



## **Maharashtra Metro Rail Corporation Limited**

### **(Nagpur Metro Rail Project)**

**Name of Work:** Design, Supply, Installation, Testing and Commissioning of water & Air Cooled chillers along with associated, air distribution system, mechanical ventilation system, Geo thermal system for metro Bhawan of Maha-Metro Rail Corporation.

### **Corrigendum-IV**

**Date: 24.08.2017**

Tender No. : **N1EG- 08/2016**

Maha-Metro E-Tender Portal: <http://mahametrorail.etenders.in>

Tender No. (As uploaded in the E-Tender Portal of Maha-Metro): **No.100**

### **Corrigendum**

**and**

### **Bid Submission Date Extension**

<b>Event</b>	<b>As per corrigendum VI</b>	<b>Revised Date</b>
Last Date of submission of Bid	29.08.2017 upto 16:00 Hrs	09.09.2017 upto 16:00 Hrs
Opening of Bid	29.08.2017 upto 16:30 Hrs	09.09.2017 upto 16:30 Hrs

**GM/Procurement**

**Maharashtra Metro Rail Corporation Ltd.**

<b>Project:-</b>	<b>Design, Supply, installation, testing and commissioning of water &amp; air cooled chillers along with associated, air distribution system, mechanical ventilation system, Geo thermal system for Metro Bhawan of Nagpur metro rail project</b>		
	<b>Maharashtra Metro Rail Corporation Limited</b>		
	<b>Corrigendum IV- Tender No:- N1EG-08/2017</b>		
<b>Sr. No.</b>	<b>Clause</b>	<b>Item</b>	<b>Amendment</b>
1	Part-4, Financial Bid & Bill of Quantity	Summary Sheet of Schedules (Bill of Quantity)	Replaced as below
2	Part-4, Financial Bid & Bill of Quantity	Schedule F	Original Schedule F is replaced and to be read as attached Schedule F (Annexure-1)
3	PART II: WORKS REQUIREMENT S SECTION VII-B: PARTICULAR SPECIFICATION	PART-B Geothermal Particular Specification Geothermal System	Original Particular Specification of Geothermal System are replaced and to be read as attached Part-B (Annexure-2)

1.

**ORIGINAL**

<b>Summary Sheet of Schedules (Bill of Quantity)</b>							
<b>Name of Work: Design, Supply, Storage, Installation, Testing and Commissioning of VRV/VRF Air-conditioning system along with Geo Thermal System for Metro Bhawan for MAHA Metro Rail Corporation Ltd. Nagpur.</b>							
<b>Sl. No.</b>	<b>Schedule No.</b>	<b>Description of Works</b>	<b>Amount (INR)</b>	<b>Quote By Contractor</b>			
				<b>% at Par/ Above/ Below</b>		<b>Total Amount of each section considering Quoted %</b>	
				<b>In Figure</b>	<b>In Words</b>	<b>In Figure</b>	<b>In Words</b>
1	Total of Schedule-A	EQUIPMENT	4,60,97,500				
2	Total of Schedule-B	PIPING	56,67,450				
3	Total of Schedule-C	AIR DISTRIBUTION	2,26,25,700				
4	Total of Schedule-D	THERMAL INSULATION	57,15,175				
5	Total of Schedule-E	ELECTRICAL INSTALLATION	64,97,600				
6	Total of Schedule-F	GEO THERMAL	2,58,55,383				

7	Total of Schedule-G	COMPREHENSIVE OPERATION & MAINTENANCE COST	-	-	-	
I	Grand Total		11,24,58,808		-	-
II	Total Amount in Words		Rs. Eleven Crores Twenty Four Lacs Fifty Eight Thousand Eight Hundred Eight Only			

**REPLACED AND TO BE READ AS**

Summary Sheet of Schedules (Bill of Quantity)							
Name of Work: Design, Supply, Storage, Installation, Testing and Commissioning of VRV/VRF Air-conditioning system along with Geo Thermal System for Metro Bhawan for MAHA Metro Rail Corporation Ltd. Nagpur.							
Sl. No.	Schedule No.	Description of Works	Amount (INR)	Quote By Contractor			
				% at Par/ Above/ Below		Total Amount of each section considering Quoted %	
				In Figure	In Words	In Figure	In Words
1	Total of Schedule-A	EQUIPMENT	4,60,97,500				
2	Total of Schedule-B	PIPING	56,67,450				
3	Total of Schedule-C	AIR DISTRIBUTION	2,26,25,700				
4	Total of Schedule-D	THERMAL INSULATION	57,15,175				
5	Total of Schedule-E	ELECTRICAL INSTALLATION	64,97,600				
6	Total of Schedule-F	GEO THERMAL	2,69,69,000				
7	Total of Schedule-G	COMPREHENSIVE OPERATION & MAINTENANCE COST	-	-	-		
I	Grand Total		11,35,72,425	-	-		
II	Total Amount in Words		Rs. Eleven Crores Thirty Five Lacs Seventy Two Thousand Four Hundred Twenty Five Only				

