maximum Support Spacing (m)					
Pipe Dia (mm)	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**	**Nominal Pipe Dia (mm)**	**Support Distance (M)**
Upto 15	1.0	32	1.0	65	1.2
20	1.0	40	1.0	90	1.4
25	1.0	50	1,1	80	1.5

Typical Arrangement for Drain pipe support from Wall



8.0 BALANCING VALVE

9.1. SELF BALANCING DYNAMIC FLOW CONTROL VALVES [15-40 MM SIZE]

1. PRESSURE INDEPENDENT DYNAMIC CONTROL VALVE

i. Valve shall be electronic, dynamic, modulating, 2-way, control device.

ii. Dynamic control valve shall accurately control flow, independent of system pressure fluctuation.

iii. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size.

2. VALVE ACTUATOR

i. Valve actuator housing shall be rated to IP 44.

ii. Actuator shall be driven by a 24 VDC motor, and shall accept 2-10 VDC, 0-10 VDC, 4-20 mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.

iii. Actuator shall be capable of providing 4-20 mA or 2-10V DC feedback signal to the control system.

iv. External LED read-out of current valve position and maximum valve position setting shall be available.

3. VALVE HOUSING

i. Housing shall be constructed of forged ASTM (CuZn39Pb2) brass rated at no less than 2500 kPa static pressure and 120°C.

ii. Valve housing shall be double union construction with a range of pipe connections available for the appropriate pipe size.

iii. Identification tags shall be available for all valves; tags shall be indelibly marked with part number, production date and pressure differential range. Tags shall be of aluminium and in size 50mm x 25mm.

4. FLOW REGULATION UNIT

i. Flow regulation unit shall consist of stainless steel and hydrogenated acrylonitrile butadiene rubber and shall be capable of controlling flow within +/- 5% of each rated flow.

ii. Flow regulation unit shall be accessible, for maintenance.

iii. Optional dual pressure/temperature test plugs for verifying accuracy of flow performance shall be available for all valve sizes.

9.2. SELF BALANCING DYNAMIC FLOW CONTROL VALVES [50-150 MM SIZE]

A. PRESSURE INDEPENDENT DYNAMIC CONTROL VALVE

i. Valve shall be electronic, dynamic, modulating, 2-way, control device.

ii. Dynamic control valve shall accurately control flow, independent of system pressure fluctuation.

iii. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size.

B. VALVE ACTUATOR

i. Valve actuator housing shall be rated to IP 44.

ii. Actuator shall be driven by a 24 VDC motor, and shall accept 2-10 VDC, 0-10 VDC, 4-20 mA, 3-point floating or pulse width modulation electric signal and shall include resistor to

facilitate any of these signals.

iii. Actuator shall be capable of providing 4-20 mA or 2-10 VDC feedback signal to the control system.

iv. Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be available.

v. External LED read-out of current valve position and maximum valve position setting shall be standard.

C. VALVE HOUSING

i. Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 4000 kPa static pressure and 120°C.

ii. Identification tags shall be available for all valves; tags shall be indelibly marked with part number, production date and pressure differential range. Tags shall be of aluminium and in size 50mm x 25mm.

D. FLOW REGULATION UNIT

i. Flow regulation unit shall consist of 316 Stainless steel and hydrogenated acrylonitrile butadiene rubber and shall be capable of controlling flow within +/-5% of each rated flow.

ii. Flow regulation unit shall be accessible, for maintenance.

iii. Optional dual pressure/temperature test plugs for verifying accuracy of flow.

9.3. SEMI AUTOMATIC DIGITAL BALANCING VALVE

A. TYPICAL SPECIFICATION FOR BALANCING VALVES

1. Balancing valves shall be supplied and installed as shown on the drawings to ensure proper balancing of water flows in the hydronic heating and cooling system.
2. Flow measurement and balancing shall be possible with an accuracy of 4 to 7% in the normal measuring range of the valve. (When valve opening position is more than 50%)
3. Pressure measuring nipples shall be provided for measuring differential pressure and be integral with the body and incorporate means for positive leak tight shut-off when not in use.
4. Adjustment and presetting of flows shall be made with a digital hand wheel.
5. The setting shall be lockable with a mechanical stop to allow the valve to be closed but not opened further than to the pre-set value.
6. For valves in size 10 to 50mm the balancing valves shall offer a facility for draining of water with a separate hose connection and a stop valve. The optional draining facility shall be capable of being mounted on or removed from the balancing valve without interruption to the system operation.
7. Material and Pressure Ratings
   a) Balancing valves with thread connections in sizes from 10 to 50mm shall be made in a dezincification resistant copper alloy with Brinell hardness of at least 130 and a body pressure rating of at least 20 bar (300psi) at 150 degrees C-(AMETAL).
   b) Balancing valves with flange connections from 20 to 300mm shall be made in cast iron equivalent to BS 1452 for a body pressure rating of at least 16 bar –25 bar 150 degrees C. Valves sized 65mm-300mm shall to be fitted with a pressure balanced cone to reduce closing torque to allow the valve to be closed and opened easily.

8. Balancing valves shall be sized to operate in a normal measuring range of 50% to 100% of full opening to ensure maximum accuracy.
9. All the balancing valves shall be manufactured in accordance ISO9001.
10. Certificate of Origin and Certificate of Quality from factory shall be submitted for inspection when the balancing valves are delivered to site before installation.
11. Installation of balancing valves without the specified Certificates shall not be permitted.
12. A computerized balancing instrument (CBI) with ISO9000 calibration certificate shall be handed over after testing & commissioning.

B. CHECKLIST FOR BALANCING VALVES

1. To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a microprocessor instrument which shall enable the operator to read the flow directly without the use of diagrams or tables.
2. The balancing of the system shall be verified in a written report, documenting valve position and water flow which shall be handed over to the consultant for approval and acceptance.
3. The CBI shall have two main components:

   An instrument which contains a micro computer, input touch pad and LCD display, and re-chargeable batteries and built-in charger. A sensor unit which contain a piezo-resisting pressure sensor, one measurement valve and connection hoses. The measurement valve shall have a safety function which protects the sensor from high differential pressures.

4. In addition to measuring flowrate, differential pressure and temperature, the CBI shall have a computer programme to provide the following functions:-
   a. to balance the installation of HVAC system and calculate the necessary valve settings, based on system measurements
   b. to store the results of balancing
   c. to log measured values from a valve (differential pressure, flowrate or temperature)
   d. to printout saved data in computerized measurement protocol (CMP) consisting of:
      i) Name and size of Balancing Valve (BV)
      ii) Presetting position of BV
      iii) ΔP at BV
      iv) flow at BV
      v) design flow

9.0 FANS

SCOPE

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

TYPE

Centrifugal, in-line propeller fans and roof mounted units shall be of the type as indicated on Drawings and identified in Schedule of Quantities.

CAPACITY

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

FRESH / EXHAUST FAN-

Fresh / Exhaust fan will be heavy-duty industrial type, suitable for three / single- phase power supply and continuous operation with epoxy painting and direct driven motor. The fresh / exhaust air fans shall have casing as that of air handling unit.

All exhaust fans and roof extractor shall be installed as shown in drawing and shall be provided with cowl bend, in take louvers, bird screen etc.

The exhaust fan, cowl bend, in take louvers, bird screen etc. shall be measured as one unit under exhaust fan / roof extractor.

13.1. CENTRIFUGAL FAN

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

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

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

b. Fan Wheel shall be backward-curved non-over loading type. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mm dia, fan outlet velocity shall not exceed 550 meter/minute and maximum fan speed shall not exceed 1450 rpm. For fans above 450 mm dia, the outlet velocity be within 700 meter/minute and maximum fan speed shall not exceed 1000 RPM. High static pressure fan speed shall be as per manufacturer.

c. Shaft shall be constructed of steel, turned, ground and polished.

d. **Bearings:** shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type.

e. **Motor:** Fan motor shall be energy efficient and suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, and of approved make. Motor name plate horsepower shall exceed brake horsepower by a minimum of 10%. Motor shall be designed especially for quiet operation and motor speed shall not exceed 1440 rpm.

The fan and motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest.

f. Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.

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

13.2. AXIAL FLOW FAN

Fan shall be complete with motor, motor mount, belt driven (or direct driven) and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

a. **Casing:** Casing shall be constructed of heavy gage sheet steel. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be minimum 15 mm thick and machined to receive motor flange.

An inspection door with handle and neoprene gasket shall be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be bonderized, primed and finish coated with enamel paint.

b. **Rotor:** Rotor hub and blades shall be cast aluminium or cast steel construction. Blades shall be die-formed aerofoil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. The fan pitch control may be manually readjusted at site upon installation, for obtaining actual air flow values, as specified and quoted.

c. **Motor:** Motor shall be energy efficient squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, provided with class `F' insulation. Motor shall be specially designed for quiet operation. The speed of the fans shall not exceed 1000 RPM for fans with impeller diameter above 450 mm, and 1440 RPM for fans with impeller diameter 450 mm and less. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit.

d. **Drive:** to fan shall be provided through belt drive with adjustable motor sheave and standard sheet steel belt guard with vented front for heat dissipation. Belts shall be of oil-resistant type.

e. **Vibration Isolation:** The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber-in.

13.3. PROPELLER FAN

Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

a. **Mounting Plate** shall be of steel construction, square with streamlined venture inlet (reversed for supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

b. **Fan Blades** shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.

c. **Shaft** shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.

d. **Motor** shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for 415±6% volts, 50 cycles 3 phase power supply, and for smaller fans shall be suitable for 220 ± 6% volts, 50 cycles single phase power supply. Motors shall be suitable for either horizontal or vertical service as indicated on Drawings and in Schedule of Quantities.

e. **Accessories:** The following accessories shall be provided with propeller fans:

i. Wire guard on inlet side and bird-screen at the outlet.
ii. Fixed or gravity louvers built into a steel frame at the outlet.
iii. Regulator for controlling fan speed for single phase fan motor.
iv. Single phase preventors for 3 phase fans.

10.0 SHEET METAL WORK-

11.1 SMACNA STANDARDS

Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards ("HVAC Duct Construction Standards – Metal and Flexible – Second Edition – 1995"-SMACNA). All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I. raw material furnished with accompanying Mill Test Certificates. Galvanizing shall be of 120gms/sq.m. (Total coating on both sides). In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

11.2 SELECTION OF G.I. GAUGE AND TRANSVERSE CONNECTORS

Duct Construction shall be in compliance with 1" (250 Pa) w.g. static norms as per SMACNA. All transverse connectors shall be the 4-bolt slip-on flange system standard makes of similar 4-bolt systems with built-in sealant.

The specific class of transverse connector and duct gauge for a given duct dimensions will be as per Table given below for the 1" (250 Pa) pressure class.

Non-toxic, AC-applications grade P.E. or PVC Gasketing is required between all mating flanged joints. Gasket sizes should conform to flange manufacturer's specification.

SMACNA STANDARDS						
FOR SELECTION OF FLANGE CLASS AND DUCT GAUGES **AT 1200 MM SPACING**						
Duct Dimension	**Duct Pressure in Inches / (Pascal)**					
	1"(250)*[5]	**2"(500)**	**3"(750)**	**4"(1000)**	**6"(1500)*[4]**	**10"(2500)**
(in mm)	**Reinforcement Class - Duct Gauge**					
upto 250	*[3]E-26	E-26	E-26	E-26	E-26	E-24
251-300	E-26	E-26	E-26	E-26	E-24	E-24
301-350	E-26	E-26	E-26	E-26	E-24	E-22
351-400	E-26	E-26	E-26	E-26	E-24	E-22
401-450	E-26	E-26	E-26	E-26	E-24	H-20
451-500	E-26	E-26	E-24	E-24	E-24	H-20
501-550	E-26	E-26	E-24	E-24	H-24	H-20
551-600	E-26	E-26	E-24	E-24	H-22	H-20
601-650	E-26	E-26	E-24	E-24	H-22	H-20
651-700*[2]	E-26	E-26	E-24	H-24	H-22	H-18
701-750	E-26	E-26	E-24	H-24	H-22	J-18
751-900	E-26	E-24	H-22	H-22	H-20	J-18
901-1000	E-26	H-24	H-22	H-20	J-18	J-16
10 01-1200	E-24	H-22	H-20	J-18	J-18	
12 01-1300	*[3]H-24	H-20	J-18	J-18	J-16	
13 01-1500	H-24	H-18	J-18	J-16		
15 01-1800	H-22	J-18	J-16			
18 01-2100	*[3]J-20	*[3]J-20			NOT DESIGNED	
2101-2400	J-18	J-18				
2401-2700	J-18					

Notes:

***1- SMACNA** – Sheet Metal & Air conditioning Contractors' National Association Inc – "HVAC Duct Construction Standards- Metal and Flexible"-1995, U.S.A.

***2- Reading Guide-** For duct sizes between, say, 651 mm and 700 mm, when the pressure class is 1" w.g. static, we require a standard 'E' class flange and duct gauge of 26. For the same size range but with static pressure at 4" w.g. a standard 'H' class flange with duct gauge of 24 should be used.

***3-** The standard flange classes available are designated E, H and J. For E & H class of standard make use gasket size 10 mm wide and 4.5 mm thick. For standard J-class use 15 mm wide and 6 mm thick gasket.

11.3 DUCT CONSTRUCTION

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

Dimensional Tolerances: All fabricated dimensions will be within +/- 1.0mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerances shall be +/- 1.0 mm per meter.

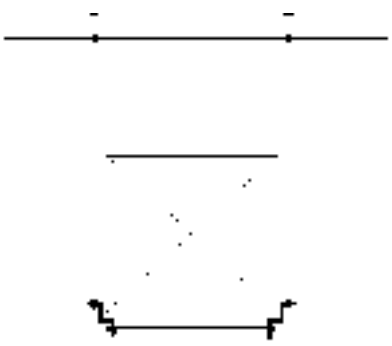
Each and every duct pieces should be identified by color coded sticker which shows specific part numbers, job name, drawing number, duct sizes and gauge . Ducts shall be straight and smooth on the inside. Longitudinal seams shall be airtight and at corners only, which shall be either Pittsburgh or Snap 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). Turning 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.

Plenums shall be shop/ Reinforcement of ducts shall be achieved by either cross breaking or straight beading depending on length of ducts

As per SMACNA page no. 1.74, fig. 1-8 "Duct Sizes 19" (483 mm) wide and larger which have more than 10 ft² of unbraced panel shall be beaded or cross broken unless ducts will have insulation covering or acoustical liner. This requirement is applicable to 20 G (1.00 mm) or less and 3" W.G. (750 Pa) pressure or less. Ducts for 4" W.G. (1000 Pa) or more do not require beads or cross-breaks." factory fabricated panel type and assembled at site.

11.4 SUPPORT FOR HORIZONTAL RECTANGULAR DUCT



Sr. No.	Maximum Duct Size (mm)	Hanger Rod Diameter	Interval (mm)
1	Upto - 700	6 mm	2400
2	701 - 1200	8 mm	2400
3	1201 - 2000	10 mm	2400
4	Above 2000	12 mm	2400

As an alternative, slotted galvanized brackets attached to the top two bolts of the Rolamate system may also be used as appropriate for the site condition. To provide the required thermal brake effect, Neoprene or equivalent material of suitable thickness shall be used between duct supports and duct profiles in all supply air ducts not enclosed by return air plenums.

11.5 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.

TESTING

After duct installation, a part of duct section (approximately 5 % of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA - "HVAC Air Duct Leakage Test Manual" (First Edition)

11.6 LOW LEAK DAMPER-

Damper shall be opposed blade type, blades shall be made of double skinned aerofoil Aluminium (G.I. for ventilation) sections with integral gasket and assembled within a rigid extruded Aluminium alloy frame.

All linkages and supporting spindles shall be made of Aluminium or nylon, turning in Teflon bushes and linkages shall be extended for motorized operation wherever specified. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Damper frames shall be sectionalized to minimize blade warping.

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

11.7 PERFORATED FACE DIFFUSER

Diffusers should be constructed from Aluminium frames and perforated face plates. The diffuser cores are removable type and damper operation from front. They should be suitable to fit in grids of tile type false ceiling.

INSTALLATION

A good quality neoprene rubber of uniform thickness and width shall be used as gasket between flange joints. The felt shall be fixed by a suitable adhesive and holes made by passing a heated rod through. The slope of the duct shall be such that the rainwater cannot enter the premise i.e. the slope of duct shall be towards the outside wall to prevent rainwater entry. Special care shall have to be taken by the contractor in the time of erection.

i. All ducts shall be rigid and shall be adequately supported and 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 airtight by soldering & 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, and tight joints shall be made by means of closely fitting heavy flanged collars.

   Ducting over false ceiling shall be supported from the slab above or from beams. In no case a duct is to be supported from the false ceiling hangers or to be permitted to rest on a hung ceiling.

ii. All holes concrete, masonry etc. made by contractor for fixing supports etc. shall be made good and restored to original finish by him.

iii. 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 100 mm long, securely bolted to duct and units. Each sleeve shall be made smooth and the connecting ductwork rigidly held in line with unit inlet or outlet.

11.8 GRILLES AND DIFFUSERS

All grilles (SA & RA), diffusers (SA & RA) will be made from heavy gauge extruded Aluminium sections duly powder coated to match the interior requirements of Architect/Client. All the supply air grilles/ diffusers will be provided with opposed blade dampers fabricated from galvanized steel sheet painted in two coats of matt black stowing enamel paint. The damper should be suitable for operation from front face of grille/diffuser.

TESTING

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 balancing of air quantity through each grille or diffuser shall be recorded and submitted to the Consultant / Employer for approval.

PAINTING

Angle iron flanges, stiffeners, hangers and supports shall be painted with two coats primer and those remaining uncovered further two coats of synthetic

11.9 DAMPERS-

All dampers shall be of 18 S.W.G. G.I sheets louver dampers of robust construction and tight fitting. The design, method of handling and control, shall be suitable for the location and service required. Dampers shall be provided with suitable links, levers and quadrants as required for their proper operation, control or setting in any desired position. Dampers and their operating devices shall be made robust, easily operable and accessible through suitable access door. Every damper shall have indication device clearly showing the damper position at all times. All the bushing will be of brass only.

A fire damper shall be provided between each air handling unit room and the rest area and at crossing of fire rated walls. The fire dampers shall be confirming to UL-655 and other applicable fire codes. The dampers shall be operated through either fusible link or solenoid valve.

11.10 FIRE & SMOKE DAMPERS

a. All supply and return air ducts at AHU room crossings and at all floor crossings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating as per UL555/1995 tested by CBRI. These shall be of multi-leaf type and provided with Spring

Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span.

b. Fire damper blades and outer frames shall be of 16G galvanized steel construction fitted with 18 gage extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheet steel. For preventing smoke leakage metallic compression seals will be provided.

c. The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct/ return air duct or temperature sensor. The fire damper shall also close upon sensing temperature rise in supply air ducts thru the electronic temperature sensor.

d. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:

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

e. Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with its control panel. Control panel shall be wall mounted type.

f. It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.

g. HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.

h. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.

i. HVAC Contractor shall strictly follow the instructions of the Damper Supplier oravail his services at site before carrying out testing at site.

j. Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts within AHU room in accordance with the manufacturer's recommendations.

k. The Contractor shall also furnish to the Owner, the necessary additional spare actuators and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

11.11 SUPPLY & RETURN AIR REGISTERS

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

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

a. All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.

b. All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.

c. Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivot-able to provide pattern with 0 to +45 degree horizontal arc and upto 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.

d. Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.

e. All volume control dampers shall be anodized aluminum in mat black shade.

11.12 GRILLES AND DIFFUSERS-

All grilles (SA & RA), diffusers (SA & RA) will be made from heavy gauge extruded Aluminum sections / M.S. (As specified in the BOQ) duly powder coated to match the interior requirements of Architect / Client. All the supply air grilles/diffusers will be provided with opposed blade dampers fabricated from Al. The damper should be suitable for operation from front face of grille/diffuser.

INSTALLATION-

A good quality felt/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.

1. 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.

2. All holes in concrete, masonry etc. made by contractor for fixing supports etc. shall be made good and restored to original finish by him.
3. 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 AND BALANCING

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection.