2. Schedule-F, Annexure-1
3. Particular Condition Geothermal, Part-B, Annexure-2

**Annexure-1****Schedule-F**

- 1 The work shall be carried out strictly in compliance with this tender and design requirement. The onus of demonstrating satisfactory performance of entire system shall be sole responsibility of the contractor and supplied material shall be as per specifications and approved shop drawings. Relevant Indian Standards shall be adhered. It is to be understood that all liabilities and risks arising out of the stated conditions of contract shall be covered by contractor and Owner/Consultant shall be indemnified.
- 2 The unit rate for all items in the BOQ shall be quoted in Indian Rupees (INR) and include cost of equipment, wastage, accessories, tools, appliances, labour, installation, testing & commissioning upto satisfactory handover.
- 3 The contractor shall ensure that unit price of each item includes cost of Equipment, materials, fixing accessories, appliances, tools, plants, transport, labour and incidentals required in preparation for and in the full and entire execution, testing, balancing, commissioning and completion of work called for in
- 4 The contractor to ensure that all waste and debris is collected and satisfactorily disposed off from site.
- 5 The contractor shall ensure that unit price of each item includes loading, transporting, unloading, handling/double handling, hoisting to all levels, setting, fixing in position and insurance upto satisfactory handover including security.
- 6 The specifications and drawings shall be read in conjunction to the Bill of Quantities. In case of conflict between Bill of Quantities and other documents including the specifications, the most stringent shall apply. The interpretation of the Architect / Consultant /Project Manager shall be final and binding
- 7 The quantities mentioned in the BOQ are for contractor guidance only.The actual procurement of material shall be done only after written approval of shop drawings & technical submittals. This shall also apply to the Contractor's requisition for Owner supplied materials. The contractor shall be solely responsible for material supplied at site.
- 9 The contractor shall ensure work is carried out in conformity with the approved shop drawings and taking cognizance of latest architectural and other discipline drawings. The execution at site should be based on coordinated shop drawings or after obtaining written approval of Project Manager/Architect/Consultant.
- 10 The progress of work shall be in accordance with approved pert chart which will be prepared by Contractor at the time of award of work and duly revised from time to time.
- 11 All shop drawings will be made on Autocad or Revit as per Project Manager Requirement. Colored prints shall be provided for site work. The shop drawings will clearly indicate requirement of hangars, supports, quantities and instructions for installation.

S. No.	Description of Items	Unit	Qty	Rate (INR)	Amount (INR)
<b>A. EQUIPMENT</b>					
1	Carrying out comprehensive Geophysical analysis of the entire plot that includes vertical electrical soundings, electrical resistivity analysis, precision vertical drilling, and development of CFVS geothermal sink by IGSHPA accredited driller and installer. The work shall be complete in all respect based on which contractor shall execute the Geo Thermal system.	Lot	1	1,500,000	1,500,000
2	Supply, installation, testing and commissioning of CTI Certified Closed Circuit Cooling Tower 175 TR actual capacity with SS construction Coils, GSS casing and basin. The steel cooling tower shall a separate pump and for evaporative cooled water which shall be sprayed over the SS tube bundle carrying the closed circuit water. Cooling tower shall meet the tender specifications. <i>Note : The Cooling tower shall be used for regeneration of the energy piles during winter months. Same shall be taken care with motorized butterfly valves and contractor to include all items required for achieving this requirement.</i>				
2.1	Motors shall be for outdoor application (IP55), suitable for 415±10% volt, 50 cycle's 3 phase power supply meeting criterion as per ASHRAE standard 90.1-2016 and high efficiency.				
2.2	Isolators at cooling tower enclosed in weather proof panel shall also be included.				
2.3	Selected cooling tower shall be certified as per CTI ATC-105 and CTI STD-201.				
2.4	The Closed Circuit Cooling Tower performance shall be as follows:  Actual Cooling tower Capacity - 175 TR Inlet Condenser Water - 97.8 °F (36.5 DegC) Outlet Chilled Water Temperature - 87.8 °F (31 DegC) Wet Bulb Temperture - 81.2 °F (27.3 DegC) Condenser Water Flow - 525 USGPM Blower Motor HP (Recommended) - 1 No. 15 kW  Spray Pump Motor HP (Recommended) - 1 No. 3.7 kW Noise level - Not exceeding 70 dB(A) at 5m distance Cooling Tower as described above	Set	1	3,500,000	3,500,000
3	Supply, Installation, Testing & Commissioning of HDPE construction Double U Energy Piles (4 no. Pipes with each borehole of 100 m depth or upto top surface of first aquifer), 32 mm diameter with 3 mm wall thickness, density of pipe 0.94 g/cm <sup>3</sup> , Pressure rating 100 Bar, including making and pressure testing of Geo Exchange U LOOPS of required length upto the header connection. Bends shall be joined by socket fusion joining method with HDPE Pipes. All pipes shall be joined by Butt Fusion.	Set	50	60,000	3,000,000
4	Supply, installation, testing and commissioning of Centrifugal End Suction back pull out pumps duly factory mounted on a base with electric motor. The pump motor shall be IE 2 efficiency (minimum 90%) and suitable for 415 ± 10% volts, 50 cycles, 3 phase power supply. Pumps will adhere to following performance characteristics :				
4.1	The pump performance shall meet the criterion laid down under ASHRAE 90.1-2016 and with minimum efficiency as specified.				
4.2	The rating of pumps shall be as follows:				
4.2.1	Condenser Geo-exchange Water Pumps  Water flow rate : 225 USGPM Head : 100 Ft. of water Motor HP not to exceed : 10 HP Efficiency : 75% or more				
4.3.2	Condenser Geo exchange Water pump as described above including 1 No. standby Condenser Closed circuit Cooling Tower Water Pumps  Water flow rate : 300 USGPM Head : 75 Ft. of water Motor HP not to exceed : 10 HP Efficiency : 75% or more	No.	2	150,000	300,000
	Condenser CCCT Water pump as described above including 1 No. standby	No.	2	150,000	300,000
5	Carrying out Boring up to a depth of 100 m into ground or upto top surface of the first aquifer (whichever is lesser) in soft / hard soil as required by Site Incharge of 150 mm dia nominal size or as required to accommodate the Energy Piles. Cost shall include lowering in position of Geo- Exchange U-Loop HDPE Pipes in Bores for the full depth of bore along with termite line pipes, refilling the bore completely with a slurry mixture of native soil and Bentonite in the ratio of 1:3 (1 Bentonite : 3 Native soil without any rocks or pebbles) including removal of termite line pipes with progress of filling. The process is to be done in continuation to the completion of boring (150mm Dia.) to the required depth. All HDPE U - loops and pipes shall be flushed twice before installation to remove any debris and pressure tested for any leakage.	Set	50	130,000	6,500,000
6	Supply, installation, testing and commissioning of Closed type pressurized water expansion tank complete with necessary connection for piping, vent, valves and accessories. The requirement shall be as follows:  The total volume of water in Geo loops water pipes shall be worked out by HVAC contractor and contractor will work out the total volume. Proposed tank size shall be submitted by the contractor at the time of bidding.				

Accessories like centrifugal air separator, pumps etc. Shall be included in quoted price for satisfactory operation. Tank shall be located at Plant room level. The tank shall be nitrogen recharged steel expansion tank with replaceable heavy duty butyl rubber bladder.  
The tank shall have suitable sized inlet connection, drain along with valves for isolation/shutdown of system connection and drain and charging valve connection to facilitate the onsite charging of the tank to meet system requirement.

6.1	Expansion Tank and Air separator as described above	Set	1	400,000	<u>400,000</u>
	<b>TOTAL CARRIED TO SUMMARY</b>				<b>15,500,000</b>