The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

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 enamel paints of approved color.

11.13 FLEXIBLE DUCTING

The scope of this section comprise supply, installation, testing and commissioning of flexible ducting conforming to this specification & in accordance with the requirements of drawings and schedule of quantities.

Wherever specified un-insulated flexible duct shall be made of double lamination of Metalized Polyester film permanently bonded to a coated spring steel wire helix. Duct shall be tear & puncture resistant construction.

Wherever insulated flexible duct are specified inner core for the same should be made of double lamination of Metalized Polyester film permanently bonded to a coated spring steel wire helix. Fiber glass insulation of minimum 14 kg/cu meter density having R-value 4.2° F - Ft^2 - hr/Btu & 32 mm thickness shall be wrapped over the inner core & covered with strong outer jacket cum vapor barrier made of fiberglass reinforced Metalized polyester film laminate.

Care must be taken to install the entire flexible duct in fully extended position & bends made with adequate radius as per manufacturer recommended practices.

Duct should confirm to Australian Fire Standard AS 4254.

11.0 PRE-INSULATED DUCTS

Pre-Insulated Ducting shall be fabricated from 20 mm thickness air duct panel sheet having dimensions of 3000 (Length) mm by 1200 (Width) mm and produced and Sandwiched with Polyisocyanurate (PIR) first quality insulating Foam having 35 Kg / m^3 density. The Ducting Sheet shall have Lacquered & Embossed Aluminium facing on both sides.

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

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

- BS 476:PART6--FirePropagationforProducts
- BS 476:PART7---Surface Flame Spread (Class1)
- ClassOFireRatingasperBuildingRegulationrequirements.
- Thermal ConductivityCoefficientat 10^0C--0.022 W/m.K
- SmokeOpacityIndex—lessthan10
- Rigidityclass:200000Nmm^2/mm
- Watervaporpermeabilityoflaminations=0

All required accessories; Connecting Flanges, Invisible Bayonet, Adhesive, Sealant, Duct Supports (as per clause 5.2) shall be part of ducting work for fabrication of the HVAC ducting in Square, rectangle, radius, offsetconstruction etc.,appropriate sizes of Aluminium flanges with self-adhesive good quality gasket shall be provided as a joinery or connection of duct pieces.

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes (as per clause 5.2) and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 3.0 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using self-grip double channel lock shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners.

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

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

12.1. PANEL SPECIFICATION: -

Description	InternalAreas	ExternalAreasofBuilding
Dimensionsofpanel	3000x1200mm	3000x1200mm
Thicknessofpanel	20 mm	20/30 mm
Thicknessofaluminiumlaminations	60/60microns	60/200microns
Densityofthefoam	35kg/m^3	35kg/m3
Surfacefinish	Embossed/Embossed	Embossed/Embossed
Anti-rust lacquer	2gm/m^2bothsides	2gm/m^2 $both_{sides}$

12.2. PRE-INSULATED DUCTING - ECO+

Smart PIR(Eco+) Ducting system (Using SandwichedPanels ofPolyisocyanurateFoambetween Aluminium Foils)

The duct shall be fabricated out of sandwiched panels made up of CFC / HCFC Free **P**oly **I**socyanurate **R**igid **F**oam between Aluminium Foils as per the parameters given below: -

A. DUCT MATERIALS SPECIFICATIONS

The duct shall be fabricated out of sandwiched panels made up of embossed aluminium foils (anti microbial, anti fungal, anti dust and uv protection coating) on both sides with pin holes perforation internally to increase acoustic property and in between sandwiched with PIR foam. Insulating foam material shall be Expanded Rigid Polyisocyanurate Foam having closed cell content not less than 95%, CFC/ HCFC free, Non-Toxic, Non-Combustible, Zero Ozone Depletion, Zero Global Warming Potential and Non Ignitable as per the parameters given below:

Physical Characteristics of the panels shall be as follows:

Comfort Cooling Application		
Thickness of Panels	**Air-conditioned Areas**	
	20	Mm
Thickness of Aluminium	80 /80	Microns
Density of the Foam- Minimum	51	kg/m³
Finishing of Aluminium	Embossed	Embossed

B. INTERNAL AREAS (AIR-CONDITIONED SPACE NOT EXPOSED TO SUNLIGHT):

20MM THICK PANEL

Irrespective of Duct size Stiffening should be provided for the duct size above 1000mm. Both sides of the Aluminium foils should act as vapour barrier.

The said panel material should be test certified for **Fire Properties** by competent authority:

1) It should be certified for 'for Class 'O' according to BS 476 Part 6& 7 by Authorized International Fire Testing Laboratories i.e. 'Warrington Fire Laboratories, UK & US.

 Signature & Seal of Contractor

2) It should be certified for similar Fire properties by Authorized Indian fire test laboratories i.e. C.B.R.I, Roorkee.
3) For Flame Spread Index it should be certified for Class "A" certification as per 'ASTM E84' by relevant international authorities.
4) For Smoke Developed Index, it should be certified for Class "A" certification as per 'ASTM E84' and similar safety codes by relevant international authorities.
5) Toxicity Index shall not exceed 5.7 according to 'NES 713' by international fire testing laboratories i.e. 'WARRINGTON FIRE LABORATORIES, UK.
6) The Panel should have 2 hours fire rating.
7) The Duct should comply have EN 13403 certification.
The Panel Manufacturer should additionally comply with following **Quality and Operational Standards** for not only panels but accessories also:

1) ISO 9001:2008 for Quality Management System
2) ISO 14001:2004 for Environmental Management System

PRESSURE RANGE:

No relevant modification of insulation, chemical or physical characteristics of the panels to be measurable, when conveying air up to the pressure of 2000 Pascal for 20 mm thick panels.

THERMAL INSULATION CHARACTERISTICS:

Thermal insulation characteristics shall be as follows:

- Physiologically and chemically inert and insoluble.
- Vermin proof.
- Fungus proof.
- Non-Metabolisable.
- Thermal Conductivity: 0.019 W/mK at Delta 30°C.
- Water Absorption shall be less than 0.5% by 24 hours immersion test.

TEMPERATURE RANGE:

No relevant reduction of insulation, chemical or physical characteristics of the panels to be measurable, when conveying air in the temperature range of –45°C to +150°C.

EXTENDED WARRANTY ON INSULATION CHARACTERISTICS:

Original Panel Manufacturer should offer 10-years Warranty for the Insulation material Characteristics.

DUCT ACCESSORIES:

All the duct accessories like duct jointing profiles, profile inserts, adhesives, sealants, aluminium tape, GI corner and Polymer covers of profiles are to be used from the original Duct Panel Manufacturers only to achieve accuracy and best efficiency in construction of duct.

DUCT FABRICATION AND INSTALLATION STANDARDS:

The ducts shall be fabricated as per the drawing provided by manufacturer team and should be supplied at site in Boxed form and should be complete with all suitable joint fittings & profiles, inserts, using proper adhesive and sealing arrangements etc.

Changes in section of duct work shall be affected by tapering the ducts with as long a taper

as possible. All 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.

For bigger Duct sizes Internal Stiffener arrangement with tiger clamp to be provided for rigidity.

GOVERNING STANDARDS:

Unless otherwise specified here, all duct work shall be provided with adequate pre fabricated hangers or support and to prevent vibrations.

All ducts shall be supported from the ceiling / slab/ Purlins by means of wire and lock type system (manufacture recommended), with suitable capacity.

INSTALLATION SUPERVISION:

Installation shall be Supervised &Certified by the Manufacturer's representative.

JOINT SYSTEM:

The joints between the ducts shall be using polymer invisible flanges and slide-in-channel to be used and to be connected by special cover corners, having a holding pin, which goes inside the flange and the insulation, to avoid any field connection and to give the system more strength.

Ductwork shall be installed, using supports, as described in DW144 & according to manufacturer's requirements. Maximum distance between supports shall not exceed:

- 4000mm for ducts with section not exceeding 1200 x 1000mm.
- 2000mm for ducts with section exceeding 1200 x 1000mm.

All duct work shall be of high quality approved PIR Sheets guaranteed not to crack or peel on bending or fabrication of ducts. Care should be taken at site so that the Aluminum foil covering the panel is maintained intact during Installation to ensure Vapour Barrier continuity.

All joints shall be air tight and shall be made in the direction of air flow. All duct joints shall be inserted with exact size cut inserts to suit the profiles and corners should be covered with PVC caps.

Fixing of Pre Insulated Ducts with various ducting items like Volume Control Dampers or Fire dampers etc. shall be done using Polymer Flanges of the desired type.

REINFORCEMENTS:

Appropriate number of internal stiffening of Threaded Bar, Nut and Bolt and load-distribution GI Discs for very large ducts are provided.

For positive pressure (supply ducts) and for negative pressure (return ducts) load distributing GI Discs are placed externally and internally for better strength.

Reinforcements will be fixed perpendicular to the larger duct dimension. These will be installed on ducts exceeding 1000 mm W/H any dimension, as per following spacing.

- 1200 – 1500 – 1 No x 1/2 - 1/2
- 1500 – 1800 – 2 Nos x 1/4 – 1/2 -1/4
- 1800 – 2100 – 3 Nos x 1/6 – 1/3 – 1/3 – 1/6
- 2100 – 2400 – 4 Nos x 1/8 – 1/4 – 1/4 – 1/4 – 1/8

However, as per site requirement and constraints, certain duct pieces can be fabricated and made at site using the same above standards to suit pieces.

Great care should be taken to ensure that the ducting work does not extend outside and beyond height limits as noted on the drawings.

The ducting work shall be varied in shape and position to fit actual conditions at building site. All changes shall be subjected to the approval of the Engineer – In – Charge. The contractor shall verify all measurements at site and shall notify the Engineer – In – Charge.

12.0 INSULATION

FOR G.I. DUCTING - SPECIFICATION FOR THERMAL & ACOUSTIC INSULATION

SCOPE

The scope of this section comprises the supply and application of insulation conforming to these specifications.

13.1 DUCT THERMAL INSULATION

MATERIAL

1. Insulation material shall be Closed Cell Elastomeric **NITRILE RUBBER**
2. Density of Material shall be between 40 to 60 Kg/m3
3. Thermal conductivity of elastomeric NITRILE RUBBER shall not exceed 0.**034** W/m. K at mean temperature of 0°C
4. Insulation material shall have anti-microbial product, which is EPA (Environmental Protection Agency), USA approved, as an integral part of insulation that cannot be washed off or worn off. **(NITRILE RUBBER is anti-Microbial polymer)**
5. It shall give enhanced level of protection against harmful Microbes such as bacteria, mold, mildew and fungi and should confirm to following standards: Fungi Resistance – ASTM G21 and Bacterial resistance – ASTM G 22 / ASTM 2180.
6. Insulation shall have fire performance such that it passes **ASTM–E–84 test** Method
7. Material should be FM (Factory Mutual), USA approved.
8. Water vapor permeability shall not exceed 1.74 x 10-14 Kg / (m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 10000.

Thickness of the insulation shall be as specified for the individual application.

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION Design Basis: Condensation Control	
OUTDOOR, ATTIC & UNCONDITIONED SPACES VENTED TO OUTDOOR Design Conditions: 32 Deg. C & 85% RH (as per ASHRAE guidelines)	
DUCT INSULATION	
Duct	**Required Thickness (mm)**
Supply Air Duct (Line Temperature 14 Deg.C)	25
Return Air Duct (Line Temperature 22 Deg.C)	25

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION Design Basis: Condensation Control	
INDOOR (CONDITIONED / SEMICONDITIONED AREAS) Design Conditions: 26.8 Deg.C & 85% RH (With Proper Ventilation)	
DUCT INSULATION	
Duct	**Required Thickness (mm)**
Supply Air Duct (Line Temperature 14 Deg.C)	19
Return Air Duct (Line Temperature 22 Deg.C)	13
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	13

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION Design Basis: Condensation Control	
Non - Coastal Areas Pune, Delhi, Hyderabad, Bangalore etc.	
DUCT INSULATION	
Duct	**Required Thickness (mm)**
Supply Air Duct (Line Temperature 14 Deg.C)	19
Return Air Duct (Line Temperature 22 Deg.C)	13
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	13

External thermal insulation shall be provided as follow:

The thickness of the NITRILE RUBBER shall be as shown on drawing or identified in the schedule of quantity. Following installation procedure should be adopted:

1. Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.
2. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension.
3. Material shall be fitted under compression and no stretching of material should be allowed.
4. A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface.
5. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
6. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
7. The adhesive shall be strictly as recommended by the manufacturer.
8. Detailed Application specifications are as per the manufacturer's recommendation.

13.2 INSTALLATION OF DUCTS EXPOSED DIRECTLY TO SUNLIGHT:

For installations exposed to sunlight, after giving 36 hours curing time for the adhesive apply manufacturer's recommended UV/Mechanical Protection. Please refer the separate detailed guidelines on UV/Mechanical Protection.

13.3 INSULATION FOR CHILLED WATER/DRAIN PIPING

The complete chilled water piping including with pipes, bends, flanges, valves, hanger support etc. will be insulated as per the following –

MATERIAL

1. Insulation material shall be Closed Cell Elastomeric Nitrile Rubber
2. Density of Material shall be between 40 to 60 Kg/m3
3. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m°K at an average temperature of 0°C
4. 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
5. Material should be FM (Factory Mutual), USA approved.
6. Thickness of the insulation shall be as specified for the individual application.
7. Water vapor permeability shall not exceed 0.017 Perm inch (2.48 x 10-14 Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 7000.
8. All chilled water, refrigerant and condensate drain pipe shall be insulated in the manner

specified herein.

9. An air gap of 100 mm shall be present between adjacent insulated surfaces carrying chilled water or refrigerant & also between the insulated surface & the wall to allow natural ventilation without affecting its external surface coefficient of heat transfer.
10. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc.

Nitrile Rubber insulation shall be applied as follows:

a. Insulating material in tube form shall be sleeved on the pipes.
b. On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer.
c. Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre.
d. Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
e. The insulation shall be continuous over the entire run of piping, fittings and valves.
f. All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

The detailed application specifications are as mentioned separately. The manufacturer's trained installer should only be used for installation.

RECOMMENDED ADHESIVE:

In all cases, the manufacturer's recommended Adhesive should be used.

13.4 PUMP INSULATION

Chilled water pumps shall be insulated to same thickness as pipe to which they are connected & application shall be same as above. Care shall be taken to apply insulation in a manner as to allow dismantling of pumps without damaging insulation.

13.5 SHELL INSULATION

Chiller shells shall be factory / site insulated in accordance with manufacturer's stds.

COLD WATER AND EXPANSION TANK INSULATION

Cold water tank, and chilled water expansion tank shall be insulated as per manufacturer's standard.

PIPE SUPPORTS

All pipe supports should be factory made as detailed specification attached.

13.6 INSTALLATION EXPOSED DIRECTLY TO SUNLIGHT:

For installations exposed to sunlight, after giving 36 hours curing time for the adhesive apply manufacturer's recommended UV/Mechanical Protection. Please refer the separate detailed guidelines on UV/Mechanical Protection.

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION Design Basis: Condensation Control	
OUTDOOR, ATTIC & UNCONDITIONED SPACES VENTED TO OUTDOOR Design Conditions: 28.3 Deg. C & 90% RH (as per ASHRAE guidelines)	
CHILLED WATER PIPING LINE TEMP 7 Deg.C	
Pipe NB (mm)	**Required Thickness (mm)**
25 to 40	32
50 to 150	38
200 to 600	44
Cold Water Tank	44

REFRIGERANT PIPING LINE TEMP 3 Deg C	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 50	38
Up to 100	44

DUCT INSULATION	
Duct	**Required Thickness (mm)**
Supply Air Duct (Line Temperature 14 Deg. C)	23
Return Air Duct (Line Temperature 22 Deg. C)	8

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION Design Basis: Condensation Control	
INDOOR (CONDITIONED / SEMICONDITIONED AREAS) Design Conditions: 26.8 Deg.C & 85% RH	
CHILLED WATER PIPE LINE TEMP (7 Deg.C)	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 65	19
Up to 600	25

DRAIN PIPING LINE TEMP (15 Deg.C)	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 50	13

REFRIGERANT PIPING LINE TEMP 3 Deg C	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 40	25
Up to 100	32

DUCT INSULATION	
Duct	**Required Thickness (mm)**
Supply Air Duct (Line Temperature 14 Deg.C)	19
Return Air Duct (Line Temperature 22 Deg.C)	9
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	9

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION Design Basis: Condensation Control	
OUTDOOR & INDOOR Design Conditions: 30 Deg. C & 82 % RH	
CHILLED WATER PIPE LINE TEMP (7 Deg.C)	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 32	19
Up to 600	25
Chilled Water Tank	25

DRAIN PIPING LINE TEMP (15 Deg.C)	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 50	13

REFRIGERANT PIPING LINE TEMP 3 Deg C	
Pipe NB (mm)	**Required Thickness (mm)**
Up to 50	25
Up to 100	32

DUCT INSULATION	
Duct	**Required Thickness (mm)**
Supply Air Duct (Line Temperature 14 Deg. C)	19
Return Air Duct (Line Temperature 22 Deg. C)	9
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	9

13.7 ACOUSTIC INSULATION

1. Material shall be engineered NITRILE RUBBER open cell foam
2. The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, should be minimum as per enclosed chart

Freq (Hz)	125	250	500	1000	2000	4000	NRC
10 mm	0.03	0.04	0.14	0.04	0.88	1.00	0.35
15 mm	0.01	0.09	0.29	0.74	1.08	0.83	0.55
20 mm	0.04	0.13	0.4	0.9	1.04	0.90	0.60
25 mm	0.02	0.25	0.86	1.14	0.88	0.99	0.80
30 mm	0.07	0.32	0.99	1.16	0.93	1.08	0.85
50 mm	0.23	0.73	1.29	0.99	1.09	1.11	1.05

3. The material should be fiber free
4. The density of the same shall be within 140-180 Kg/m3
5. It should have antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180.
6. The material should have a thermal conductivity not exceeding 0.047 W/m. K @ 20 Deg. C
7. The material should withstand maximum surface temperature of +850C and minimum surface temperature of -200C
8. 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.
9. 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.

13.8 INTERNAL (ACOUSTIC) INSULATION OF AHU WALLS:

Acoustic insulation shall be provided for the AHU walls.

Insulation material shall be Glass Wool insulation boards of thickness 25 mm and density 70-80 kg / m3 and faced One Side FSK & Other side Black Glass Cloth. The thermal conductivity (K) value shall not be more than 0.031 W/m K at 10 deg. C. The channels used for supporting shall be 20 G GSS.

Mechanical fasteners shall be used to ensure adherence of insulation to Channel.

13.9 DUCT ACOUSTIC LINING

Ducts so identified and marked on Drawings and included in Schedule of Quantities shall be provided with acoustic lining of thermal insulation material for a distance of minimum 5 meters.

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

A. ARMAFLEX PROTECT R 90 - THE FIRE-STOP PENETRATION SEAL FOR PIPES

The flexible fire stop pipe seal with a fire resistance of > 90 min. for non-combustible/combustible supply pipes and/or non-combustible waste pipes in solid ceilings/walls or light weight walls.

Create fire-resistant seals for pipework using closed-cell, flexible elastomeric insulation with intumescent effect

The material should have following properties-

Temperature Range: -50 Deg. C to +85 Deg.C
Thermal Conductivity: 0.05 W/m. K at 0 Deg.C
Water Vapor Diffusion Factor $\mu < 10,000$
Reaction to Fire: B2 in accordance to DIN 4102
Fire reaction to structural element: R 30 to R 90
(in accordance to prEN 1366-3.2: N185 2007-07 and DIN EN 13501-2: 2008-01, section 7.5.8)

INSTALLATION:

The intumescent insulation is to be either sleeved over the pipe or slit and sealed using manufacturer's recommended adhesive. Longitudinal seams and butt joints are to be covered with EPDM / NITRILE RUBBER rubber self-adhesive tape. The gap remaining between the insulation and the wall/ceiling is to be closed completely using mineral mortar. In lightweight walls, the gap is closed using loose fill within the wall and filler against the gypsum board (annular gap up to 50 mm).