S. No.	Description of Items	Unit	Qty	Rate (INR)	Amount (INR)
<b>B.</b>	<b>PIPING- HDPE PIPE &amp; CONDENSER WATER PIPE</b>				
1	Supply of HDPE pipes with 4.6 MM wall thickness cut to required lengths as per the specifications.				
a	50 mm dia pipes (OD)	RM	1000	875	875,000
2	Providing the following HDPE pipes jointing connectors with end caps and Elbow with sockets as per the specifications. Bends shall be butt welded with HDPE Pipes.				
a	50 mm dia pipes (OD)- Elbows/Socket	No.	300	800	240,000
b	32 mm dia pipes (OD)- Elbows/Socket	No.	5000	335	1,675,000
c	50 mm dia pipes (OD)- Tee	No.	50	1,600	80,000
d	32 mm dia pipes (OD)- Tee	No.	150	800	120,000
3	Excavating trenches of required width for pipes, sockets, dressing of sides, ramming of bottom upto depth of 1.5 meter including removing the excavated soil and then refilling the soil as required in layers not exceeding 0.2 meter in depth, consolidating each deposited layer by ramming and watering. Disposal of excess soil within 50 meter distance as required by Engineer Incharge.	cum	500	500	250,000
4	Providing and filling in trenches with good sand for a thickness of 0.15 meter to cover HDPE pipes including watering, ramming, consolidating and dressing complete in all respect as required by Engineer Incharge.	cum	80	2,500	200,000
5	Pipe spacers at four meter center to center distance in Bores for the full depth of bore along with termie line pipes.	Set	1250	320	400,000
6	Providing and fixing the Double U fitting at base of each energy pile	Set	50	2,800	140,000
7	Supply, Installation, Testing and Commissioning of 4 way wall mounted Hydronic Manifold with PVC Cabinet for MS/HDPE pipe interface.	Set	10	190,000	1,900,000
8	Supply, Installation, Testing and Commissioning of Hydronic Catchment Module for Geo sink/CCCT water distribution.	Set	2	550,000	1,100,000
9	Providing & fixing the following factory rolled MS pipes with specified wall thickness cut to required lengths and installed with all welded / grooved joints, providing and fixing in position necessary fittings like bends, elbows, tees, reducers, mating flanges & sockets for BAS, fabricated to size and shape in workshop or brought out ready-made where available of acceptable quality.				
a	MS pipes of 250 mm dia (8mm thick)	RM	R/o		
b	MS pipes of 200 mm dia (8mm thick)	RM	R/o		
10	Supplying and fixing MS class 'C' pipes cut to required lengths and complete with welded joints. Quoted price shall include providing and fixing in position fittings, elbows, tees, reducers, expanders, mating flanges & sockets for Building Automation System as required.. The pipes shall be of following sizes:				
a	MS pipes of 150 mm dia	RM	200	2,000	400,000
b	MS pipes of 125 mm dia	RM	100	1,500	150,000
c	MS pipes of 100 mm dia	RM	750	1,200	900,000
d	MS pipes of 80 mm dia	RM	50	790	39,500
e	MS pipes of 65 mm dia	RM	50	680	34,000
f	MS pipes of 50 mm dia	RM	100	525	52,500
g	MS pipes of 40 mm dia	RM	50	400	20,000
h	MS pipes of 32 mm dia	RM	50	370	18,500
i	MS pipes of 25 mm dia	RM	R/o		
j	MS pipes of 20 mm dia	RM	R/o		
11	Supplying, installing and fixing in position butterfly valves of PN 16 rating and suitable for following pipe sizes:				
a	Valves of 250 mm dia	No.	R/o		
b	Valves of 200 mm dia	No.	3	16,000	48,000
c	Valves of 150 mm dia	No.	R/o		
d	Valves of 125 mm dia	No.	10	7,500	75,000
e	Valves of 100 mm dia	No.	6	5,000	30,000
f	Valves of 80 mm dia	No.	2	4,000	8,000
g	Valves of 65 mm dia	No.	1	3,000	3,000
h	Valves of 50 mm dia	No.	42	3,000	126,000
i	Valves of 40 mm dia	No.	R/o		

S. No.	Description of Items	Unit	Qty	Rate (INR)	Amount (INR)
12	Supplying, installing and fixing in position Motorized butterfly valves of PN 16 rating and suitable for following pipe sizes:				
a	Valves of 200 mm dia	No.	2	85,000	170,000
b	Valves of 125 mm dia	No.	2	65,000	130,000
c	Valves of 100 mm dia	No.	4	55,000	220,000
d	Valves of 65 mm dia	No.	R/o		
e	Valves of 50 mm dia	No.	R/o		
f	Valves of 40 mm dia	No.	R/o		
13	Supplying, installing and fixing in position balancing valves of PN 16 rating and suitable for following pipe sizes:				
a	Valves of 200 mm dia	No.	2	30,000	60,000
b	Valves of 150 mm dia	No.	R/o		
c	Valves of 125 mm dia	No.	4	20,000	80,000
d	Valves of 100 mm dia	No.	4	16,000	64,000
e	Valves of 80 mm dia	No.	R/o		
f	Valves of 65 mm dia	No.	R/o		
g	Valves of 50 mm dia	No.	20	4,000	80,000
h	Valves of 32 mm dia	No.	R/o		
14	Supplying, installing and fixing in position ball valves of PN 16 rating and suitable for following pipe sizes:				
a	Valves of 50 mm dia	No.	20	3,500	70,000
b	Valves of 40 mm dia	No.	R/o		
c	Valves of 32 mm dia	No.	210	1,500	315,000
15	Supplying, installing and fixing in position check valves of PN 16 rating and suitable for following pipe sizes:				
a	Valves of 150 mm dia	No.	R/o		
b	Valves of 125 mm dia	No.	2	16,000	32,000
c	Valves of 100 mm dia	No.	2	14,000	28,000
d	Valves of 50 mm dia	No.	R/o	10,000	
16	Supplying, installing and fixing in position Y Strainers of PN 16 rating and suitable for following pipe sizes:				
a	Strainers of 150 mm dia	No.	R/o	28,000	
b	Strainers of 125 mm dia	No.	2	26,000	52,000
c	Strainers of 100 mm dia	No.	2	22,500	45,000
d	Strainers of 50 mm dia	No.	R/o	16,000	
17	Supply, installing and fixing in position flexible connections of required pressure rating installed at pump suction & discharge and at pipes crossing building expansion joints.				
a	Flexible connections for 250 mm dia pipes.	No.	R/o		
b	Flexible connections for 200 mm dia pipes.	No.	R/o		
c	Flexible connections for 125 mm dia pipes.	No.	4	15,000	60,000
d	Flexible connections for 100 mm dia pipes.	No.	4	13,000	52,000
18	Supplying, installing and fixing in position Auto air vents of PN 10 rating.	No.	20	2,500	50,000
19	Supplying, installing and fixing in position industrial type SS 304 construction pressure gauges with gun metal including GI nipple valves.	No.	60	3,000	180,000
20	Supplying, installing and fixing in position mercury-in- glass industrial type SS 304 construction thermometers within brass encasing	No.	52	3,000	156,000
<b>TOTAL CARRIED TO SUMMARY</b>					<b>10,728,500</b>



S. No.	Description of Items	Unit	Qty	Rate (INR)	Amount (INR)
<b>C. WATER SOFTENING PLANT</b>					
1.0	Providing, fixing, testing and commissioning of single stage, horizontal, centrifugal, 2 pole, 50 HZ, AC, mono-block pumps (as per IS : 9079) incorporating C.I. casing and frame, stainless steel shaft, bronze / SS impeller, TEFC induction motor directly coupled to the pump, IP44 protection, class B insulated, C.I. body, hydraulically and dynamically balanced to give vibration free operation, with mechanical seal arrangement, fixed on a base plate with suitable vibration eliminator pads complete with level controller, starter panel, necessary wiring (from tank to pumps & panel), pressure gauge on the delivery side and strainer on suction side, including non-return valve and isolating valves on suction and delivering sides as required, including suction and delivery headers in G.I. complete in all respects. (1 Working + 1 standby)				
	The pumps shall be rated for following duty:				
1.1	<b>Softner feed Pump</b> Flow rate (each) = 1.5 m3/Hr Head = 35 m Location : STP Plant room Pump set as described above	Set	1	85,000	85,000
1.2	<b>Soft Water Transfer Pump</b> Flow rate (each) = 2.5 m3/Hr Head = 35 m Location : Near Over ground Tank Operation of pump shall be based on level controller proposed to be installed in overhead tank as per site location. Pump set as described above	Set	1	90,000	90,000
2	<b>SOFTENER</b> Supply, installation, testing and commissioning of Water Softening Plant. The Water softener vessel shall be constructed of FRP/composite material with inner shell of integrated Polyethylene with Fiber Reinforced Plastic as per manufacturer standard. The inner distribution system and the under bed draw off system shall be of Hub & Lateral type / Riser tube with top & bottom strainers of Polypropylene material. Softener shall be supplied with initial charge resin with supporting media like silix, gravel etc. The softener shall be complete with pressure gauge at inlet & outlet, sample cock, PVC face piping / interconnected piping, multiport valve (control valve), overflow & drain, outlet fitting complete regeneration assembly comprising of power valve, ejector, brine suction valve and all associated pipe work. A density meter for brine shall be included. <b>Salt Saturation Arrangement:</b> The brine tank shall be provided with salt saturation arrangement including suitable HDPE brine tank of 2 regeneration capacity complete with resins of approved quality and make complete with bypass arrangement including piping, CI Valves (3 Nos.) and accessories of required size. (All the frontal piping, valves and their fitting should be designed on 1.5m/s velocity) Plant Sizes: Flow Rate : 1.5 m <sup>3</sup> /hr Input Hardness - Considered 600 PPM (Considered) Output Hardness - Less than 50 PPM MOC FRP OBR-15 KL Test pressure - 5.5 Kg/Sq.cm	Set	1	45,000	45,000
3.0	Providing, fixing, jointing and testing in position C-PVC (Chlorinated Poly Vinyl Chloride) of approved manufacturer for water supply pipes and fittings as per CTS SDR - 11 pipes at a working pressure of 22.50 kg/sq.cm at 23 deg C and 5.5 kg/sq.cm at 82 deg.C using moulded CPVC fittings e.g Tees, Elbows, Couplers, Unions, Reducers, Adapters, Bushings etc. including transition fittings connection between CPVC & metal pipe/ GI with Brass Adaptors (both Male & Female threaded) conforming to ASTM D-2846 with only CPVC solvent cement conforming to ASTM F-493 with fabricated & subsequently hot dip galvanized rubber lined clamps (2 coats of enamel paint) supports as required / directed at site including cutting and fixing the same with anchor fasteners, including painting the exposed pipes with one coat of desired shade of enamel paint. All termination points for installation shall have brass termination fittings. The rates to include for chasing in brick masonry with wire mesh / PCC for internal water supply pipes and making good the same in 1:4 cement mortar, cleaning the debris and carting outside the site premises. Including excavation and backfilling as required complete in all respect.				
3.1	15 mm Nominal size / 15.90 mm OD / 12.44 mm ID (min. wall thickness - 1.70 mm)	RM	R/o	210	
3.2	20 mm Nominal Size / 22.20 mm OD / 18.14 mm ID (min. wall thickness - 2.00 mm)	RM	R/o	235	
3.3	25 mm Nominal Size / 28.60 mm OD / 23.42 mm ID (min. wall thickness - 2.59 mm)	RM	50	310	15,500
3.4	32 mm Nominal Size / 34.90 mm OD / 28.54 mm ID (min. wall thickness - 3.18 mm)	RM	R/o	375	
3.5	40 mm Nominal Size / 41.30 mm OD / 33.78 mm ID (min. wall thickness - 3.76 mm)	RM	R/o	475	
4.0	Providing, fixing, testing & commissioning of Three Layer PVC storage tank with including all the fittings, float valve, nipples, isolation valve, overflow pipe, foundation required etc complete in all respect.				
4.1	5000 Ltrs	Ltrs	5000	12	60,000
4.2	10000 Ltrs	Ltrs	10000	12	120,000
<b>TOTAL CARRIED TO SUMMARY</b>					<b>415,500</b>