The length of the intumescent insulation is to be determined depending on the pipe material and diameter according to manufacturer's recommendation as per the standard / test report for the R 90 test.

The Pipe diameters above 89 mm can be insulated with sheets which are additionally fixed with the binding wire (wound around 6 times per running meter). Binding of wire should

be done for tubes as well.

Installation with zero clearance between the insulated pipes is permitted in the area of penetration is permitted. In case of chilled water lines condensation aspect should be considered.

Work should be carried out in accordance with relevant R 90 testing standard / test report.

13.10 PIPE SUPPORT WITH ARMAFIX

SPECIFICATION CLAUSE:

Insulated pipe support, single piece with self-adhesive closure, PUR/PIR load bearing Insert (Density 140 -180 kg/m³) embedded in elastomeric EPDM / NITRILE RUBBER rubber insulation with two outer metal shells made of aluminum sheet, which also acts as a vapor barrier for the PUR/PIR inserts.

TECHNICAL DETAILS -

Temperature Range : -50°Cto+105°C
Moisture Resistance Factorμ : 5000
Thermal Conductivity at 0°C : 0.035W/(m·K)
Thermal Conductivity at 40°C : 0.039 W/(m · K)
Color : Black

13.11 UV / MECHANICAL PROTECTION FOR PIPING / DUCTING / VESSEL

a) Covering with ... Arma-ChekGC

SPECIFICATION CLAUSE:

For protection against mechanical impact and Scratch – treated woven glass fiber covering - should be applied.
(For Indoor application only)

TECHNICAL DETAILS -

Temperature Range	: -50°Cto+150°Coverall
Temperature Range Rubber Insulation	: - 50°C to +105°C If based on EPDM / Nitrile Rubber
Temperature Range Rubber Insulation	: - 50°C to +150°C If based on EPDM / Nitrile Rubber
Color	: Black
Density	: 205+10gms/sq.meter

APPLICATION NOTES:

The covering should be cut to size according the circumference of the insulated pipe – please allow an additional 50mm for the overlap of the covering material. The Overlap shall be securely fixed using recommended Adhesive.

Spread thin film of recommended on the 50mm overlap and close the seam. When covering fittings, please consult the manufacturer's Application Manual. All fittings have to be covered to the same standards as the covering of the pipe work. No additional vapor barrier is needed.

b) Covering...with Arma-ChekCL

SPECIFICATION CLAUSE:

For protection against mechanical impact & scratch, a lightweight, Aluminum foil with woven glass fiber reinforcement covering –- with a good resistance to Oil and Chemicals - should be applied. (For Indoor application only)

TECHNICAL DETAILS -

Temperature Range	: -50°Cto+150°Coverall
Temperature Range Rubber Insulation	: - 50°C to +105°C If based on EPDM / NITRILE RUBBER
Temperature Range Rubber Insulation	: - 50°C to +150°C If based on EPDM / NITRILE RUBBER
Dust & Fiber Free	
Color	: Silver

APPLICATION NOTES:

The covering should be cut to size according the circumference of the insulated pipe – please allow an additional 50mm for the overlap of the covering material. The Overlap shall be securely fixed using recommended Adhesive.

Spread thin film of recommended on the 50mm overlap and close the seam. When covering fittings, please consult the manufacturer's Application Manual. All fittings have to be covered to the same standards as the covering of the pipe work. No additional vapor barrier is needed.

c) ArmaChek T - (with UV Resistant Paint and CSM)

It's a two component composite system of Chopped Strand Mat (CSM) and special UV resistant paint.

PROCEDURE:

i. Apply UV paint liberally on Insulation.
ii. Immediately spread the 225 GSM Chopped Strand Mat (with minimum overlap of 1 inch at joints) on insulation without allowing paint to dry.
iii. Immediately apply another coat of paint liberally on CSM.
iv. Even out with brush and allow it to dry for 2-3 hours.

Note: Mechanical Protection should be applied after 36 hours of Curing of adhesive. It is the minimum time required for complete curing of adhesive.

13.12 FALSE CEILING INSULATION

The false ceiling shall be insulated with 50 mm thick fiberglass slab of 16 Kg. / Cu. M. density. The fiberglass slab shall be wrapped in polyethylene bags.

13.13 UNDERDECK INSULATION

MATERIAL

Insulation material shall be Closed Cell Elastomeric **NITRILE RUBBER**

1. Density of Material shall be between 40 to 60 Kg/m3
2. Thickness of the insulation shall be 25mm.
3. Thermal conductivity of elastomeric EPDM / NITRILE RUBBER shall not exceed **0.034** W/m.K at mean temperature of 0°C
4. Insulation material shall have anti-microbial product, which is EPA (Environmental Protection Agency), USA approved, as an integral part of insulation that cannot be washed off or worn off. **(NITRILE RUBBER is anti-Microbial polymer)**
5. It shall give enhanced level of protection against harmful Microbes such as bacteria, mold, mildew and fungi and should confirm to following standards: Fungi Resistance – ASTM G21 and Bacterial resistance – ASTM G 22 / ASTM 2180.
6. The insulation shall have fire performance such that it passes **ASTM-E-84 test** Method.
7. Material should be FM (Factory Mutual), USA approved.
8. Water vapor permeability shall not exceed 1.74 x 10-14 Kg / (m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 10000.

13.14 AHU ROOM ACOUSTIC INSULATION

1. Material shall be engineered NITRILE RUBBER open cell foam
2. The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, should be minimum as per enclosed chart

Freq (Hz)	125	250	500	1000	2000	4000	NRC
20 mm	0.04	0.13	0.4	0.9	1.04	0.90	0.60

3. The material should be fiber free.
4. The density of the same shall be within 140-180 Kg/m3.
5. It should have antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180.
6. The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C.
7. The material should withstand maximum surface temperature of +850C and minimum surface temperature of -200C.
8. 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.
9. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).
10. Thickness of the material shall be as specified for the individual application.
11. The insulation should be installed as per manufacturer's recommendation.

13.15 CAVITY/RAISED FLOOR INSULATION

MATERIAL

1. Insulation material shall be Closed Cell Elastomeric Nitrile Rubber.
2. Density of Material shall be between 40 to 60 Kg/m3.
3. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.037 W/m°K at an average temperature of 0° C.
4. 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 Standards & B-1 as per DIN Standards.
5. Water vapor permeability shall not exceed 0.03 Perm inch (2x 10-10 Kgs/m.hr.Pa).
6. Thickness of the insulation shall be 25 mm.

INSTALLATION PROCEDURES

1. First the supports for raised floor should be installed on to the floor. Then the floor shall be cleaned with brush to remove all dirt, cement etc. If floor is uneven it should be made smooth prior to carrying out insulation work.
2. Allow an additional 5 mm to the total dimensions while cutting Insulation sheet. Ensure you measure the cutting dimensions on the top surface of the insulation sheet. This can be identified by the products markings; “they are always on the top surface. This surface is the one you will see after installation.
3. All Insulation sheet and floor surfaces shall have all-over adhesive coverage. Adhesive should be applied on the side that has no product markings and identification printing. This side is the one that curves inwards.
4. During installation avoid air bubbles. Always apply pressure on fixing the Insulation sheet, this action will ensure maximum bond strength.
5. All cut Insulation sheet edges shall be of a “clean cut nature & not cut rough”.
6. All seams and joint shall be sealed with SR 505 adhesive. All seams and joints should have no more than 10mm of adhesive showing on the outer skin of the finished Insulation sheet installation.
7. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension. Material shall be fitted under compression and no stretching of material shall be permitted. A thin film of adhesive shall be applied on floor with brush and then on to the back of the insulating material sheet with brush/small piece of sheet metal having smooth edges. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond. All joints shall be sealed. SR 505 adhesive of Pidilite should be used for all cavity floor applications.

13.0 CROSS TALK SILENCER

The cross talk silencer should incorporate aerodynamic side lines with erosion protected class "O" acoustic in fills covered with perforated sheet metal. The casing should be manufactured as per DW 142 class B code and should be of galvanized sheet metal 1 mm thick to BS 2989 grade Z2 G275.

14.0 ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions. The panel shall be metal enclosed 14 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.

All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. lamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the color decided in consultation with the Architect/Consultant.

Note: All panel enclosures used in plant room spaces and external to building shall be suitable for outdoor application (IP 54 protection) and UL listed.

15.0 CONDUITS AND WIRING

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Architect/Engineers Any modifications suggested by the Contractor shall be got approved by the Architect /Engineers before the actual laying of conduits is commenced.

16.1 CONDUITS / TRUNKER

Conduits and accessories shall conform to relevant Indian Standards. PVC conduits of required dia shall be used as called for in the schedule of quantities. Joints between conduits and accessories shall be securely made, with help of adhesive. The conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

16.2 CONNECTIONS

All jointing methods shall be subject to the approval of the Architect/Engineer. Separate conduits shall run for all power wiring. The threads and sockets shall be free from grease and oil.

Connections between conduit and controller metal boxes shall be by means of brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be smooth to avoid damage to insulation of conductors while pulling them through the conduits.

16.3 BENDS IN CONDUIT

Where necessary, bends or diversions may be achieved by means of bends and/or circular inspection boxes with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with a finished wall surface. No bends shall have radius less than 2-1/2 times the outside diameter of the conduit.

16.4 FIXING CONDUITS

The conduits, junction boxes, outlet boxes and controller boxes once installed in position, shall have their outlets properly plugged or covered so that water, mortar, insects or any other foreign matter does not enter into the conduit system. Surface conduits shall be fixed by means of spacer bar saddles at intervals not more than 500 mm.

The saddles shall be 2 mm x 19 mm galvanized steel flat, properly treated, primer coated & painted, securely fixed to supports by means of nuts and bolts/rawl bolts and brass machines screws.

16.5 DRAWING OF CONDUCTORS

While drawing insulated wires/cable into the conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors. No joint shall be allowed in case of breakage of any conductor. No joint shall be shaved off like length of the conductors. Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square to avoid depression/cutting of conducting material.

Strands of wires shall not be cut to accommodate & connect to the terminals. Terminals shall have sufficient cross-sectional area to take all the strands.

No wire shall be drawn into any conduit until all work of any nature that may cause injury to wire is completed. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction. Where wires are connected to detectors, or panel, sufficient extra length of wires shall be provided to facilitate easy connections and maintenance. If numbers of cables are > 4 than cable tray of appropriate size to be used.

Only licensed supervisors/wiremen shall be employed for cabling and other connected work. Only approved make of cables shall be used. The cables shall be brought to the site in original packing.

16.0 SIGNAL CABLING & COMMUNICATION CABLING

The signal cable shall be of the following specifications:

a) Wire : Annealed Tinned Copper
b) Size : 1.5 sq. mm, 7 strands
c) No. of conductors : Two (One pair)
d) Shielding : Overall beld foil Aluminium polyester shield.
e) Jacket : Chrome PVC
f) Nominal DCR : 17.6 ohm/km for conductor
57.0 ohm/km for shield
g) Nominal OD : 8.5 mm
h) Nominal capacitance : 130 pF/m between conductors at 1 KHz180 pF/m between one conductor and other conductors connected to shield.
i) Color : Black and Red

17.1 COMMUNICATION CABLE

The communication cable shall be of the following specifications:

a) Wire : Annealed Tinned Copper
b) Size : Minimum 24 AWG stranded
c) No. of conductors : Two pair (4 conductor)
d) Shielding : Overall beld foil Aluminium polyester shield.
e) Jacket : Chrome PVC
f) Nominal DCR : 78.7 ohm/km for conductor 55.8 ohm/km for shield
g) Nominal OD : 5.64 mm
h) Nominal capacitance : 131 pF/m between conductors @ 1 KHz, 243 pF/m between one conductor and conductors connected to shield other
i) Color : Black and Red, Black and White)

17.2 LOCAL AREA NETWORK CABLE

Depending on the type of LAN system being used by the contractor, standard, manufacturer's specification shall apply for CAT 5 / CAT 6 cable.

B ELECTRICAL WORKS

1.0 LT CABLES -1.1KV GRADE

1.1 GENERAL

The cables shall be supplied, inspected, laid, tested and commissioned in accordance with drawings, Specifications, relevant Indian Standard and cable manufacturer's instruction.

1.2 MATERIAL

Specification of 1.1KV grade Single / Multicore XLPE insulated, PVC sheathed Aluminium / Copper conductor Armoured / Unarmoured cables shall be as per IS: 7098 Part-1:

i. Conductor:

- Material : Aluminium / Copper : Electrolytic grade
- Shape : Aluminium conductor : 6 & 10 sqmm. Solid circular
  : 16 sqmm. & above stranded compacted shaped
  : Copper conductor : 4 & 6 sqmm. stranded non-compacted circular
  : 10 sqmm. stranded compacted circular
  : 16 sqmm. & above stranded compacted shaped

ii. Insulation Material: Cross linked polyethylene XLPE (Red, Yellow, Blue & Black)
iii. Inner Sheath: Extruded inner PVC sheath
iv. Armouring: Single layer of galvanized steel round wires / flat strips
v. Outer sheath: FR-LSH PVC Sheath
vi. Colour of sheath: Black

Note: Single core armoured cables shall be with "Non-magnetic" type armouring.

1.3 CABLE LAYING AND HANDLING

It should be ensured that both ends of the cable are properly sealed to prevent ingress / absorption of moisture.

1.4 CABLE HANDLING

When cable drums have to be moved over short distance, they should be rolled in the direction of the arrow marked on the drum.

While removing cables, the drums shall be properly mounted on jacks or on a cable wheels or any other suitable means, making sure the spindle, jack etc. are strong enough to take the weight of the drum.
The cables shall not be given a sharp bend to a small radius. The minimum safe bending radius for all types of PVC/XLPE cables shall be taken as 12 times the overall diameter of the cable. Wherever practicable, larger radius should be adopted. At joints and terminations, the bending radius of individual cores of a multicore cable shall not be less than 15 times its overall diameter.

Cable with kinks and straightened kinks, or with similar apparent defects like defective armoring etc. shall not be installed / laid.
Cables of different voltages as well as power and control cables should be kept in different trenches/racks with adequate separation. Where available space is restricted, LV/MV cable shall be laid above HV cables.
Where cables cross over cannot be avoided, the cable of higher voltage shall be laid at a lower level than the cable of lower voltage.

Installation of cables including jointing shall be carried out as per IS: 1255 amended and revised to date.
Power and communication cables shall, as far as possible cross at right angles. Where power cables are laid in proximity to communication cables, the horizontal and vertical clearances shall not normally be less than 60 cm.

Cables shall be laid direct in ground, in pipes / closed ducts, in open ducts or on surface depending on environmental conditions, and as required in schedule of quantities.

During the preliminary stages of laying the cable, consideration should be given to proper location of the joint position so that when the cable is actually laid, the joints are made in the most suitable places and as approved by Consultant. As far as possible, water logged locations, carriage ways, pavements, proximity to telephone cables, gas or water mains, inaccessible places, ducts, pipes, racks, etc. shall be avoided.

The cable shall not in any circumstances be bent so as to form an abrupt right angle but must be rounded off at the corners to a radius not less than 12 times the overall diameter of the cable.

In case, where there are chances of any damage to the wiring/cables, such wiring/cables shall be covered with a sheet metal protective covering (not less than 16 SWG), the base of the covering being flush with the plaster or brickwork as the case may be, or the wiring /cables shall be drawn through a heavy gauge metal conduit pipe by complying with all the requirements of conduit wiring system.

Such protective covering shall, in all cases, be fitted on all down drops within 1.5 m from the floor or from floor level upto the switch board, whichever is less.

While cutting and stripping of the outer sheathing of the cable, care shall be taken that the sharp edge of the cutting instrument does not touch the inner insulation of the conductors. The protective outer covering of the cable shall be stripped off near connecting terminal and this protective covering shall be maintained upto close proximity of connecting terminals. The cables laid near junction boxes shall be made moisture proof with a plastic compound.

1.5 CABLE JOINTING & TERMINATION

Jointing shall be as per the manufacturer's recommendations using standard kits. Cable joints shall be made in suitable, approved cable joint boxes, jointing of cables in the joint boxes and filling of compound shall be done as per manufacturer's recommendations. Heat shrinkable joints shall be made.

Cables shall be terminated onto the terminals of switchgear through crimping lugs of proper size and of heavy duty. Cable lugs shall be fitted onto the cable by crimping or compression jointing.

Continuity of cable armouring is to be maintained. Double compression glands to be used. Proper crimping tools to be used.

1.6 TRENCHING & CABLE LAYING

The minimum width of trench shall be 45 cm and depth shall be 75cm for laying of cable. Where more than one cable is to be laid in the same trench in horizontal formation, the width of trench shall be increased such that the minimum gap between the cables is one diameter of the cable unless specified otherwise.

The clearance between axis of the end cables and the sides of the trench shall be minimum 1.5 D (diameter) of the end cable.

The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature shall be provided.

Where gradients and changes in depth are unavoidable, these shall be gradual.
The bottom of the trenches shall be level and free from stone, brick bats etc. The trench shall then be provided with a layer of clean, dry sand cushion of not less than 9 cm in depth.

Cable laid in trenches in a single tier formation shall have a covering of clean, dry sand of not less than 20 cms. above the base cushion of sand before the protective cover is laid.

In the case of vertical multi-tier formation, after the first cable has been laid, a sand cushion of 30 cms shall be provided over the initial bed before second tier is laid. If additional tiers are formed, each of the subsequent tiers shall have a sand cushion of 30 cms as stated above. The top-most cable shall have final sand covering not less than 17 cms before the protective cover is laid.

Unless otherwise specified, the cables shall be protected by second class bricks of not less than 20 cm x 10 cm x 10 cm (nominal size) as per CPWD building specification, or protection covers placed on top of the sand, (brick to be laid breadth wise) for the full length of the cable to satisfaction of the owner. Where more than one cable is to be laid in the same trench, this protective covering shall cover all the cables and project at least 5 cm over the sides of and cables.

The trenches shall be then back filled with excavated earth free from stone or other sharp-edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 30 cm. Unless otherwise specified, a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench shall be left to allow for subsidence. The crown of earth, however, should not exceed 10 cms.

Where road bends or lawns have been cut or kerb stones displaced, the same shall be repaired to the satisfaction of the architect and all surplus earth or rock removed to places as specified.

In locations such as road crossing, entry to building in paved areas etc. cables shall be laid in pipes or closed ducts.

All cable entry/exit points into the building through pipe sleeves shall be properly sealed with water and fire safe sealants in an approved manner to avoid any seepage of water into the building.

Manholes of adequate size, as decided by the Architect, shall be provided to facilitate of adequate strength feeding/drawing in of cables and to provide working space for persons. Suitable manhole covers with frame of proper design shall cover Manholes.

CABLE LOOPS: Sufficient cable loop length shall be left at both ends.

1.7 CABLES ON HANGERS OR RACKS / TRAYS

The contractor shall provide and install all iron hangers' racks, or racks with die-cast cleat, with fixing rag bolts or girder clamps or other specialist fixing as required.

Where hangers or racks are to be fixed to wall sides ceiling and other concrete structures, the contractor shall be responsible for cutting away, fixing and grouting in rag bolts and making good the damages as required.

The hangers or racks shall be designed to leave at least 25 mm clearance between the cables and the face to which it fixed. Multiple hangers shall have two or more fixing holes. All cables shall be saddled at not more than 500 mm intervals. These shall be designed to keep provision of some spare capacity for future development. Minimum spacing between the cables shall be one diameter of the cable or as specified.

1.8 CABLE TRAY

a. Cable trays shall be hot dip galvanized as called for in the schedule of quantities.
b. Cable trays shall be complete with bends, joints, coupler plates and accessories as may be required for joining the cable trays.
c. Cable trays shall be either perforated or ladder type as called for in the schedule of quantities.

1.9 PERFORATED CABLE TRAYS

Standard Technical details of perforated cable tray shall be as follows:

S.	SIZE OF TRAY (Width)	THICKNESS & COLLAR HEIGHT
1.	n to 450mm width	hick & 50mm collar
2.	n to 750mm width	hick & 50mm collar
3.	n to 1200mm width	hick & 50mm collar

Note: Supports shall not be charged extra. It shall be considered to be included in the rate of the tray.

1.10 LADDER TYPE CABLE TRAYS

Standard technical details of ladder type cable trays shall be as follows:

SIZE OF TRAY	SIZE OF MAIN CHANNEL OR RUNNER	SIZE OF RUNG & SPACING	CABLE TRAY SUPPORT
900mm to 1500mm	25 x 100 x 25 x 2.5mm	20 x 50 x 20 x 2.5mm @ 250 C/C	50 x 50x 5mm angle @ 1000mm spacing.
450mm to 750mm	20 x 75 x 20 x 2.0mm	20 x 50 x 20 x 2mm @ 250 C/C	40 x 40 x 5mm angle @ 1250mm spacing.
150mm to 300mm	20 x 75 x 20 x 2.0mm	15 x 35 x 15 x 2mm @ 250 C/C	40 x 40 x 3mm angle @ 1500mm spacing.

Hangers shall be minimum 10mm dia GI Round bar.

Fixing /supporting arrangement shall be as approved by the Consultant / Owner / PMC

Hardware to be used in cable tray system shall be Hot Dip galvanized or zinc passivated.

Note: Supports shall not be charged extra. It shall be considered to be included in the rate of the tray. All structural steel shall be according to the latest revision of IS: 226 & 808.

a. Quality of Zinc

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS: 209-1992.

b. Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square meter shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs; rust stains bulky white deposits, blisters.
Mild steel flats / wires shall undergo a process of degreasing, pickling in acid, cold rinsing and then galvanizing.

1.11 TESTING OF CABLES

The Megger value in normal dry weather shall be 50 mega ohms for 1.1 KV grade cable. Cables shall be tested at works for the following tests before being dispatched to site by the project team:

a. Insulation Resistance Test.
b. Continuity resistance test.
c. Sheathing continuity test.
d. Earth test. (in armoured cables)

e. Hi Pot Test.

Test shall also be conducted at site for insulation between phases and between phase and earth for each length of cable, before and after jointing. On completion of cable laying work, the following tests shall be conducted in the presence of the Owner's site representative:

a. Insulation Resistance Test (Sectional and overall)
b. Continuity resistance test.
c. Sheathing continuity test.
d. Earth test.

All tests shall be carried out in accordance with relevant Standard Code of Practice and Electricity Rules. The Contractor shall provide necessary instruments, equipment and labour for conducting the above tests and shall bear all expenses in connection with such tests. All tests shall be carried out in the presence of the PMC / Owner representative.

1.12 CABLE AGS

Cable tags shall be made out of 2mm thick aluminum sheets. Each tag shall be 2" in dia or 3" x 3" square with one hole of 2.5mm dia, 6 mm below the periphery, or as approved by Consultant. Cable designations are to be punched with letters / number punches and the tags are to be tied to cables with piano wires of approve quality & size. Tags shall be tied inside the panels beyond the glanding as well as above the glands at cable entries. Along trays tags are to be tied at all bends. On straight lengths, tags shall be provided at every 5 meters.

Cables shall be secured to cable trays with 3mm thick x 25mm wide aluminum strips/suitable GI clamp, or as approved by Consultant, at 1000 mm intervals and screwed by means of rust proof screws, washers and bolts, of adequate but not excessive lengths. Cable trays for horizontal runs suspended from the ceiling will be supported with mild steel straps or brackets, at 1000 mm intervals and the overall tray arrangement shall be of a rigid construction. External cabling route marker with GI plate marked with "DANGER 1.1 kV CABLE" with 1-meter long GI angle iron grouting bracket including 1:3:6 ratio cement concrete base block of minimum size 200 x 200 x 350 mm to be provided or as approved by Elect. Supply Company.

ANNEXURE - I

SPECIFICATIONS FOR PAINTING WORK

1. Cleaning the surface
2. Apply a primer coat of Red Oxide
3. Applying tow coats of enamel paint of APPROVED colour code after applying cement primer for plastered surface.
4. Standard colour code.

a)	Compressor, Condenser, Belt-guards, Pump sets	: Battleship Grey.
b)	Motor	: Siemens Grey
c)	Chiller	: Dark Blue
d)	Air Handling Units	: Mulshell Grey
e)	Pot Strainers (Base)	: Grey
f)	Hot Gas Line	: PO Red
g)	Liquid line	: Orange
h)	Suction Line	: Green/Blue
i)	B.M. Valve/Copper Line	: Golden Paint
j)	Gauge panel	: Siemens Grey
k)	Chilled Water Line Inlet line (Hot)	: Dark Blue
	Outlet line (Cold)	: Light Blue
l)	All supports /stands	: Black
m)	Gas Equalizer Line	: Yellow
	Oil Equalizer Line	: Dark Brown
n)	Ducting	
	Concealed	: Black Rust Proof
	Exposed to Grilles insulated/uninsulated duct	: Black
	Exposed	: Fiesta Blue

Electric Panels : Steel Grey

The colour of the chiller package supplied by the vendor may be accepted.

MODE OF MEASUREMENT

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

ANNEXURE - II

I. S. CODES

Following IS CODES will be applicable for the project.

1. IS : 655 – 1963 : Ducting work.
2. IS : 659 - 1964 : Safety Code for Air-conditioning.
3. IS : 660 - 1963 : Safety Code for Mechanical Ref.
4. IS : 5111-1969 : Code of Practice & Measurement Procedure for Testing Refrigerant compressors.
5. IS : 325-1970 : Specifications for 3 Ph. Induction Motor.
   Also confirm to IS : 1231 : Foot Mounted motors.
   and IS : 2223 : flange mounted motors.
6. IS : 2147-1962 : Degree of protection provided by enclosures for low voltage switch gears and control gears.
7. IS : 3012-1965 : Code of Practice for installation (PART-I) maintenance of switch gear.
8. IS : 3061-1982 : Code of Practice for Fire precautions in welding & cutting operations.
9. IS : 3651-1967 : Glossary of terms used in Refrigeration & Air-conditioning.
10. IS STD. for Insulation work
    a. IS : 4671-1984 : Expanded polystyrene For Thermal Insulation purposes
    b. IS : 661-1974 : Code of Practice for Thermal Insulation of Cold Storages.
    c. IS : 7240-1981 : Code of Practice for Application & finishing of Thermal Insulation material at Temp. from 80°C to 40°C.
    d. IS : 7413-1981 : Code of Practice for Application & finishing of Thermal Insulation material at Temp. from 40°C to 700°c.
    e. IS : 8183 - 1976 : Specifications for Bonded Mineral Wool.
11. IS : 1239 : Pipes up to 150 MM Dia.
12. IS : 3589 : Pipes above 200 MM Dia.
13. IS : 780/ISI Certificates : Valves of PN 1.6 rating
14. IS : 5312 / ISI Certificate : Check Valves
15. IS : 277 : For Sheet galvanising spec.
16. IS : 900 : Installation of motor
17. IS : 4064 & 4047 : Switch fuse unit.
18. IS : 2516 : ACB
19. Relevant ISS : MCCB
20. IS : 3043 - 1963 : Earthing
21. IS : 3043 : Earth Station.
22. IS : 732 - 1963 : Testing of Electrical Installation
23. IS : 520 : Standard for positive displacement Refrigeration,

compressor & condensing unit

24. IS : 2825 : Unfired pressure vessels
25. IS : 4503 : Shell & Tube type Heat Exchanger
26. IS : 1520 : Horizontal Centrifugal Pumps for Chiller, Cold, Fresh Water
27. IS : 737 : Specification for Wrought al. & al. Sheet & strip
28. IS : 3069 : Glossary of items symbols & units relating to thermal materials
29. IS : 702 : Industrial bitumen
30. IS : 8183 : Rounded Mineral Wool

NOISE CONTROL

SCOPE

The scope of this section comprises of the supply, installation, testing & commissioning of noise & vibration control equipment & accessories.

STANDARDS

The testing of all noise control equipment & the methods used in measuring the noise rating of air conditioning plant & equipment shall be in accordance with the relevant sections of the following British Standards, unless otherwise stated :

BS 4718: 1971 : Methods of Test of Silencers for Air Distribution Systems

BS 2750: Parts 1-9: 1980 : Laboratory & Field Measurement of Airborne Sound Insulation of Various Building Elements. Recommendations for Field Laboratory Measurement of Airborne & Impact Sound Transmission in Buildings.

BS 3638: 1987 : Methods of Measurement of Sound Adsorption in a Reverberation Room.

BS 4773: Part 2: 1976 : Acoustic Testing.

BS 4856: Part 2:1976 : Acoustic performance without additional ducting of forced fan convection equipment.

BS 4856: Part 5: 1976 : Acoustic performance with additional ducting of forced fan convection equipment.

BS 4857: Part 2: 1978(1983) : Acoustic Testing & Rating of High Pressure Terminal Reheat Units.

BS 4954: Part 2:1978(1987) : Acoustic Testing & Rating of Induction Units.

BS 5643 : 1984 : Glossary of Refrigeration, Heating, Ventilating and Air Conditioning Terms.

GENERAL

Mechanical services shall generally be designed & installed with provisions to contain noise & the transmission of vibration, generated by moving plant & equipment at source where illustrated on the tender drawings & plant & equipment schedules to achieve acceptable noise rating specified for occupied areas.

In addition to the provisions specified in the Specification, particular attention must be given to the following details at time of ordering plant & equipment & their installation :-

a. All moving plant , machinery & apparatus shall be statically & dynamically balanced at manufacturers works & certificates issued.
b. The isolation of moving plant, machinery & apparatus including lines equipment from the building structure.
c. Where duct work & pipe work services pass through walls, floors & ceilings, or where supported shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure & minimize the outbreak of noise from plant rooms.
d. The reduction of noise breakout from plant rooms & the selection of externally equipment & plant to meet ambient noise level requirements of the Specifications.
e. Electrical conduits & connections to all moving plant & equipment shall be carried out in flexible conduit & cables to prevent the transmission of vibration to the structure & nullify the provisions of anti-vibration mountings.
f. All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units. Duct work connections to the fan inlets / outlets shall be concentricity aligned so that the flexible connections are not subjected to any strain & not used as a means of correcting bas misalignment.
g. All resilient acoustic absorbing materials shall be non flammable, vermin & rot proof & shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.
h. Where practicable, silencers shall be built into walls & floors to prevent the flanking of noise the duct work systems & their penetrations sealed in the manner previously described. Where this is not feasible, the exposed surface of the duct work between the silencer & the wall subjected to noise infiltration shall be acoustically clad as specified.

SILENCERS

At tender stage all silencers as scheduled in the specification or on tender drawings will be selected based on preliminary sound power levels obtained from fan/air handling unit manufacturers or fan duties to achieve a noise rating in the occupied space as specified in “Basis of Design”

All plant attenuators shall be selected to maintain noise criteria given in this Specification.

Attenuators shall be constructed from high quality pre-galvanized steel sheet casings with lock formed joints along the casing length. Angle iron cross jointing flanges shall be fitted to silencer casings, drilled as required & finished with red oxide primer paint.

Acoustic splitters shall be formed by chancel section pre-galvanized sheet steel framework retaining acoustic fill of a density to attain the required performance. Splitters shall have round nose ends to give smooth entry & exit conditions to minimize air pressure drops.

The acoustic fill shall be protected from the air flow by 22 swg minimum perforated galvanized sheet steel.

All silencers shall be selected against a maximum allowable air pressure drop of 75 a.

It will be the responsibility of the Contractor at the time of placing orders for fan equipment to obtain from the manufacturers, certified sound power levels to enable the selected duct silencers to be checked against the original design information, prior to orders being placed.

ANTI-VIBRATION MOUNTINGS

All items of rotating & reciprocating plant & equipment shall be isolated from the structure by the use of anti-vibration materials, mountings or spring loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.

Centrifugal fans & motors within air handling units shall be isolated from the frame of the air handling unit by suitable anti-vibration mountings. Fan discharge air connections shall be fitted with approved flexible connections internally isolating the fan scroll from the air handling unit casing.

Axial flow fans shall be mounted on steel legs as diaphragm plates supported on neoprene in shear anti-vibration mountings, or suspended using spring loaded hangers to suite the application.

Centrifugal pumps shall be mounted on inertia bases consisting of reinforced concrete subbase, anti-vibration mountings & concrete filled steel upper plinth. The Contractor shall be responsible for issuing the steel upper plinth & mountings to the Contractor for building-in.

Pipe work connections to circulating pumps, chillers, cooler coils & other equipment shall be made with flexible connections as per Specifications.

The construction of anti-vibration mountings shall generally comply with following : -

a. ENCLOSED SPRING MOUNTING (CAGED OR RESTRAINED SPRINGS)

Each mounting shall consist of cast or fabricated telescopic top & bottom housing enclosing one or more helical steel springs as the principle isolation elements, & shall incorporate a built- in levelling device.

The springs shall have an outside diameter of not less than 75% of the operating height, & be selected to have at least 50% overload capacity before becoming coil bound.

The bottom plate of each mounting shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

Mountings incorporating snubbers of restraining devices shall be designed so that the snubbing damping or restraining mechanism, is capable f being adjusted to have no significant effect during the normal running of the isolated machine.

Restrained isolator shall be provided on chillers subject to approval by the manufacturers.

b. OPEN SPRING MOUNTINGS.

Each mounting shall consist of one or more helical steel springs as the principal isolation elements, & shall incorporate a built-in levelling device. The spring shall be fixed or otherwise securely located to cast or fabricated top & bottom plates, & shall have an outside diameter of not less than 75% of the operating height, & shall be selected to have at least 50% overload capacity before becoming coil-bound.

The bottom plate shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

c. NEOPRENE-IN-SHEAR MOUNTINGS.

Each mounting shall consist of a steel top plate & base plate completely embedded in oil resistant neoprene. Each mounting shall be capable of being fitted with a levelling device, & bolt holes in the base plate & tapped holes in the top plate so that they may be bolted to the floor & equipment where required.

d. INERTIA BASES FOR PUMPS.

The inertia base shall be an all welded mild steel channel frame the minimum depth of which shall be 1/12 of the longest span between isolator but not less than 150 mm. filled with concrete the density of which shall be 2300 kg/m3.

The inertia base shall be sufficiently large to provide support for all parts of the equipment, including any component which overhands the equipment base, such as suction & discharge elbows on centrifugal pumps.

The frame shall include pre-located equipment anchor bolts fixed into position & housed in a steel sleeve allowing minor bolt location adjustment.

Isolator support brackets shall be welded into the corners of the base & suitably re-enforced for the load of the equipment & base.

Additional reinforcing roads shall be provided at 200 mm. centres to ensure the concrete & frame is adequately stiffened against distortion.

e. FLEXIBLE CONNECTIONS

Flexible connections shall be provided on all duct work connections to fans, rotating plant & equipment isolated from structure & anti-vibration materials or mountings. Pipe work & duct work crossing building movement or construction joints shall be installed with flexible connections.

Flexible connections on duct work to fans etc. shall be a minimum / maximum free length of 100 mm. / 200 mm. respectively to minimize noise transmission & noise breakout. They shall be completely free from stress & shall not be required to accept any weight.

Thickness & strength of flexible connection materials shall be suitable to withstand the positive & negative fan pressures to which they will be subjected to & shall not allow perceptible leakage. The materials shall be durable, non flammable having food acoustical quality.

Flexible connections shall be fitted to all pump suction & discharge connections, chillers & other vibrating equipment & where anti-vibration mounts & inertia basis are fitted.

Flexible connections shall be fitted to all cooler coil chilled water pipe work connections.

Flexible connections shall allow freedom of movement of plant in all plans.

Making flanges to pipe work flexible connections shall be of the smooth faced weld-nick type.

Rubber Bellows shall be fitted as close to the source of vibration at practicable. The pipe at the other end of the bellows shall be a fixed point.

Rubber bellows shall be single convolution of multiply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be able to swivel & be removable. The date of manufacture shall be moulded on the bellows. For traceability membranes shall have an indelible identification showing manufacturer, country of origin, the type & a batch number.Tie bars with rubber top hat washers shall be used on bellows.

For working temperatures up to 70o C the rubber bellows shall be high tensile synthetic fibre reinforced.

For working temperature between 70oC & 100oC the bellows carcase shall be steel wire mesh reinforced throughout. Steel reinforced bellows shall be manufactured & approved to the Standards.

For temperatures above 100oC bellow shall be multiply stainless steel with Van Stone ends swivel flanges. The overall length shall not exceed 130 mm.

Flexible connections with screwed connections shall be reinforced EPDM rubber hoses & shall have at least one full union to avoid torquing on installation.

Flexible pipe connections on chilled water systems shall be suitable for a working pressure of 10 bar & test pressure of 17 bar.

ANNEXURE - III

1.0 TESTING OF AIR CONDITIONING SYSTEM

1.1 Routine & types tests for various items of equipment shall be performed at the contractor's work & the test certificates furnished. Functional test shall be conducted at site.

1.2 The performance test to determine whether OR not the full indent of the specification is met shall be conducted by the contractor. After notification to the Employer's that the installation has been completed & the plant has run continuously for a period of at least two weeks, the contractor shall conduct under the direction of the Consultant's & in the presence of Employer's representatives test, such test as specified to establish the capacity of various equipment supplied & installed by the contractor.

1.3 The contractor shall operate test & adjust the air conditioning system units, fans, motors, all air conditioning appliances including adjustment of regulators, dampers etc.

1.4 All test equipment, labour, operating personnel, oil & refrigerant required for this test shall be furnished by the contractor to enable the plant to be put in continuous running test for a period of 3 days after all other tests & adjustments have been made.

The contractor will be provided with electrical power water for testing by the client. The performance test shall be conducted during peak summer & peak monsoon.

2.0 PROCEDURE

2.1 DESIGN CONDITIONS :

The inside & outside conditions will be recorded for 48 hrs. (2 days) duration on hourly basis. The outside & inside Dry Bulb & Wet Bulb temperatures shall be recorded by the means of a sling psychrometer with mercury thermometers. The relative humidity shall be computed from the psychrometeric chart. The inside Dry Bulb temp. & relative humidity shall fall within the specified limits.

2.2 CAPACITY OF THE PLANT :

The following aspects shall be checked before conducting the performance tests :

a. The outside conditions shall be as close to the design values as possible. The tests shall be arranged during the peak summer & monsoon.
b. The internal loads of various spaces shall be close to the design values as far as possible.
c. The plant shall be fully loaded & the temperatures stabilized.
d. Hourly readings of water flow shall be recorded by a calibrated flow meter.
e. Hourly readings of pressure, temperature, electrical current, voltage & power factor shall be properly recorded.

The capacity of the plant & various other equipment & accessories shall be ascertained as follows.

2.3 COOLING COIL OF AHU'S & FCU'S :

The flow of air over the cooling coil will be measured by recording the velocity of air across each filter placed before the cooling coil. The velocity shall be measured by means of end anemometer

Air quantity across the filters = velocity of air across the filters in FPM x net filter area (in sq. ft.).

The wet bulb temperature of air entering the coil & that leaving the coil shall be measured. The enthalpy of entering & leaving air shall be noted from the psychrometeric chart, corresponding to the wet bulb temp. recorded.

SAY, he - Enthalpy of Entering Air in Btu /lb

H1 - Enthalpy of Leaving Air in Btu / lb.

Ve - Specific Volume of Entering Air (CFT. / lb. of air)

V1 - Specific volume of Leaving Air (CFT. / lb. of air)

Average specific volume = (Ve + V1) / 2 = v (CFT/ lb of air)

Cap. Of cooling coil = (CFM x 60) / v x (He - H1) /1200

(CFM x {He -H1} x 4.5 / 12000)

i) Heat rejection by the condenser (HR in BTU/HR.) = Water flow through the Condenser in lb/hr.x (Temperature difference in Deg.F)

2.4 COMPRESSOR :

The following readings shall be recorded :

i. Suction gas pressure
ii. Discharge gas pressure
iii. Suction gas temperature.
iv. Discharge gas temperature.
v. Readings of Ammeter, voltmeter & power factor meter.