S. No.	Description of Items	Unit	Qty	Rate (INR)	Amount (INR)
D.	<b>ELECTRICAL INSTALLATION</b>				
1	<b>MOTOR CONTROL CENTRES (IP 55 rated)</b>  Design, manufacture, supply, installation, testing and commissioning of the following cubicle type, dead front, sheet steel, floor mounted control panels including anchoring into the wall, wiring, incoming, earthing & terminating into MCCB in each panel shall be provided by the electrical contractor. Control & power cable with earthing from panel to motor shall be included in the cost.  All outgoing shall be provided with Stop/Manual/ Auto selector switch to facilitate operation through BAS. All starters shall be provided with potential free Contact for Connections to Building Automation System.  Motor Control Centre- Section 01 (415 V) bus section consisting of :  1.1 1 No. Incoming each consisting of the following :  1 No. 125 amps MCCB complete with the following : 0 - 500 volts 96 x 96 sq mm digital voltmeter with selector switch. -1Set 0 - 125 amps 96 x 96 sq mm digital ammeter with 3 No. 125/ 5 amps CT's and selector switch.-1Set Phase indicating lamps.  TPN bus bars shall be of Aluminum and shall be sleeved. Phase bus bars shall be rated at 200 amps and neutral bus bar shall be of 50% capacity.  1.2 Outgoings  2 No. suitable rating MPCB, Star Delta starter for 10 HP motor over load relay with built in single phasing protection and outgoing feeder to Condenser water pump motor. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. ( Geo Thermal Exchange)  2 No. suitable rating MPCB, Star Delta starter for 10 HP motor over load relay with built in single phasing protection and outgoing feeder to Condenser water pump motor. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. ( Closed Ckt Cooling tower)  1 No. suitable rating MPCB, Star Delta starter for 20 HP motor over load relay with built in single phasing protection and outgoing feeder to Cooling tower. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. (Cooling tower)  1 No. Suitable MPCB, DOL starter for 5 HP motor over load relay with built in single phasing protection and outgoing feeder to Cooling tower. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. (Cooling tower)  1 No. Suitable MPCB, S/D starter for 10 HP motor over load relay with built in single phasing protection and outgoing feeder to Cooling tower. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. (Spare feeder)  1 No. Suitable MPCB, S/D starter for 7.5 HP motor over load relay with built in single phasing protection and outgoing feeder to Cooling tower. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. (Spare feeder)  Motor Control Centre No. 1 as described above.	Set	1	250,000	250,000
2	<b>PUMP PANEL</b>  Design, manufacture, supply, installation, testing and commissioning of the following cubicle type, dead front, sheet steel, floor mounted control panels including anchoring into the wall, wiring, incoming, earthing & terminating into MCCB in each panel shall be provided by the electrical contractor. Control & power cable with earthing from panel to motor shall be included in the cost.  All outgoing shall be provided with Stop/Manual/ Auto selector switch to facilitate operation through BAS. All starters shall be provided with potential free Contact for Connections to Building Automation System.  Motor Control Centre- Section 01 (415 V) bus section consisting of :  1.1 1 No. Incoming each consisting of the following :  1 No. 63 amps MCCB complete with the following : 0 - 500 volts 96 x 96 sq mm digital voltmeter with selector switch. -1Set 0 - 63 amps 96 x 96 sq mm digital ammeter with 3 No. 63/ 5 amps CT's and selector switch.-1Set Phase indicating lamps.  TPN bus bars shall be of Aluminum and shall be sleeved. Phase bus bars shall be rated at 100 amps and neutral bus bar shall be of 50% capacity.  1.2 Outgoings  2 No. suitable rating MPCB, DOL starter for 3 HP motor over load relay with built in single phasing protection and outgoing feeder to water pump motor. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. (Softener)				