Same pressure gauge shall be used for different pressure measurements & the same thermometers shall be used for different temperature measurements. The capacity of the compressor shall be computed from the performance chart supplied by the manufacturer.

$$\text{IKW / Ton of compressor} = \frac{\text{(Power in put in KW)}}{\text{Compressor Cap. in Tons.}}$$

2.5 AIR BALANCING :

After the desired inside conditions are achieved, the quantity of air through every outlet shall be measured. Air quantity in CFM = Air velocity at the outlet in FPM x effective area of the outlet in Sq. Ft.

2.6 TESTING OF VARIOUS LOADING CONDITIONS :

The performance test shall be conducted for various loads such as 100%, 75%, 50% of the capacity of the plant, if feasible.

3.0 FUNCTIONAL TESTS :

3.1 ELECTRICAL EQUIPMENT :

i. Cables :

All the cables shall be tested for continuity & absence of cross phasing. Insulation resistance between the phase conductors & earth shall be measured with the help of a 500 V megger,

ii. Motors :

a. Insulation resistance of all motors shall be tested with a megger & the value shall not be less than 1 Meg-Ohms. If observed value is less than 1 Meg-Ohms, the voltmeter winding shall be tried out & winding shall be given a coat of approved insulating varnish.
b. Starting current shall be recorded every time the motor is started.
c. Starter operation shall be checked for a single phasing by removing one of phase.

d. Over load protection shall be checked by altering starter thermal over load setting.

3.2 SAFETY DEVICES & CONTROLS :

i. Interlocks for compressor motor with that of chilled water pumps, condenser water pumps & cooling tower fan shall be checked.
ii. Flow switches in the chilled water lines shall be throttling the valves.
iii. High pressure stat - shall be checked by varying the Settings of the cutout.
iv. Low pressure stat - shall be tested by closing the pilot solenoid valve.
v. Anti-freeze thermostat shall be tested by varying the settings.
vi. Oil failure switch shall be tested by varying the settings.

3.3 CAPACITY CONTROLS :

The capacity control arrangement shall be tested by varying the load on the plant. Any other procedure recommended by the manufactures may be adopted with the prior permission of the Employers & Consultants.

4.0 TEST READINGS :

4.1 The following reading shall be recorded hourly during the tests & capacity of the plant shall be computed.

i. Compressor :

1) Suction pressure - Kg/Cm2 (PSI)
2) Suction Temperature - °C (°F)
3) Discharge pressure - Kg/Cm2 (PSI)
4) Condensing Temperature - °C (°F)
5) Oil Pressure - Kg/Cm2 (PSI)
6) Compressor Speed - RPM
7) Motor
   a. Rated Capacity - HP
   b. Rated Volts - Volts
   c. Rated Current - Amps
   d. Starting Current - Amps
8) Power Consumption for
   - 100%
   - 75%
   - 50% loads

   a. Motor current in amps
   b. Voltage
   c. Starting Current

ii. Condenser :

1) Refrigerator condensing Pressure - Kg/Cm2 (PSI)
2) Refrigerator condensing Temperature - “C (“F)
3) Water flow rate - (GPM)
4) Entering Water Temp. - °C (°F)
5) Leaving Water Temp. - °C (°F)
6) Pressure drop through Condenser - Kg/Cm2 (PSI)

iii. Chiller :

1) Refrigerator evaporating pressure - Kg/Cm2 (PSI)
2) Refrigerator evaporating Temperature - °C (°F)
3) Water Flow Rate - Ltr. Sec. (GPM)
4) Entering Water Temp - °C (°F)
5) Leaving Water Temp. - °C (°F)
6) Pressure drop through Chiller - Kg/Cm2 (PSI)

iv. Air Handling Units & Fan Coil Units :

1) Air velocity - M/Hr. (FPM)
2) Coil Face Area - M²(SFT)
3) Air Quantity - Cu. M/Hr. (CFM)
4) Entering Air Temp. DB. - °C (°F)
5) Entering Air Temp. WB. - °C (°F)
6) Leaving Air Temp. DB. - °C (°F)
7) Leaving Air Temp WB. - °C (°F)
8) Entering Water Temp - °C (°F)
9) Leaving Water Temp - °C (°F)
10) Entering Water Pressure - Kg/Cm2 (PSI)
11) Leaving Water Pressure - Kg/Cm2 (PSI)
12) Motor
    a. Rated Horse Power - HP
    b. Rated volts - volts
    c. Rated Current - Amps
    d. Actual Current - Amps
    e. Actual volts - Volts
    f. Actual Current - Amps
    g. Starting Current - Amps

v. Pumps :

1) Flow Rate - Ltr/ Sec (GPM)
2) Discharge Pressure - Kg/Cm2 (PSI)
3) Section Pressure - Kg/Cm2 (PSI)
4) Motor
    a. Rated Horse Power - HP
    b. Rated Current - Amps
    c. Rated volts - Volts
    d. Actual Current - Amps
    e. Starting Current - Amps

vi. Supply Air Grilles :

1) Area of Grill - M² (SFT)
2) Velocity - M/HR. (FPM)
3) Air Flow Rate - M² (FPM)
4) Temperature DB - °C (°F)
5) Temperature WB - °C (°F)

vii. Filters

1) Total Area - M^2 (SFT)
2) Effective Area - M^2 (SFT) /M/ Hr.
3) Velocity of Air - M/Hr (FPM)
4) Quantity of Air - M3 /Hr. (CFM)

viii. Controls, Interlocks etc. :

The observations of the test shall be recorded for each item separately.

NOTE :

All caliberated intruments with calibration certificate will be arranged by contractor for measurement purpose.

ANNEXURE - IV

1.0 MODE OF MEASUREMENT :

The following measurement code shall apply to this contract :-

1.1 FOR CHILLER :

The entire water chilling package with all accessories, Starters, Controls, Control Panel, Control Wiring, Refrigerant charge, Oil etc., Erection, Commissioning & Testing shall be regarded as one unit for purpose of measurement.

1.2 FOR CHILLER PUMPS :

The pump together with the Coupling, Coupling Guards, Base Plate, Vibration mounts in the Thermal Insulation, Erection, testing, & commissioning will be one unit of measurement. Motor for chiller & condenser pumps shall be measured as one unit.

1.3 FOR AHU :

AHU with filters, fan & coil section, without motor, with base frame motor, drive & guard suitable for motor, mounting frame, vibration mounts as specified in BOQ shall from one unit of measurement.

Each Motor of AHUs shall be considered one unit of measurement.

Installation, testing & commissioning is a part of above points.

2.0 SHEET METAL WORK :

2.1 DUCTING :

a. All sheet metal ducting work will be measured in terms of final sheet area installed in Sq. meters.
b. No measurement of vanes, splitters, duct, dampers deflectors, access doors etc. which are required to be installed in the duct work will be made as the same shall be deemed to be part of ducting work.

2.2 GRILLES :

All grilles will be measured in in running lengths (meters) for different sizes.

2.3 DIFFUSERS :

Diffusers will be measured in terms of nos. for different sizes.

2.4 DAMPERS :

a. All duct dampers shall be measured separately in terms of effective area.
b. Fire dampers will be measured in terms of effective area in Sq. metes.
c. Fresh air / exhaust air dampers will be measured as (II) above. No separate measurement will be made for inlet/ outlet louvers, bird screen etc.

Example : 24" x 4" will be measured as 0.667 FT^2.

3.0 PIPING :

a. Piping will be measured in running lengths (meters)
b. No special measurement of bends, elbows, reducer, expanders, tees, cross etc. will be made. All such fittings/ accessories will be treated as normal piping.

c. The length of the piping including accessories & fittings will be measured along the enter line of piping.
d. No measurement for flange shall be made. All flanges shall form the part of the piping work.
e. No measurement of pipe supports, hangers, spring isolator, anchors, etc. will be made. All such items shall be deemed to form part of piping work.
f. No measurement will be made for sockets for thermometers & pressure gauges.

4.0 INSULATION :

4.1 DUCTING INSULATION :

a. Duct insulation will be measured on the basis of Inner line of insulation & not the outer line of insulation.

Example : (Perimeter) x 1 meter length.

b. No special measurement shall be made for insulation of bends, transformation pieces, tap offs, elbows, etc. All such insulation shall be treated as standard duct insulation
c. Insulation items shall include all accessories & finishes as specified. No separate measurement will be made for such items.
d. Duct fittings such as bends, elbows tap offs, collars, transformation pieces etc. shall be treated as ordinary duct pieces with their length measured along their center line.
e. No duct support, stiffening, member etc. shall be measured separately. All such supports/ hangers shall form part of the duct work.
f. Equipment connections such as canvas/ rein shall be deemed to be part of the duct work & no separate measurement will be allowed.

4.2 PIPING INSULATION :

a. All piping insulation shall be in linear measure along the inner line of the pipe & rounded off to the nearest centimeter, over all fittings excluding flanges & valves.
b. No separate measurement of insulation shall be made for fittings such as bends, elbows, reduces, expanders, tees, crosses, flanges, etc. All such insulation shall be linear in meters measurement along the center line of piping.
c. All accessories & finishes connected with the insulation work shall be deemed to form part of insulation & no separate measurement will be made for such items.

Insulation of valves will be measured as a unit for particular size of valve.

Example : 50 mm dia valve insulation (25 mm thick) 1 No.

4.3 EQUIPMENT INSULATION :

No measurement for insulation of any equipment will be made. Insulation of equipment shall be deemed to form part of the equipment.

5.0 ELECTRICAL WORK :

a. All cables shall be measured in running lengths as finally installed at site. No wastage measurement will be allowed.
b. Control cable /wiring for a plant inside the plant room shall be treated as a lump sum item.
c. All measuring instruments, indicating lamps etc. shall form part of the equipment specified and no separate measurement shall be made for such items.

CHILLER TECHNICAL DATA SHEET :

Sr.	Equipment	300 TR Water Cooled Screw Chiller O/I Temperature (7 - 12) ºC
A	**Water Cooled Chilling Machine**	
1.0	**Unit information / Origin**	
1.1	Machine No.	
1.2	Make/Model	
1.3	Nominal Capacity TR - each	
1.4	No. of compressors per machine	
1.5	Leaving / Entering Chilled Water Temperature - ºC	
1.6	Operating Condensing Temperature- ºC	
1.7	Compressor Suction Temperature- ºC	
1.8	Capacity at Design Operating Conditions	
1.9	Overall Dimension - L x W x H - mm	
1.10	Overall Weight - Kgs	
1.11	Operating Refrigerant Charge - Kgs	
1.12	Noise Level at 1.5 Metre from the Unit - dBA	
2.0	**Compressor(s)**	
2.1	Compressor Type:	
2.2	Construction (hermetic/semi hermetic)	
2.3	Manufacturer's Name and Model	
2.4	Refrigerant	
2.5	Cylinder/Screw data	
2.6	Speeds (Operating/Max.) RPM	
2.7	Operating condensing and suction temperatures ºC	
2.8	Capacity at Design conditions. TR	
2.9	KW at operating conditions KW	
2.10	Motor losses %	

2.11	Other losses if any %				
2.12	Motor intake power KW				
2.13	KW per TR at operating conditions KW				
2.14	Capacity control - automatic or otherwise				
2.15	No. of steps of capacity control				
2.16	Capacities and corresponding power consumption values				
	Load	Capacity - TR	IKW/TR (as per ARI)	KW/TR (Constant condenser entering water temp, constant chilled water In/Out temp)	
	100%				
	75%				
	50%				
	25%				
3.0	**Motors**				
3.1	Manufacturer's Name				
3.2	Type of motor, i.e.				
	Whether SPDP, TEFC				
	Whether it conforms to IP-55 requirements?				
3.3	Motor KW/rpm				
3.4	Rated current Amps				
1.3.5	Motor efficiency %				
1.3.6	Starting current with type of starter offered				
1.3.7	Model / Frame size				
4.0	Starter				
4.1	Type				
4.2	Make				
4.3	Whether single phase preventer included				
4.4	Whether over load relay included				
5.0	Drive				
5.1	Type of drive				
5.2	Any special requirements				
6.0	Condensers (Water-Cooled)				
6.1	Manufacturer's Name				
6.2	Dimensions - L x B x H mm				
6.3	Condenser water Entering Temperature - ° C				
6.4	Condenser water Leaving Temperature - ° C				
6.5	Discharge temperature - °C				
6.6	Fouling Factor				
6.7	Refrigerant sight glasses provided (Yes/No)				

7.0	**Evaporator or Cooler**	
7.1	Type of Chiller (dx / flooded / Hybrid Falling film)	
7.2	Shell OD - mm	
7.3	ASME Stamped (yes or No)	
7.4	Overall length - mm	
7.5	Overall weight - Kg.	
7.6	No. of tubes	
7.7	Tube OD - mm	
7.8	Nature of tubes (Whether integrally finned or tubes carry inserts)	
7.9	Length of tube between tube sheets - mm	
7.10	Material of tube	
7.11	Material of shell	
7.12	Water side surface area - Sq. Mtr.	
7.13	Refrigerant side surface area - Sq. Mtr.	
7.14	Minimum operating charge of refrigerant - Kg	
7.15	Flow rate - Lpm / Gym	
7.16	Leaving water temperature - °C / °F	
7.17	Entering water temperature - °C / °F	
7.18	Refrigerant temperature - °C / °F	
7.19	Temperature difference - °C / °F	
7.20	No. of passes	
7.21	Tube velocity - mps	
7.22	Pressure drop - Water - Kg / Sq.Cm or Ft of water	
7.23	Fouling Factor	
7.24	Min Flow possibility in case of Variable primary flow (30% of design flow)	
7.25	% rate of change of flow / minute, allowed (Min 30%)	

AHU TENDER SPECIFICATION

AIR HANDLING UNITS	CSU	CSU	CSU	HFM	HFM	HFM
CFM						
1. Manufacturer -						
2. Model No. -						
3. Type of unit horizontal or vertical -						
4. Overall dimension mm -						
5. Weight (Including water circulation) Kg -						
6. Noise Level -						
7. Static & dynamic load -						
8. Vibration level -						
9. skin sheet gauge -						
10. Make of the construction material -						
FAN SECTION						
1. Type of fan -						
2. Air quantity. M3/hr -						
3. Total static pressure mm						
4. Fans speed RPM (normal/critical/maximum)						
5. Fan motor HP (connected/consumed) -						
6. Fan efficiency -						
7. Drive efficiency -						
8. Total efficiency -						
9. Outlet velocity mtr/min -						
10. Fan dia. mm -						
11. Balancing (Static and/or dynamic) -						
12. Material of construction -						
13. No. Of Vanes -						
14. Type of impeller blades						
15. Fundamental frequency						
16. Static pressure MM WG -						
17. Dynamic Pressure MM WG -						
18. Operating temperature oC -						
19. Density KG/M3 -						
20. Bearings (type/make) -						
21. Bearings life -						
22. Non-over load power -						

COOLING COIL						
1. Coil fin & tube material & fin spacing mm -						
2. Grand total heat cap. cal/hr						
3. Air quantity through coil M3/hr -						
4. Entering water temperature -						
5. Leaving water temperature -						
6. Entering air temperature. DB -						
7. Entering air temperature. WB -						
8. Leaving air temperature. DB						
9. Leaving air temperature. WB						
10. Re-circulating water quantity ltr/min -						
11. Water quantity through coil ltr/min -						
12. Degree of super heat -						
13. S.H.F. -						
14. A.D.P. -						
15. Bypass Factor -						
16. Pressure drop mm -						
17. Face area M^2 -						
18. Rows deep -						
19. Type of control -						
20. Press. test certificate of coil with pressure rating -						
21. Static load -						
22. Excess capacity required for dust ladden air -						
23. Max. cooling capacity available with offered coil -						
FILTER SECTION						
1. Gross filter area M^2 -						
2. Velocity through filter mtr/min -						
3. Initial Pressure WG -						
4. Pressure drop WG -						
5. Maximum Pressure drop WG -						
6. Efficiency % -						
7. Filter media -						

8. Frame work material -						
9. Static load -						
10. Filter standards -						

ELECTRIC MOTORS FOR EACH AHU						
1. Manufacture -						
2. Model No. & frame size -						
3. Rated output HP -						
4. Range of working voltage -						
5. Rated speed RPM -						
6. Full load current amps -						
7. Class of insulation -						
8. Temperature -						
9. Efficiency & P.F. at 100% & 60% load with each motor -						
10. Total cap. in MFD. of the capacitor with each motor -						
11. Static & Dynamic load						
12. Class of Insulation -						
13. Degree of protection -						
14. Starting torque -						
15. G.D.2 value						

PUMPS TECHNICAL DATA :

Sr.	Particulars	300 TR Water Cooled Screw Chiller with VFD		
		Primary Chilled Water Pump	**Variable Secondary Chilled Water Pump**	**Cooling Water Pump**
A	**PUMPS**			
1	Manufacture			
2	Model No.			
3	Speed RPM			
4	Discharge (LPM)			
5	Head m			
6	BHP			
7	Motor HP			
8	Motor PF			
9	Actual power consumption			
10	Efficiency			
11	Gland leakage losses (LPM)			
12	Type of greasing			
13	Type of bearing & material			
14	Type of casing material			
15	Type of shaft material			
16	Type of coupling			
17	Impeller material			
18	Impeller size			
B	**ELECTRIC MOTORS**			
1	Manufacture			
2	Model No. & frame size			
3	Rated output HP			
4	Range of working voltage			
5	Rated speed RPM			
6	Full load current amps			
7	Class of insulation			
8	Temperature			
9	Efficiency & PF at 100% & 60% load with each motor			
10	Total cap. in MFD. of capacitor with each motor			
11	Static & Dynamic load			
12	Class of Insulation			
13	Degree of protection			
14	Starting torque			
15	GD.2 value			

COOLING TOWER TECHNICAL DATA :

Sr.	Particulars	300 TR Water Cooled Screw Chiller with VFD
	Cooling Tower	
1	Manufacture	
2	Model No.	
3	Water Entering Temp.	
4	Water Leaving temp.	
5	Wet bulb approach	
6	Efficiency	
7	Fan blade material	
8	Sprinkler material	
9	Fan motor HP	
10	Fan motor RPM	
11	Tower range	
12	Air quantity	
13	Actual power consumption	
14	Water flow rate	
15	Pressure drop thru CT	
16	Size of each cell (mm)	
17	Size of cooling tower (mm)	
18	Casing & sump material	
19	Material fills	
20	Material of drift eliminator	
21	Evaporation & drift losses	
22	Accessories provided	

VENTILATION FAN TECHNICAL DATA SHEET :

Sr.	Particulars	Toilet Exhaust	Plant Room Exhaust	Pump Room Exhaust	Car Park Exhaust	Electrical Room Exhaust	STP Exhaust
A	**VENTILATION FANS**						
	Manufacture						
	Diameter mm						
	Speed RPM & HP						
	CFM / Static Pressure						
	Static/Dynamic balancing						
	Overall dimension						
	Type of fan / model						
	Operating weight						
	Noise level @ 3 METER						
	Efficiency						
B	**ELECTRIC MOTORS**						
	Manufacture						
	Model No.						
	Rated output HP						
	Range of working voltage						
	Rated speed RPM						
	Full load current amps						
	Class of insulation						
	Temperature						
	Efficiency & power factor at 100% load with each motor						
	Total capacity in MFD. of the capacitor with each motor						

Signature & Seal of Contractor

Sr.	Particulars	Toilet Fresh Air	Plant Room Fresh Air	Pump Room Fresh Air	Car Park Fresh Air	Electrical Room Fresh Air	STP Fresh Air
A	**VENTILATION FANS**						
	Manufacture						
	Diameter mm						
	Speed RPM & HP						
	CFM / Static Pressure						
	Static/Dynamic balancing						
	Overall dimension						
	Type of fan / model						
	Operating weight						
	Noise level @ 3 METER						
	Efficiency						
B	**ELECTRIC MOTORS**						
	Manufacture						
	Model No.						
	Rated output HP						
	Range of working voltage						
	Rated speed RPM						
	Full load current amps						
	Class of insulation						
	Temperature						
	Efficiency & power factor at 100% load with each motor						
	Total capacity in MFD. of the capacitor with each motor						

SYSTEM TESTING, INSPECTION PROCEDURE & PERFORMANCE TEST READINGS

1.0 INSPECTION PROCEDURE

1.1 Central Air-Conditioning Plant

AllmajorequipmentssuchasChillingmachine,AHU,ElectricalPanel,etc.shallbegotinspected&testedbeforedispatchofequipmentsbytheEngineerinChargeatworksifhesodesires.Alltypeofroutineandtypetestsshallbecarriedoutattheworks.TheEngineershallbefreetowitnessanyoralltestsifhesodesires.IncasetheEngineerinchargeorhisrepresentativeisunable towitnessthetestatthemanufacturer'sworks,thecontractorshallfurnishthemanufacturerstestcertificatetothesatisfactionoftheEngineerincharge.TheACcontractorshallintimatetheEngineerinChargeinadvanceaboutthe date ofreadiness of equipments forinspection& testing. The inspectionprocedurefortestingofACequipmentsaregivenbelow:-

2.0 INITIAL INSPECTION

2.1 Chilling Machine

Salient features such as model no. of compressor, chiller & condenser, dimension of the machine; microprocessor panel etc shall be verified against the requirement.

Manufacturer's internal test certificate shall be scrutinized to check compliance with the requirement as per specification.

Salient features of condenser & chiller such as number of tubes, inside diameter of tubes, tube thickness & material, No. of passes, type of fins, length of condenser & chiller etc. shall be verified.

2.2 Cooling Coils:

Salient features of cooling coils such as material of tube, tube diameter, tube wall thickness, fin material & no. of fins per inch, gauge of fins & no. of rows shall be furnished and verified with reference to contract requirement.

Manufacturer's internal test certificate indicating results of pneumatic / hydraulic pressure test shall be scrutinized to check compliance with the requirement as per specification.

2.3 Air Handling Units:

Salient features such as model, size, physical dimension & other details of various section, fan motor details, fan dimension etc. shall be verified against the contract requirement.

Manufacturer's internal test certificate for the motor and air handling units shall be Furnished and scrutinized as per contract requirement.

Test certificate for static and dynamic balancing of the blower should be furnished.

2.4 Pumps

Salient features such as model and make shall be checked as per contract requirement. The manufacturer's test certificate will be furnished and verified against contract Requirement.

2.5 Switch, Gear, Control Gear, Measuring Instruments & Power / Control Cables

They should be of approved make. For air circuit breakers the contractor shall furnish manufacturer's test certificate and the same shall be verified as per contract requirement.

2.6 Electric Motor

Electric motor should be of approved make. Test certificate for electric motor shall be furnished & verified as per contract.

2.7 Pipes & Valves:

Make of pipe & valves shall be verified as per contract. Wall thickness of pipes shall be verified as per contract.

2.8 Ducting:

The GS sheet used for ducting shall be checked for physical test at site. The physical test should include the sheet thickness, bend test and galvanizing test as per relevant IS specifications.

TESTING & BALANCING

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection. The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

2.9 Thermal Acoustic / Insulation:

Physical verification for thickness and make should be as per contract before application of insulation.

Manufacturer's test certificate for density & thermal conductivity should be furnished.

3.0 FINAL INSPECTION

After completion of entire installation, as per specifications in all respects, the AC contractor shall demonstrate trouble free operation of the AC equipment for a period of 30 working days subject to a minimum of 300 hours of running. Any defects found during this operation shall be rectified immediately before the initial test period of 30 days is over.

The initial test, which has to be carried out by the contractor at his own, expense & shall be as follows but not limited to:

a) To check satisfactory functioning of all major equipments such asChilling m/c,electricalmotors,pumps,coolingtower,switchgear,airhandlers etc.
b) To check alignments of motors.
c) To operate chillingm/c, pumpsets, airhandlers etc. and adjust waterflow in all line i.e. chilled water line and in the coolingcoils.
d) To check and balance air distribution system.

NOTE: All test instruments such as thermometer, psychrometer, pressure gauges, anemometer, flowmeter, decibel meter or the contractor at his own expense shall arrange any other necessary instrument.

After initial test the plant shall be run continuously for a period of 10 working days before the guarantee comes into force. In addition to the initial test as explained in this section the contractor shall also give the two continuous running test of the system during peak summer, monsoon & winter for 10 hrs. For 3 days when the ambient are closed to the designed conditions.

In case, the peak ambient conditions in the respective seasons are not found to be close to

designed ambient conditions, the test shall be conducted on closest ambient conditions and capacity of equipments shall be computed and compared with capacities indicated in the contract. Water and power for testing and commissioning of the system shall be provided free of cost by the Client.

4.0 CAPACITY OF PLANT

The test readings shall be recorded & capacity of various of major equipments such as, compressor, condenser, chiller, cooling coil, cooling tower, fan coil units, pump sets etc. shall be worked out as per computation formulas given in this section.

4.1 PowerConsumption/CapacityOfVariousEquipment.

a. COMPRESSOR

IKW/Ton = Power input in KW Compressor Cap.intons

The contractor shall compare the capacity & IKW/TR of compressor from manufacturers computer selections supplied.

b. CONDENSER / CHILLER

$$\text{Heat Rejection of Condenser} = \frac{\text{Water flow through condenser (Usgpm)} \times \text{Temp. Difference Deg.F}}{24}$$

c. COOLING COILS OF AIR HANDLERS AND FAN COIL UNITS

$$\text{Capacity of cooling coil} = \frac{\text{CFM} \times 60 \times (h_e - h_l)}{\text{Avg.Specific Volume (V)} \times 12000}$$

Where,

h_e =Enthalpyofenteringairinbtu/lb
h_l =Enthalpyof leavingairinbtu/lb
V $=V_e+V_l$
V_e =SpecificvolumeofairenteringCFT/lbofair
V_l = SpecificvolumeofleavingairCFT/lbofair.

The interlocking connection of compressor motor with condenser and chilled water pumps cooling towerfan etc. shall be checked.

PERFORMANCE TEST READING

The Test Readings shall be recorded on hourly basis during the summer / monsoon seasons after satisfactory commissioning of AC System at site as per the Performa indicated in Testing, Adjusting and Balancing Section of Tender Document.

a. OUTSIDE DESIGN CONDITIONS

i. Season :
ii. Drybulbtemp.°C:
iii. Wetbulbtemp.°C :

b. INSIDE DESIGN CONDITIONS IN EACH AREA.

i. Dry bulb temp. °C :
ii. Wet bulb temp. °C :
iii. Relative Humidity % :

c. All electrical panels / cables / starters / single phase preventer etc. shall be tested as per standard code of practice.

5.0 TESTING, ADJUSTING & BALANCING

The AC Contractor shall have a dedicated experienced, specialized, approved, testing and commissioning (T&C)team/agency responsible for coordination with other trades, preparation of T&C plan method statement & T&C procedures, organizing & scheduling the T&C activities along with the progress of works, supervision any re-testing, coordination with third parties for commissioning & certification, organizing & performing testing for satisfaction of all Statutory Bodies, T&C record documentation & handover

1.0 GENERAL

a. Testing, adjusting and balancing of heating, ventilating & air- conditioning systems at site.
b. Testing, adjusting and balancing of HVAC Hydronic system at site.
c. Testing, adjusting and balancing of exhaust system at site.

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

ASHRAE : 2007 HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution system.

d. AC Contractor shall submit a Test, adjust, balance procedure/method statements/ charts for approval to Client.

2.0 PERFORMANCE

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

3.0 DEFINITIONS

a. Test : To determine quantitative performance of equipment.
b. Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)
c. Balance : To proportion within distribution system (submains, Branches and terminals) in accordance with design quantities.

4.0 TESTING, ADJUSTING AND BALANCING (TAB) PROCEDURES

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

5.0 DESCRIPTION OF SYSTEM AND REQUIREMENTS

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

a. All supply, return and outside air systems.
b. All exhaust air systems.
c. All chilled water systems.

d. All cooling tower (condenser) water systems.
e. Emergency purge systems.

6.0 AIR SYSTEMS

6.1 Air Handlers Performance

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

a. Air-IN DB and WB temperature.
b. Air-OUT DB and WB temperature.
c. Dew point air leaving.
d. Sensible heat flow.
e. Latent heat flow.
f. Sensible heat factor.
g. Fan air volume.
h. Fan air outlet velocity.
i. Fan static pressure.
j. Fan power consumption.
k. Fan speed.

6.2 Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts.

6.3 The Preparatory Work

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

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

7.0 HYDRONIC SYSTEM BALANCING

7.1 The Hydronic system shall involve the checking and balancing of all water pumps, piping network (main & branches), the heat exchange equipment like cooling and heating coils, condensers and chillers and cooling towers in order to provide design water flows.

7.2 The essential preparation work, must be done by the HVAC Contractor prior to actual testing, adjusting and balancing of HVAC system and ensure following :

a. Availability of co-ordinated drawings and approved submittals and system sketch with design water flows specified thereon.
b. Hydronic system is free of leaks, is hydrostatically tested and is thoroughly cleaned, flushed and refilled.
c. Hydronic system is vented.

7.3 The AC Contractor shall confirm completion of the basic procedures and prepare check lists for readiness of system balance.

a. Check pumps operation for proper rotation and motor current drawn etc.
b. Confirm that provisions for TAB measurements (Temperature, pressure and flow measurements) have been made.
c. Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the preset position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.

Balancing work for both Chilled Water System and Condenser Water System shall be carried out in a professional manner and test reports in the specified format shall be prepared and presented to the Client / Consultant for endorsement.

8.0 READINESS FOR COMMENCEMENT OF TAB

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

9.0 TAB INSTRUMENTS

9.1 Air Measuring Instruments

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

9.2 Hydronic Measuring Instruments

a. For measurement of water flow across balancing valves, instruments as provided by the manufacturer of the valves specific to the type of valves shall be need. This shall include but not be limited to differential pressure manometers. Temperature shall be measured using electric thermometers from thermowells provided at strategic location by the HVAC Contractor. The water balancing shall be carried out being computer simulation program provided / certified by the balancing valve manufacturer.

9.3 Rotation Measuring Instrument

a. Electronic Digital Tachometer.

9.4 Temperature & RH Measuring Instrument

a. TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

9.5 Electrical Measuring Devices

a. Clamp on Volt ammeter.
b. Continuity Meter.

9.6 Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each circulating water pump, water chilling unit, air handling unit and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the PMC.

Sound level readings shall be taken at ten (10) locations in the building as selected by the Contractor / Client. The readings shall be taken on an Octave Band analyzer in a manner acceptable to him. The AC Contractor shall submit test equipment data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All tests shall be performed in the presence of Client / Consultant or his authorized representative.

10.0 SYSTEM READY TO BALANCE CHECK LIST (NOT LIMITED TO FOLLOWING)

Sr.	Description	Ready		Date Corrected
		Yes	No	
1	**HVACUnits(AHU)**			
a	**General**			
i	Louversinstalled			
ii	Manualdampersopen&locked			
iii	Automaticdamperssetproperly			
iv	HousingConstructionleakage			
v	Accessdoors-leakage			
vi	Condensatedrainpiping			
vii	Pan Freefromdirtanddebris			
viii	Nameplatedata			
b	**Filters**			
i	Type			
ii	Size			
iii	Number			
iv	Clean			
v	Frame-Leakage			
c	**Coils(Hydronic)**			
i	Sizeandrows			
ii	Fin spacing and condition			
iii	Obstructions and / or debris			
iv	Airflow and direction			
v	Piping leakage			
vi	Correct piping Connections			
vii	Flow Valves open			
viii	Set Air vents			
ix	Steam traps provision made of TAB Measurements			
d	**Fans**			
i	Rotation			
ii	Wheel Clearance			
iii	Balance Bearing			
iv	Motor lubrication			
v	Drive alignment			
vi	Belt tension			
vii	Drive set screws tight			
viii	Belt guard in place			
ix	Flexible duct connector alignment			
x	Starters and disconnect switches			
xi	Electrical service & connections			
xii	Nameplate data			
e	**VibrationIsolation**			
i	Springs&Compression			
ii	BaseLevel&Free			

Sr.	Description	Ready Yes	Ready No	Date Corrected
2	**DuctSystem**			
a	**General**			
i	Manual dampers open & locked			
ii	Access doors closed and tight			
iii	Fire dampers open and accessible			
iv	Terminal units open and set			
v	Registers and diffusers open and set			
vi	Turning vanes in square elbows			
vii	Provisions made for TAB measurements			
viii	Systems installed as per plans			
ix	Ductwork sealed as required			
b	**Architectural**			
i	Windows installed and closed			
ii	Doors closed as required			
iii	Ceiling plenums installed and sealed			
iv	Access doors closed and tight			
v	Air shafts and openings as required			
3	**Pumps**			
a	**Motors**			
i	Rotation Lubrication Alignment			
ii	Set screws tight			
iii	Guards in place			
iv	Tank level and controls			
v	Starters and disconnect switches			
vi	Electrical service & connections			
vii	Nameplate data			
b	**Piping**			
i	Correct flow			
ii	Correct connections			
iii	Leakage			
iv	Valves open or set			
v	Strainer clean			
vi	Air vented			
vii	Flexible connectors			
	Provisions made for TAB measurements			
c	**Bases**			
i	Vibration isolation			
ii	Grouting			
iii	Leveling			

Sr.	Description	Ready Yes	Ready No	Date Corrected
4	**Hydronic Equipment**			
a	**Heat Exchangers**			
i	HW coil			
ii	Correct flow and connections			
iii	Valves open or set			
iv	Air vents or steam traps			
v	Leakage			
vi	Provisions made for TAB measurements			
vii	Nameplate data			
B	**Cooling towers**			
i	Correct flow and connections			
ii	Valves open or set			
iii	Leakage			
iv	Provisions made for TAB measurements			
v	Sump water level			
vi	Spray nozzles			
vii	Fan/pump rotation			
viii	Motor/fan lubrication			
ix	Drives and alignment Guards in place			
5	**Refrigeration Equipment**			
i	Crankcase heaters energized			
ii	Operating controls and devices			
iii	Safety controls and devices			
iv	Valves open			
v	Piping connections and flow			
vi	Flexible connectors			
vii	Oil level and lubrication			
viii	Alignment and drives			
ix	Guards in place			
x	Vibration isolation			
xi	Starters, contactors & disconnect switches			
xii	Electrical connectors			
xiii	Nameplate data			
6	**Hydronic Piping systems**			
i	Leak tested			
ii	Fluid levels and make-up			
iii	Relief or safety valves			
iv	Compression tanks and air vents			
v	Steam traps and connections			
vi	Strainers clean			
vii	Valves open or set			
viii	Provisions made for TAB measurements			
	Systems installed as per plans			

 Signature & Seal of Contractor

Sr.		Description	Ready Yes	Ready No	Date Corrected
7		**ControlsSystem**			
	i	Datacenters			
	ii	Outdoorreturnairreset			
	iii	Economizer Staticpressure Roomcontrols			
8		**OtherChecks**			
	i	Othertradesorpersonnelnotifiedof TABworkrequirements.			
	ii	Preliminarydatacomplete			
	iii	Testreportformsprepared			

11. INSTRUMENTCALIBRATIONREPORT

PROJECT_____

Sr.	INSTRUMENT/ SERIAL NO.	APPLICATION	DATESOF USE	CALIBRATION TESTDATE
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				

REMARKS

TEST DATE_____READINGS BY_____

12. PUMP TEST REPORT

PROJECT_____

Sr.	DATA	Pump No.1	Pump No.2	Pump No.3	Pump No.4	Pump No.5
1	LocationService					
2	Manufacturer Model					
3	SerialNumber					
4	GPM/HeadReq. NPSH					
5	PumpRPMImpellerDia.					
6	MotorMfr./Frame Motor					
7	HP/RPM					
8	Volts/Phase/Hertz F.L					
9	Amps					
10	SealType					
11	PumpOff - Press. ValveShutDiff.					
12	Act.ImpellerDia.ValveOpendiff.					
13	Valve Open					
14	GPM Final					
15	Discharge Pressure					
16	Final Suction Press					
17	Final Ap					
18	Final GPM					
19	Voltage / Amperage					

REMARKS

TEST DATE_____READINGS BY_____

Signature & Seal of Contractor

14. AIR HANDLING EQUIPMENT TEST REPORT

PROJECT_____

SYSTEM/UNIT_____**LOCATION**_____

Description	**Data**
a) UNIT Make/Model No. Type/Size	
Serial Number	
Arr./Class Discharge Pully dia/Bore	
No. Belts/make/size No.Filters/type.size (Pre.) No.Filters/type/size (secondary)	
b) MOTOR	
Make / Frame H.P / RPM Volts/Phase/cycles F.L amps.	
Pully Dia/Bore	
Pully /Distance. Total Cfm	
Total S.P Fan RPM Motor Volts. T	
Outside air Cfm Return air Cfm Discharge S.P Cooling Coil S.P Filters S.P	

REMARKS

TEST DATE_____**READINGS BY** _____

 Signature & Seal of Contractor

15. COOLING / HEATING TEST REPORT (AHU)

PROJECT_____

COIL DATA	**COIL NO.**	**COIL NO.**	**COIL NO.**	**COIL NO.**
System Number				
Location				
Coil Type				
No. Rows Fins/In				
Manufacturer Model Number Face Area, Sq.Ft.				

TEST DATA	**DESIGN/ ACTUAL**	**DESIGN/ ACTUAL**	**DESIGN/ ACTUAL**	**DESIGN/ ACTUAL**
Air Qty. CFM Air Vel.FPM Press.Drop In. Out.Air DB/WB Ret. Air DB/WB Ent.Air DB/WB Lvg.Air DB/WB Air AT				
Water flow. GPM Press.Drop.PSI Ent.Water Temp Lvg .Water Temp Water AT				
Exp.Valve/Refrig				
Refrig.Suction Pr.				
Refrig.Suct.Temp Inlet				
Steam press.				

REMARKS

TEST DATE _____**READINGS BY** _____

16. FAN COIL TEST REPORT

PROJECT_____

DATE_____LOCATION_____

MANUFACTURER_____

AREA SERVED	FCU MAKE	CAPACITY TR	TEMPERATURE DEG. F	
			GRILLE	ROOM
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				

REMARKS

TEST DATE _____READINGS BY _____

17. FAN TEST REPORT

PROJECT_____

FAN DATA	**FAN NO.**	**FAN NO.**	**FAN NO.**
Location Service Manufacturer Model No. Serial No. Type / Class			
Motor Make / Style Motor H.P/RPM/ Frame Volts/Phase/Cycles			
F.L Amps.			
Motor pully Dia./Bore Fan pully Dia./Bore No. Belts/ Make/Size Pully Distance.			
CFM			
FAN RPM S.P IN/OUT TOTAL S.P Voltage Amperage			

REMARKS

TEST DATE _____READINGS BY _____

18. RECTANGULAR DUCT TRAVERSE REPORT

PROJECT_____SYSTEM_____

LOCATION / ZONE_____ACTUAL AIR TEMP. _____DUCT S.P_____

DUCT REQUIRED ACTUAL
SIZE____SQ.FT._____FPM ____CFM_____FPM ____CFM_____

POSITION	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
VEL1OCITY SUBTOTALS											

REMARKS

TEST DATE_____READINGS BY _____

19. GRILLES AND DIFFUSERS TEST REPORT

PROJECT_____SYSTEM _____

OUTLET_____MANUFACTURER_____

TEST APPARATUS_____

S/N	AREA SERVED	OUT LET NO./TYPE/SIZE VEL/CFM	DESIGN CFM/VEL	PRLIMINARY	FINAL VEL/CFM
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

REMARKS

TEST DATE_____READINGS BY _____

A. LT CABLES (1.1 KV GRADE)

i. TESTS & INSPECTION

The Megger value in normal dry weather shall be 50 mega ohm for 1.1 KV grade cable. Cables shall be tested at works for the following tests before being dispatched to site by the project team:

a) Insulation Resistance Test.
b) Continuity resistance test.
c) Sheathing continuity test.
d) Earth test.(in armoured cables)
e) Hi Pot Test.