S. No.	Description of Items	Unit	Qty	Rate (INR)	Amount (INR)
	1 No.suitable rating MPCB, DOL starter for 3 HP motor over load relay with built in single phasing protection and outgoing feeder to water pump motor. The compartment shall contain an indicating lamp with MCB for 'ON' status of fan motor. (Spare)				
	Panel as described above.	Set	1	75,000	75,000
	<b>TOTAL CARRIED TO SUMMARY</b>				<b>325,000</b>

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**SUMMARY OF COSTS**

<b>S. No.</b>	<b>Description of Item</b>	<b>Amount</b>	<b>(INR)</b>
1	EQUIPMENT	15,500,000	
2	PIPING	10,728,500	
3	WATER SOFTENING PLANT	415,500	
4	ELECTRICAL INSTALLATION	325,000	
	<b>TOTAL</b>	<b>26,969,000</b>	

**Annexure-2**

**PART-B**  
**ADDITIONAL PARTICULAR CONDITIONS OF CONTRACT**  
**(To be read in conjunction with the Particular conditions for main HVAC Tender)**

These Particular Conditions are to be read in conjunction with other documents issued along with tender. In case of any discrepancy between Design drawings, General conditions or Bill of quantity, more stringent of the same shall be applicable.

The contractor shall refer the following tender drawings :

S. No	Drawing No.	Title
1.	AEON/HVAC – 01	HVAC Plant Room and bore Hole Layout

The contractor shall refer the following annexure while bidding and will read them in conjunction with specifications as well as bill of quantity

Annexure -I	:	Design Criterion
Annexure -II	:	List of approved makes
Annexure -III	:	Technical Specifications

**1. WORK DESCRIPTION**

The work shall be strictly carried out as per the scope listed in this document and in accordance with the specifications. The equipment & material supplied at site will also be selected out of the list of approved makes. Bill of quantity provided with the document is for contractor guidance. It is expected that after award of work, contractor shall prepare shop drawings for approval by the Consultant & Client representative and also submit Technical documentation duly identifying shortlisted make of material/equipment along with its data sheets. Actual ordering shall be based on approved shop drawings & documents.

The work at site shall comply with the approved shop drawings and will meet the satisfaction of Client representative. The contractor shall be required to demonstrate satisfactory operation of entire system (including client supplied equipment installed by contractor) and furnish the required labour, material & tools to install & commission the system.

The broad scope of work for proposed Geo thermal system covered under this contract shall include supply, installation, testing & commissioning of the following:

- Geo thermal bores
- HDPE and MS pipes with valves and fittings
- Condenser water Pumping system
- Associated electrical works
- Closed circuit cooling towers
- Catchment and Manifolds
- Installation of water softening & filtration plant in STP room and bringing treated recycled water upto the cooling tower.
- Testing Adjusting & Balancing of the Geo thermal system.

Besides above, contractor shall also be required to undertake following:

- Obtain approval from Local Authorities prior & post installation for operation of system.
- Civil works which include making bore wells and making good of the same.

Commissioning of the plant including test reports to demonstrate satisfactory working prior to handing over.

Provide as-built drawings and handing over document comprising of list of recommended spares, catalogues and service schedule for each equipment/material.

Training of Client's staff.

## 2. REGULATIONS & PERMITS

Prior to starting work at site, the contractor shall obtain required permits/ licenses required for satisfactory execution and operation of the installation. All receipted amounts shall be reimbursed by Client on production of proof of payment by the contractor.

The executed work shall strictly confirm to applicable laws, regulations and Indian Standards which become applicable. In case the specifications and drawings contained in this document call for higher standard than those required by prevailing regulations, then these specifications & drawings shall become applicable. However, in case of any conflict or violation between the document/drawings and prevailing laws, then the applicable laws & regulations shall be governing & binding.

## 3. WORKS EXCLUDED UNDER THIS CONTRACT

Following works are excluded in the scope under this contract. These shall be executed by respective contractor in accordance with approved shop drawings where these details must be highlighted. However, contractor shall be responsible for providing details and thereafter supervision to ensure satisfactory & timely execution of these associated items as they have a bearing on this contract.

### Civil Works

- i. RCC basin & supports & MS Joists for Closed circuit cooling towers.
- ii. PCC foundation blocks with angle iron frame work edging for all motor control centre.
- iii. PCC foundation for pot strainers.
- iv. PCC foundation blocks for catchment and manifolds .