Test shall also be conducted at site for insulation between phases and between phase and earth for each length of cable, before and after jointing. On completion of cable laying work, the following tests shall be conducted in the presence of the Owner's site representative:

a) Insulation Resistance Test(Sectional and overall)
b) Continuity resistance test.
c) Sheathing continuity test.
d) Earth test.

All tests shall be carried out in accordance with relevant Standard Code of Practice and Electricity Rules. The Contractor shall provide necessary instruments, equipment and labour for conducting the above tests and shall bear all expenses in connection with such tests. All tests shall be carried out in the presence of the PMC / Owner representative.

B. CHILLERS

i. CODES & STANDARDS:

a) AHRI 550/590 or EUROVENT
b) ANSI / CE PED Directive

Tests to be carried out along the all productive process as imposed by ISO9001. Possibility to have performance and acoustical witness tests, with the support of qualified technical operators. Performance tests should measure electric data, water flows, operating temperature, absorbed and given power, both at full load and partial load condition. It's should even be possible to have a simulation of the most common alarm states and the pressure drops (water side) measurements.

The acoustical tests should allow verifying level of sound emissions of the unit; tests to be performed on repeating measurements of sound pressure in determined points, positioned on an ideal grid with walls 1 meter distance from the unit panels. For every measuring point a spectrum in octave band for sound pressure and the average value to be reported to the customer. The average global values for pressure at 1 meter, according to ISO3744, and the average sound power referred to the whole unit, to be counted.

ii. FACTORY TESTING

B) CAPACITY& EFFICIENCY:

One Chiller shall be tested for performance at Manufacturer works at 100% & 25% at AHRI condition and at 75% and 50% at Design condition (at constant condenser entering temperature) for verification of IKW/TR & Capacity as per submission of AHRI selection data sheet. If the inspection is outside India, the contractor shall visit and witness the test and shall submit photographs/proof to ascertain his witnessing the testing. The Client / Consultant representative (5 PAX) may also witness the test. The cost of their visit shall be borne by the Client. However, necessary coordination shall be arranged by the Contractor for their visit. In case of failure of any equipment during testing, the Contractor shall be bound to arrange for subsequent inspections. All the expenses (including travel, boarding etc.) for such inspections shall be borne entirely by the Contractor.

C. PUMPS

i. TESTS & INSPECTION

Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested at factory as per relevant BIS codes. Routine and type test certificates shall be furnished for the pumps. A standard hydrostatic test shall be conducted on the pump casing with water at 1.5 times the maximum discharge head or twice the rated discharge head., whichever is higher. While arriving at the above pressure, the maximum suction head shall be taken into account. The hydrostatic tests on the casing shall be conducted for a minimum duration of 30 minutes.

ii. PERFORMANCE TEST

(c) Standard Running Test

The pumps shall be tested as per IS 5120, at rated speed at SUB-CONTRACTOR's works to measure capacity, total head, efficiency and power. The negative tolerance on efficiency shall be limited to 2.5% (not 5 % as indicated in IS 5120. These tests shall form the basis for acceptance of pumps except for vibration and noise. The pumps shall be tested over the range covering from shut-off head to the maximum flow. The duration of the test shall be minimum one hour. Minimum five readings approximately equidistant shall be taken for plotting the performance curves.

(d) NPSH TESTS

NPSH tests shall be conducted with water as the medium.

(e) Mechanical Balancing

In addition to static balancing, impeller and balancing drum shall be balanced dynamically at or near the operating speed.

(f) Field Testing

After installation, the pumps shall be subjected to testing at site also. If the field performance is found not to meet the requirements regarding vibration and noise as specified, the equipment shall be rectified or replaced by the CONTRACTOR, at no extra cost to the EMPLOYER.

D. COOLING TOWERS

Capacity of the cooling tower shall be computed from the measurements of water flow, incoming/outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption for cooling towers shall be computed from measurements of incoming voltage and input current.

E. VRF AIRCONDITIONING SYSTEM

i. TESTING

a) Routine and types tests for various items of equipment shall be performed at the contractor's work and the test certificated furnished. Functional test shall be conducted at site.

b) The performance test to determine whether OR not the full indent of the specification is met shall be conducted by the contractor. After notification to the Employers that the installation has been completed and the system has run continuously for a period of at-least two weeks, the contractor shall conduct under the direction of the Consultants & in the presence of Employer's representatives perform such test as specified to establish the capacity of various equipment supplied and installed by the contractor.

c) The contractor shall operate test and adjust the air conditioning system units, fans, motors, all air-conditioning appliances including adjustments of regulators dampers etc.

d) All test equipment, labour, operating personnel required for this test shall be furnished by the contractor to enable the system to be put in continuous running test for a period of 3 days after all other tests and adjustments have been made.

The contractor shall make arrangement of electrical power and water for testing. The performance test shall be conducted during peak summer and peak monsoon.

ii. TEST READINGS

The following readings shall be recorded hourly during the tests and capacity of the plant shall be computed.

a) Compressor

1. Suction pressure – Kg / Cm² (PSI)
2. Suction Temperature – °C / (°F)
3. Discharge pressure – Kg / Cm² (PSI)
4. Discharge Temperature – °C (°F)
5. Oil Pressure – Kg / Cm² (PSI)
6. Compressor Speed – RPM
7. Motor – °C (°F)
   - i. Volts – Volts
   - ii. Current – Amps
   - iii. Power factor –

8. Power consumption for
   i. 100% Load –
   ii. 75% Load –
   iii. 50% Load –

b) Condenser

1.	Refrigerant condensing pressure	–	Kg / Cm² (PSI)
2.	Refrigerant condensing temperature	–	°C (°F)
3.	Water flow rate	–	Ltr. / Sec (GPM)
4.	Entering Water Temp.	–	°C (°F)
5.	Leaving Water Temp.	–	°C (°F)
6.	Pressure drop through condenser	–	Kg / Cm² (PSI)

c) Indoor Units

1.	Air velocity	–	M/Hr. (FPM)
2.	Coil Face Area	–	M²(SFT)
3.	Air Quantity	–	Cu. M/Hr. (CFM)
4.	Entering Air Temp. DB.	–	°C (°F)
5.	Entering Air Temp. WB.	–	°C (°F)
6.	Leaving Air Temp. DB.	–	°C (°F)
7.	Leaving Air Temp WB.	–	°C (°F)

d) Controls, Interlocks etc.

The observations of the test shall be recorded for each item separately.

F. AIR HANDLING UNITS

i. Factory performance testing to establish the cooling capacity of the unit, air flow rate , dry bulb and wet bulb temperatures of air entering and leaving the coil of the air handling unit using PLC controlled graphical display. All the results must be fully computerized and can be seen on real time basis.

ii. The testing setup shall be in accordance with DIN EN 14511. Minimum 4 hours continuous real time readings should be recorded for computation of operational parameters. Additionally , electrical safety Hi-pod testing , dry run testing for control logic , thermal bridging test and leakage testing of cabinet at works must be complied with as part of performance test of the air handling unit, if Specified in BOQ.

iii. Flow measurements shall be by an anemometer and temperature measurements by accurately calibrated mercury- in-glass thermometers. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

G. DUCTING (Leak Test)

After duct installation, a part of duct section (approximately 5 % of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA - “HVAC Air Duct Leakage Test Manual” (First Edition)

H. AIR DISTRIBUTION SYSTEM

i. TESTING & BALANCING

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection.

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 balancing of air quantity through each grille or diffuser shall be recorded and submitted to the Consultant / Employer for approval.

The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

I. PIPING (Pressure Test)

All water piping shall be tested to hydrostatic test pressure of at-least two times the maximum operating pressure, but not less than 10 Kg/cm2 for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Consultant. Piping repaired subsequent to the above pressure shall be retested in the same method as mentioned above.

i. TESTING

a. During construction, the contractor shall properly cap all lines, so as to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.

b. All piping shall be tested to hydrostatic test pressure of atleast two times the maximum operating pressure, but not less than 10 kg per sq. cm gauge for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved

c. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

d. Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.

e. The Contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Owner's site representative.

f. The contractors shall provide temporary pipe connections to initially by-pass condenser/chiller and circulate water through condenser/chilled water pipe lines for minimum 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.

g. Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils & other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, Contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up

and re-finishing of floors and walls if required.

h. After the piping has been installed, tested and run for atleast three days of eight hours each, all insulated exposed piping in plant room shall be given two finish coats, 3 mils each of approved colour, conforming to relevant BIS Codes. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows. For painting of insulated and clad pipes refer to Insulation section.

i. After testing, all systems shall be chemically cleaned. After cleaning, the pipe work should be rinsed multiples times until the system is neutral. Before handover Owner's site representative shall be provided with certificate of cleaning of pipe systems, signed by the contractor.

j. The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.

ii. BALANCING

a. After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.

b. All balancing valves, Automatic control valves and two-way diverting valves shall be set for full flow condition during balancing procedure. Each water circuit shall be adjusted thru balancing valves provided for this purpose; these shall be permanently marked after balancing is completed, so that they can be restored to their correct positions, if disturbed.

c. Complete certified balancing report shall be submitted for evaluation and approval by Owner's site representative. Upon approval, four copies of the balancing report shall be submitted with the as-installed drawings and completion documents.

J. FANS

i. PRESSURIZATION FANS

Factory performance test required conforming all rated and duty parameters as per IS 325 standard.

ii. CABINET & INLINE FANS

Capacity of all fans shall be measured by an anemometer. Measured airflow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current. Contractor has to carry out the field balancing, if required.

K. PANELS & SWITCH BOARDS

i. Physical, Electrical, and Operational tests of all Breakers / Switches.

ii. Operational check of all meters and relays.

iii. Dielectric strength test for insulation at 2.5kV for 1 sec.

iv. Insulation resistance test at 1000V megger,

v. Protective measures and continuity of circuits, as per IS: 8623-I, 1993.

vi. Testing of protection relays by secondary injection kit before commissioning.

vii. Interlocking Function Test.

viii. Earth continuity test between various Non-current carryings parts of equipment steel work etc. & the earth bus provided in the panel.

ix. Test Certificate Type & Routine

Test results for routine tests conducted at works should be submitted. Type tests as per IS: 8623 - Part I for Short circuit, Temperature rise, Degree of protection to meet the specifications and B.O.Q must be furnished.

APPROVED MAKES LIST :

Sr.	Component	Approved Make
1	Screw Chillers	Climaveneta / Daikin / Dunham Bush / Voltas / Trane
2	Cooling Tower (CTI Approved)	Advance / Mihir / Paharpur
3	Smart Air Handling Unit	VTS / Stulz / Edgetech / Citizen
4	Indoor Units	
a	VRF Units	Daikin / Mitsubishi Electric / Toshiba / Samsung / Blue Star / Voltas / LG / Hitachi
b	Split Units	Blue Star / Daikin / Carrier / LG / Mitsubishi Electric / Samsung / Hitachi
c	PAC Units	Stulz / Vertiv / Climaveneta
5	Filters	AAF / Mechmark / Dyna
6	Fans	
a	Centrifugal Fan	Kruger / Caryaire / Nicotra / Green Heck
b	Inline Fan	Kruger / Caryaire / Nicotra / Green Heck
c	Propeller Fan	GEC / ACCO / Khaitan / Orient / Crompton
d	Axial Fans	Kruger / Caryaire / Nicotra / Green Heck
e	Jet Fans	Kruger / Caryaire / Nicotra / Green Heck
7	Dry Scrubber	Rydair / Espair
8	Duct Work	
a	G.I. Sheets	Sail / Nippon / National / Jindal (JSW)
b	Aluminium sheet	Hindalco / Sail
c	Pre-insulated ducts	Asawa / Zeco / Unigulf
9	Insulation	
a	Fibreglass	FGP / UP Twiga / Khimco
b	Expanded Polystyrene	Beardsell / Cooline
c	Expanded Polyethylene	Nikifoam / Profeel
d	Nitrile rubber	Aeroflex / Armaflex / K-Flex
10	Grilles / Diffusers / Dampers & VAV Boxes	Cosmos / Dynacraft / Caryaire
11	PVC Eliminators / Air Inlet Louvers	Munters / SM Plastics / Approved Eqvt
12	Piping	
a	Copper Piping	Rajco / Mehta / Parasmani
b	Chilled Water Piping	Tata / Jindal / Zenith
c	PVC Piping	Supreme / Prince / Approved Equivalent - ISI
13	Duct / Pipe Supporting System	Mupro / Gripple / Walraven
14	Cushy Foot Mounts	Dunlop / Resistoflex / Poly Bond
15	Valves	
a	Butterfly Valve	Advance / Audco / BBVI / Saunders
b	Balancing Valve	Advance / ITT Bell & Gossett / Danfoss / Flowcon / T&A

c	Ball Valve	RB / Cimberio
d	Wafer Swing Check Valve	Advance / Flovel
e	“Y” & Pot Strainer	Advance / Trishul / Leader / L&T
f	Automatic Air Purging Valve	Flamco / Itap
g	Strainers / Gate / Globe Valves	Advance / Trishul / Leader
h	Mixing / 2 OR 3 Way Valves	Belimo / Honeywell / Schneider / Siemens
i	Motorised Valve	Belimo / Honeywell / Schneider / Siemens
j	Motorised Valves For FCU	Belimo / Honeywell / Schneider / Siemens
k	Energy Valves	Belimo
l	PIBCV	Belimo / Siemens
16	Pumps	Grundfos / Xylem / Armstrong
17	Variable Pumping System	Grundfos / Xylem / Armstrong
18	Variable Speed Drives	Danfoss / Hitachi / Yaskawa
19	Closed Expansion Tank	KD Agencies / Xylem / Grundfos
20	Air Separator	KD Agencies / Xylem / Grundfos
21	Motors	Crompton / Bharat Bijlee / NGEF
22	Cables	
a	Power Cables	ICC / CCI / Gloster
b	Control Cables	Finolex / Polycab
c	Signal Cables	Ratron / Associated
23	Controls / Measurement Instruments	
a	Thermometers	H. Guru / Teddington
b	Water Pr. Gauges	H.Guru / Fiebig
c	Solenoid Valves	Sporlan
d	Flare Nuts / Cu. Fittings	Castel / Kim
e	Proportionate Controller	Honeywell / Schneider / JCI
f	Voltmeter / Ammeter	Enercon /A/E – Imp/ Trinity
g	Flow Meters	Honeywell / Schneider / JCI
h	Energy Meter	IME / Ducati / L&T / Enercon / Siemens
i	Pressure Transmitter	Honeywell / Schneider / JCI
Sr.	**Component**	**Approved Make**
j	BTU Meters	Kamstrup / Siemens / Landys + Gyr / Engelmann
24	PAC Units	Stulz / Vertiv / Schneider / Climaveneta
25	Circuit Breakers	Schneider / Merlin Gerin / ABB / English Electric / L&T / C&S
26	Starters	Schneider / L&T / TC
27	Push-Buttons / Overload Relay	Schneider / L&T / C&S / RASS
28	Transducers	
a	Power Transducers	Mecon

b	Frequency Transducer	Enercon / Situ
c	Current Transducer	Enercon / Situ
d	Power Factor Transducer	Enercon / Situ
e	Kilowatt Hour Transducer	Enercon / Situ
f	Voltage Transducer	Enercon / Situ
29	Sensors	
a	CO / CO_2 Sensors	Honeywell / Greystone
b	Immersion Temperature Sensor	Honeywell / Schneider / Greystone
c	Duct Temperature Sensor	Honeywell / Schneider / Greystone
d	Outside Temperature Sensor	Honeywell / Schneider / Greystone
e	Outside Rh. Sensor	Honeywell / Schneider / Greystone
f	Outside Rh / Temp. Sensor	Honeywell / Schneider / Greystone
g	Air Quality Sensors	Honeywell / Schneider / Greystone
h	Ph Sensor	Kele
I	Water Hardness Analyser	Kele
j	Thermostat For FCU	Honeywell / Schneider / JCI
30	Switches	Schneider / L&T / C&S / English Electric
a	Water Flow Switches	Honeywell / Schneider / JCI
b	Differential Pr. Switches	Honeywell / Schneider / JCI
c	Level Switches	Honeywell / Schneider / JCI
31	Computer	IBM / HP / Compaq / Wipro
32	Printer - Inkjet	HP / Epson
33	DDC Controller	Honeywell / Schneider / Siemens / Beckhoff
34	System Integration Units	Honeywell / Schneider / JCI
35	Automatic Tube Cleaning System	HVS / CET Enviro / Ecomax
36	VRF Units	Daikin / Mitsubishi Electric / Toshiba
Sr.	**Component**	**Approved Make**
37	Panels	
a	Readymade panels as per IEC 61439 1& 2	Schneider/ Legrand / L& T / siemens
b	APFC standard capacitors (APP/MD)	Subodhan / Visa / Shreem / PMX / Vishay / L& T/ Neptune
c	ACB	Schneider / Siemens / Legrand / Mitsubishi
d	MCCB	Schneider / ABB / Siemens / Legrand
e	RCCB	Legrand / Schneider / Hager / Siemens / Mitsubishi / Havells
f	MCB	Legrand / Schneider / Hager / Siemens / Indo Asian / Eton / Mitsubishi / Havells
g	MCB DB	Legrand / Schneider / Siemens / Havells
h	Load manger / digital meter	HPL / Secure / Conserve / Elemeasure

i	APFC Relay	Beluk / L&T / Electronicon / Sycon / Shrem
j	Contactor	Siemens / Schneider / Legrand
k	Fuses	Schneider / Siemens / Legrand
l	Push Buttons	L&T / Rass / Teknik / Siemens
m	Pilot Lamps (Indications) LED	Altos / Teknik / Rass / siemens
n	PLC	Allen Bradly / Messung
o	Annunciator	Minilec / Equiv
p	Terminals	Wago / Elmex / Connectwell
q	Relays (protections)	Alsthom / L&T / ABB / Schneider
r	Auxiliary relay	OEN / Equiv
s	Industrial sockets	Legrand
t	Motors	Kirloskar / Crompton / ABB / Siemens
u	Motor starter	L&T / Siemens / Schneider / ABB
v	SPD	Obo Betterman / Phoenix / Emerson / Cape / Omcons
w	Readymade panel (NFPA 70 e base type tested for internal arc.is 61439 ,is 61641	Schneider / ABB / Siemens / Marine
x	**RTPFC** with / without reactor	une / Clariant / Sycon / Power Matrix / Subodhan / Powerfield
y	Meter (Analog)	Rishab / L&T / AE / Secure
z	Sandwich Busduct / Readymade Busbar	Schneider / Siemens. / Zucini / Legrand
aa	UPS	Eton / Socomec / Emerson/ Numeric
ab	CTS' / PT	AE / Kappa / C & S / Newtek
	Cable	
a	AL. / CU. conductor cables XLPE / PVC	Finolex / KEI / RPG / Polycab / RR
b	CU. Conductor unarmoured cables	KEI / RR / LAPP / Finolex / Polycab
c	Heavy Duty Brass cable gland	HMI / BRACO / Jainson / Havells
d	CU. Lugs	Dowell's / Atlas
e	AL. Lugs	Dowell's / Atlas
f	Cable trays & accessories	Elecon / Profab / Indiana/ Legrand / Asia Fab / Electra Fab

ANNUAL MAINTENANCE CONTRACT FOR HVAC

SCOPE OF WORK

1) Maintenance of Air-conditioning System, Chillers and minor and major repairs of the system.
2) Check and service all the equipment's every three months i.e. four times in a year.
3) Attend any numbers of complaint within 3-6 hrs.
4) Checking the functioning of unit.
5) All filter cleaning to be done quarterly.
6) Equipment will be checked for its proper working readjustment if necessary.
7) Replacements of defective / worn-out parts due to normal wear and tears.
8) Checking the gas pressure and refilling if required.
9) Cleaning of drainpipe external to the equipment.
10) The maintenance service is made available even after normal working hours and on holidays.
11) Gas charging of all the air-conditioning system.
12) Leak test of the air-conditioning if required.
13) Repairs of air filters and display kit.
14) Part to be include : Fan motor, Blade, Gas charging, and PCB kit.

EXCLUDING:

Plastic parts, remote control, Compressor, grill, metal ducting, diffusers, welding work, and condensers.

PENALTY

i) As the work involved is quite specialized and continuous monitoring is required. A penalty of Rs.1000/- (Rupees One thousand only) per day will be imposed if the problem related to air-conditioning is not solved within 24 hrs.

Place: Accepted

Date: Signature and Stamp of contractor

TECHNICAL SPECIFICATIONS OF THE 150 KVA/ KW MODULAR UPS WITH LITHIUM ION BATTERIES HAVING THIRTY MINUTES BACK UP TIME (AT 150 KVA/KW) (To be filled in and to be uploaded /submitted by the Bidder)

Sl.No.	**Parameter**	**Requirement / Specification**	**Confirmation by Bidder YES / NO.** (Strike off whichever is not applicable)
1	Type of UPS	Modular and Scalable with Hot Swappable Power Modules, Static Switches and control module.	YES / NO
2	Type of Application	Computers/printers/CCTV/Alarm Systems/ Emergency lighting etc	YES / NO
3	Capacity of UPS	150 kVA (2 x 150kVa)	YES / NO
4	Technology	a. DSP Based True Online Double Conversion with latest and advanced IGBT PWM technology Rectifier & inverter b. and advanced IGBT PWM technology Rectifier & inverter	YES / NO
		c. Parallel capability upto 10 nos. of Power Modules for vertical redundancy and upto 8 UPS units/modules for capacity	YES / NO
		d. Redundant System with redundant and hot swappable controller, Redundant and hot swappable Aux Power Supply.	YES / NO
		e. Dual CAN Bus within frame & Redundant CAN bus between parallel systems to enable UPS to be removed or inserted in parallel configuration without need of transferring it to bypass mode.	YES / NO

		f. UPS should have feature to enable automatically transferring some modules to sleep mode in case of applied load is less than certain load percentage. Modules would be switched periodically & in rotational manner under this condition.	YES / NO
		g. UPS should have feature for testing of the unit for load testing without external load.	YES / NO
5	Capacity of Rack for mounting UPS modules	For 150 kVA (2 x 150kVA rack) (Single Input and output will be provided by Bank(SBI), necessary paralleling accessories to be considered by the bidder / UPS vendor)	YES / NO
6	Capacity range of single UPS module	Min 25 kVA/kW & Max 50 kVA/kW	YES / NO
7	Nominal Input Voltage	380/400/415 V (user selectable) 3 Phase 4 Wire System / 3 Phase 3 Wire System	YES / NO
8	Input Voltage Range	350 V AC to 460V AC	YES / NO
9	Input Frequency Range	50 Hz ± 10% (45 to 55 Hz)	YES / NO
10	Input Power Factor	0.99 for any load	YES / NO
11	Input Current Harmonic Distortion (THDi)	≤3 at full load.	YES / NO
12	Output Voltage	380 /400/415 V user selectable 3 Phase 4 Wire + Ground	YES / NO
13	Output Voltage Regulation	≤1% Max	YES / NO
14	Out Put Wave Form	Pure Sine Wave	YES / NO
15	Output Frequency	50 Hz	YES / NO

16	Output frequency regulation	±0.05 Hz free running	YES / NO
17	Output Power factor	Unity	YES / NO
18	Output Voltage Distortion (THDv)	≤2% for linear load & ≤5% for non linear load.	YES / NO
19	Output Crest factor	3 : 1	YES / NO
20	Transient recovery Time	<20 msec	YES / NO
21	Overload capability	120% for 10 Minutes 150% for 1 Minutes	YES / NO
22	Efficiency	Minimum 96% at 25 to 100% of load in double conversion mode at input voltage with battery fully charged.	YES / NO
23	Battery Charger	UPS Inbuilt Battery charger compatible for Lithium Ion Batteries	YES / NO
24	Input Phase Sequence Correction	Inbuilt feature to be provided for as to avoid UPS transferring to battery mode in case of phase sequence change at input. UPS should continue to work on mains mode.	YES / NO
25	Automatic & Bi-directional static bypass	The integral bypass shall perform an automatic transfer of the critical load from the inverter to the bypass, in the events of overload , over temperature, or inverter failure conditions with zero transfer time and retransfer from bypass to inverter on removal of overload and fault conditions.	YES / NO
26	Cable Entry	UPS should have top cable entry	YES / NO
27	Digital Touch Screen Display for	a.Input AC Voltage, Current & Frequency	YES / NO
		b.Output AC Voltage, Current & Frequency	YES / NO
		c.Load (in kVA/kW/Percentage)	YES / NO
		d. Battery Voltage	YES / NO
		e. Battery Current	YES / NO

		f. Event Log to display a log of status and alarm events to be provided on the front panel display	YES / NO
		g. UPS should have capability to capture wave forms pre & post event occurs.	YES / NO
28	Inbuilt Protections	a.Over load / Over Current protection	YES / NO
		b. Short circuit Protection	YES / NO
		c.Over temperature Protection	YES / NO
29	Built in Audible Alarms	a. Mains Failure	YES / NO
		b. Low Battery	YES / NO
		c. Over Load	YES / NO
		d. Fault	YES / NO
		e. On Battery / Bypass	YES / NO
30	Remote UPS Monitoring Kits	Be able to connect to a LAN network using the main network communication protocols (SNMP or TCP/IP or HTTP)	YES / NO
31	SNMP card / Web management System	To be provided	YES / NO
32	Operating Ambient Temperature	0 to 40 degree Celsius	YES / NO
33	Operating Relative Humidity	<95% Non condesing	YES / NO
34	Audible Noise level at a distance of one meter from front side of UPS	<80 dB	YES / NO
35	IP Class	IP 20	YES / NO
36	Type of cooling	Built in Forced Cooling (multiple fans)	YES / NO
37	Other Accessories	a.Battery interconnecting cables	YES / NO
		b.SNMP Card	YES / NO
38	UPS should conform Standards & regulations	a. CE Certification	YES / NO
		b. Safety EN 62040-1	YES / NO
		c. EMC EN 62040-2	YES / NO
39	Auto restart facility	on Mains resumption	YES / NO
40	Cold Start facility	on battery without mains	YES / NO
41	Warranty	2 Years (24 Months) from the date of	YES / NO

		Successful Testing & Commissioning of UPS system at site.	
42	Year of manufacture of UPS	2025	YES / NO
43	LITHIUM ION BATTERIES (LiB)		
	a.Cell Chemistry	NMC (Nickel Manganese Cobalt / LMO (Lithium Manganese Oxide)	YES / NO
	b.Total Battery back up time	30 Minutes at 150 kVA/ kW	YES / NO
	c.Total Watt Hour Output (kWh)	Minimum 78.94 kWh energy required	YES / NO
	d.Configuration	Single or multiple rack mounted	YES / NO
	e.Battery Management System (BMS)	To be provided	YES / NO
	f.Switch Gear	MCCB,MCB, DC Fuse communication ports for module BMS & Rack BMS & System BMS DC IN Ports	YES / NO
	g.SMPS (Switched Mode Power Supplies)	Dual Type, Input AC, Output-DC to switch gear BMS Ports Communication & Dry Contacts	YES / NO
	h.Communication	Dry Contacts, Network Protocol	YES / NO
	i.Software	Licensed BMS Software (Windows 10 or above	YES / NO
	j.Safety Standards	All safety standards as applicable.	YES / NO
	k.Warranty	5 years from date of successful testing and commissioning of the Batteries at site.	YES / NO
44	Year of manufacture of LiB	2025	YES / NO

TECHNICAL DATA SHEET

(TO BE FILLED IN AND TO BE UPLOADED / SUBMITTED BY THE BIDDER)

With reference to the technical Specifications related to this GeM bidding, we furnish the details of products offered by us fully conforming to the Technical Specifications.

Sl.No.	Item Description	To be filled by the Bidder
1	Make of UPS Conforming to Technical Specifications	
2	Model No. of UPS	
3	Module capacity of UPS	
4	Total No. of Modules	
5	Total capacity of UPS in kW/kVA	
6	No. of racks to mount UPS modules	
7	Warranty period in Years for Modular UPS System	
8	Make of Lithium ion Battery (LiB)	
9	Type of technology / Cell Chemistry of LiB	
9	Total Ah per LiB Module	
10	Total kWh per LiB Module	
11	No. of LiB Modules per rack	
12	No. of LiB Module racks	
13	Total Ah of LiB	
14	Total kWh of LiB (184.21kWh Minimum)	
15	Total back up time at 350 KVA/KW	
16	Warranty period in Years for LiB Modules	

ANNEXURE-A

TEST PARAMETERS& FORMAT

Sl.No.	Parameter	Requirement / Specification	Test Results / Remarks
1	Type of UPS	Modular and Scalable with Hot Swappable Power Modules, Static Switches and control module.	
2	Capacity of UPS	150 kVA	
3	Technology	a. DSP Based True Online Double Conversion with latest and advanced IGBT PWM technology Rectifier & inverter	
		b. Parellel capability upto 10 nos. of Power Modules for vertical redundancy and upto 8 UPS units/modules for capacity	
		c. Redundant System with redundant and hot swappable controller, Redundant and hot swappable Aux Power Supply.	
		d. Dual CAN Bus within frame & Redundant CAN bus between parallel systems to enable UPS to be removed or inserted in parallel configuration without need of transferring it to bypass mode.	
		e. UPS should have feature to enable automatically transferring some modules to sleep mode in case of applied load is less than certain load percentage. Modules would be switched periodically & in rotational manner under this condition.	
		f. UPS should have feature for testing of the unit for load testing without external load.	

4	Capacity of Rack for mounting UPS modules	For 150 kVA (2 x 150kVA rack) (Single Input and output will be provided by Bank(SBI), necessary paralleling accessories to be considered by the bidder / UPS vendor)	
5	Capacity range of single UPS module	Min 25 kVA/kW & Max 50 kVA/kW	
6	Nominal Input Voltage	380/400/415 V (user selectable) 3 Phase 4 Wire System / 3 Phase 3 Wire System	
7	Input Voltage Range	320 V AC to 460V AC	
8	Input Frequency Range	50 Hz ± 10% (45 to 55 Hz)	
9	Input Power Factor	0.99 for any load	
10	Input Current Harmonic Distortion (THDi)	≤3 at full load.	
11	Output Voltage	380 /400/415 V user selectable 3 Phase 4 Wire + Ground	
12	Output Voltage Regulation	≤1% Max	
13	Out Put Wave Form	Pure Sine Wave	
14	Output Frequency	50 Hz	

15	Output frequency regulation	±0.05 Hz free running	
16	Output Power factor	Unity	
17	Output Voltage Distortion (THDv)	≤2% for linear load & ≤5% for non linear load.	
18	Output Crest factor	3 : 1	
19	Transient recovery Time	<20 msec	
20	Overload capability	120% for 10 Minutes 150% for 1 Minutes	
21	Efficiency	Minimum 96% at 25 to 100% of load in double conversion mode at input voltage with battery fully charged.	
22	Battery Charger	UPS Inbuilt Battery charger compatible for Lithium Ion Batteries	
23	Input Phase Sequence Correction	Inbuilt feature to be provided for as to avoid UPS transferring to battery mode in case of phase sequence change at input. UPS should continue to work on mains mode.	
24	Automatic & Bi-directional static bypass	The integral bypass shall perform an automatic transfer of the critical load from the inverter to the bypass, in the events of overload , over temperature, or inverter failure conditions with zero transfer time and retransfer from bypass to inverter on removal of overload and fault conditions.	
25	Cable Entry	UPS should have top cable entry	
26	Digital Touch Screen Display for	a.Input AC Voltage, Current & Frequency	
		b.Output AC Voltage, Current & Frequency	
		c.Load (in kVA/kW/Percentage)	
		d. Battery Voltage	
		e. Battery Current	

		f. Event Log to display a log of status and alarm events to be provided on the front panel display	
		g. UPS should have capability to capture wave forms pre & post event occurs.	
27	Inbuilt Protections	a.Over load / Over Current protection	
		b. Short circuit Protection	
		c.Over temperature Protection	
28	Built in Audible Alarms	f. Mains Failure	
		g. Low Battery	
		h. Over Load	
		i. Fault	
		j. On Battery / Bypass	
29	Remote UPS Monitoring Kits	Be able to connect to a LAN network using the main network communication protocols (SNMP or TCP/IP or HTTP)	
30	SNMP card / Web management System	To be provided	
31	Operating Ambient Temperature	0 to 40 degree Celsius	
32	Operating Relative Humidity	<95% Non condesing	
33	Audible Noise level at a distance of one meter from front side of UPS	<80 dB	
34	IP Class	IP 20	
35	Type of cooling	Built in Forced Cooling (multiple fans)	
36	UPS should conform Standards & regulations	d. CE Certification	
		e. Safety EN 62040-1	
		f. EMC EN 62040-2	
37	Auto restart facility	on Mains resumption	
38	Cold Start facility	on battery without mains	
39	Year of manufacture of UPS	2025	
40	LITHIUM ION BATTERIES (LiB)		

	a.Cell Chemistry	NMC (Nickel Manganese Cobalt / LMO (Lithium Manganese Oxide)	
	b.Total Battery back up time	30 Minutes at 150 kVA/ kW	
	c.Total Watt Hour Output (kWh)	Minimum 78.95 kWhr energy required	
	d.Configuration	Single or multiple rack mounted	
	e.Battery Management System (BMS)	To be provided	
	f.Switch Gear	MCCB,MCB, DC Fuse communication ports for module BMS & Rack BMS & System BMS DC IN Ports	
	g.SMPS (Switched Mode Power Supplies)	Dual Type, Input AC, Output-DC to switch gear BMS Ports Communication & Dry Contacts	
	h.Communication	Dry Contacts, Network Protocol	
	i.Software	Licensed BMS Software (Windows 10 or above	
	j.Safety Standards	All safety standards as applicable.	
44	Year of manufacture of LiB	2025	

AMC Terms and Penalties

1. The Bidder/Contractor/Vendor warrants that the Products supplied under the Contract are new, unused, of the most recent or current model and they incorporate all recent improvements in design and / or features. The Bidder/Contractor/Vendor further warrants that all the Products supplied under this Contract shall have no defect, arising from design or from any act of omission of the Vendor that may develop under normal use of the supplied Products in the conditions prevailing in India.

2. Warranty for UPS & Batteries: Onsite comprehensive warranty for the Modular UPS System including free replacement of spares, parts, kits as and when necessary will be 24 months (2 Years) from date of successful installation.

3. Onsite comprehensive warranty for the Lithium-Ion Batteries including free replacement of batteries / cells /spares, parts, kits as and when necessary will be 60 months (Five Years) from date of successful installation.

4. On-site comprehensive warranty and AMC : The warranty and AMC would be on-site and comprehensive in nature and back to back support from the OEM. OEM will warrant all the UPS, Batteries against defects arising out of faulty design, materials and workmanship etc. for the specified warranty period. OEM will provide support for UPS, Batteries and other preinstalled software components during the warranty period. Bidder/Contractor/Vendor shall repair or replace worn out or defective parts including all plastic parts of the Equipment at his own cost including the cost of transport.

5. After expiry of the warranty period of 2 years for UPS and thereafter AMC at tender finalised rates for 5 years, the Bidder/Contractor/Vendor/OEM will have to continue the AMC at mutually agreed upon (negotiated) rates within reasonable limits.

6. During the term of the Contract, OEM will maintain the equipment in perfect working order and condition and for this purpose will provide the following repairs and maintenance services:

   (a) Free maintenance services during the period of warranty and AMC. Professionally qualified personnel who have expertise in the field of Modular UPS & Lithium ion Batteries and will provide these services.

   (b) OEM shall rectify any defects, faults and failures in the equipment and shall repair/replace worn out or defective parts of the equipment during working hours i.e. from 8.00 A.M. to 8.00 P.M. on all working days (viz. Monday to Saturday). In case any defects, faults and failures in the Equipment could not be repaired or rectified during the said period, the engineers of the OEM are required to accomplish their duties beyond the said schedules in case of any situation if it warrants. In cases where unserviceable parts of the Equipment need replacement, the OEM shall replace such parts, at no extra cost to the Bank, with brand new parts or those equivalent to new parts in performance. For this purpose the Vendor shall keep sufficient stock of spares at its premises.

(c) The maximum response time for a maintenance complaint from the site of installation (i.e. time required for Vendor's maintenance engineers to report to the installations after a request call / fax /e-mail is made or letter is written) shall not exceed 1 (one) hour.

(d) Vendor shall ensure that faults and failures intimated by the Bank as above are set right within hours of being informed of the same. In any case the Equipment should be made workable and available not later than the next working day of the Bank.

(e) Vendor shall ensure that the full configuration of the Equipment is available to the Bank in proper working condition with an uptime of 99.9% each month.

(f) Penalties for Warranty/AMC uptime (Quarterly) shall be as under;

S. No.	Uptime Range	Penalty
1.	99.7 to 100%	NIL
2.	98 to less than 99.7%	10% of Quarterly AMC Charges
3.	95 to less than 98%	25% of Quarterly AMC Charges
4.	Less than 95%	50% of Quarterly AMC charges

(g) OEM shall ensure that the Mean Time between Failures (MTBF) (including any malfunctioning, breakdown or fault) in the Equipment or any part thereof, during Contract period, not more than four occasions in preceding 90 days, it shall be replaced by equivalent/ superior new Equipment or part thereof by Vendor immediately at free of cost during warranty and AMC period.

(h) **Preventive maintenance**: Vendor shall conduct preventive maintenance (including but not limited to inspection, testing, satisfactory execution of all diagnostics, cleaning and removal of dust and dirt from the interior and exterior of the Equipment, and necessary repair of the Equipment) once every quarter (3 months) during the currency of the Contract on a day and time to be mutually agreed upon.

(i) All engineering changes generally adopted hereafter by Vendor for Equipment similar to that covered by the Contract, shall be made to the Equipment at no cost to the Bank.

(j) Qualified maintenance engineers totally familiar with the Equipment shall perform all repairs and maintenance service described herein.

(k) The Bank shall maintain a register at its site in which, the Bank's operator/ supervisor shall record each event of failure and /of malfunction of the Equipment. OEM's engineer shall enter the details of the action taken in such register. Additionally every time a preventive or

corrective maintenance is carried out, the OEM's engineer shall make, effect in duplicate, a field call report which shall be signed by him and thereafter countersigned by the Bank's official. The original of the field call report shall be handed over to the Bank's official.

(l) The OEM shall provide replacement equipment if any equipment is out of the premises for repairs.

7. Any worn or defective parts withdrawn from the Equipment and replaced by OEM shall become the property of OEM and the parts replacing the withdrawn parts shall become the property of Bank.

8. Subject to the security requirement, Vendor's maintenance personnel shall, be given access to the Equipment when necessary, for purpose of performing the repair and maintenance services indicated in this GeM Bid.

9. If Bank desires to shift the Equipment to a new site and install it thereof, the OEM shall be informed of the same. The Bank shall bear the reasonable mutually agreed charges for such shifting and OEM shall provide necessary arrangement tothe Bank in doing so. The terms of this GeM Bid, after such shifting to the alternate site and reinstallation thereof would continue to apply and binding on OEM.

10. The Bank shall arrange to maintain appropriate environmental conditions, such as those relating to space, temperature, power supply, dust within the acceptable limits required for Equipment similar to that covered by this GeM Bid.

11. If, the OEM does not fulfil the provisions of clauses 4 (b), (c), (d), (e) and (h) only the proportionate maintenance charges for that period during the month will be considered payable by the Bank without prejudice to the right of the Bank to terminate the contract. In such event OEM was credited without deducting the proportionate maintenance charges for that month, the Bank can deduct the same from future payments payable or OEM shall refund the amount forthwith to Bank on demand by the Bank.

12. Future additions

(a) The Bank would have the right to:

i. Shift supplied systems to an alternative site of its choice.

ii. Expand the capacity / enhance the features / upgrade the hardware / software supplied, either from OEM, or third party.

Provided such changes or attachments do not prevent proper maintenance, from being performed or unreasonably increase Vendor cost of performing repair and maintenance service.