### Electrical Works

All associated **ELECTRICAL WORKS** listed below are excluded from the scope of this contract. These shall be installed by other agencies in accordance with approved shop drawings of, and under direct supervision of the air conditioning contractor.

- i. Providing power supply with earthing at the incoming of control panel.
- ii. Providing power and earthing at the incoming MCCB in each pump panel at locations called for on air conditioning Contractor's shop drawings.

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**ANNEXURE - I****1.0 DESIGN CRITERION****1.1 Site Details**

Following shall be the basis for developing the design:

Site Location : Nagpur  
Geographical Data : 21.6 deg. N; 79.3 deg. E  
Altitude : 310 m above mean sea level

**1.2 Outdoor Design Temperatures**

Recommended outdoor design conditions have been defined in ISHRAE Weather Data File 2014 which has been published jointly with Bureau of Energy Efficiency (BEE). The HVAC design for the entire facility shall be based on 0.4% annual cumulative frequency of occurrence for Summer & Monsoon and 99.6 % annual cumulative frequency of occurrence for Winter. The design conditions considered are as follows:

S. No	Season	Outdoor Temperatures	
		DBT	WBT
1.	Summer	43.9 Deg.C (111 °F)	22.5 Deg C (72.5 °F)
2.	Monsoon	32.3 Deg C (90.14 °F)	27.4 Deg.C (81.32 °F)
3.	Winter	11.8 Deg.C (53.24 °F)	-

## 2.0 System Description

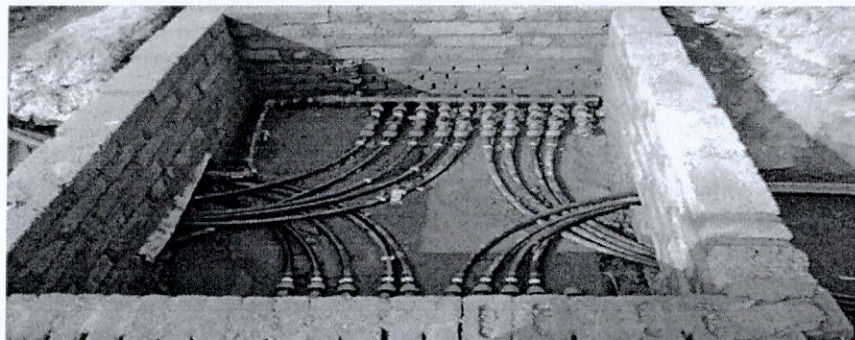
The Metro Bhawan Nagpur is to be cooled by a configuration of 3 chillers of 175 TR each including 1 No. standby. Out of three, two are air cooled and one is water cooled. The water cooled 175 TR chiller is to reject the building load into a series of Geothermal Energy Piles and Closed circuit cooling towers. For this a total of 50 geothermal energy piles with 100 m depth (or upto the surface of first aquifer, whichever is lower) have been envisaged. These Double U energy piles with 32 mm HDPE pipes will release the heat into the soil coming back at temperature very close to the equilibrium temperature. The 50 energy piles are required to reject about 75 TR into the soil. The details of energy piles are as follows :

1. 100 meter, 32 mm OD, HDPE, U-tubes (Double U).
2. Custom made 50mm OD, 4 way x 50mm manifolds with flush/purge and bleed ports and isolation valves.
3. Electro fusion fittings - including couplers, elbows and reducers.
4. 50mm and HDPE header pipe.
5. Adapter flanges to go from 50 mm HDPE to 2" steel pipework in plant room.
6. Electro fusion welding equipment, butt fusion welding equipment and technicians.

With the U-tubes on-site inserted in the boreholes, the exposed lengths of steel casing are cut back to the bottom of the header trenches. The U-tubes are to be unrolled on site, filled with water and then lowered manually into each borehole. Care is to be undertaken to avoid the U-tubes being damaged on the edges of the steel casing. Each U-tube is then pressure tested. Having passed the pressure test, it is then to be grouted of the boreholes to be undertaken. A thermally enhanced grout, like sodium bentonite grout is to be mixed on-site with a paddle mixer and injected into each borehole using a tremie pipe and a positive displacement pump.

### GROUND ARRAY INTERCONNECTION

The approach is to divide the borehole field into ten sections, each containing five boreholes. In each of the 10 sub- arrays, the borehole U-tubes are to be connected to a pair (flow and return) of pre-fabricated 4 way manifolds using 50 mm HDPE pipe laid in trenches between each borehole location and a manifold "pit".



### CLOSED CIRCUIT COOLING TOWERS

The Closed Circuit Cooling towers shall play a dual role of heat rejection of 100 TR in summer (balance 100 TR of the 175 TR water cooled chiller) and for regeneration of Energy piles in winter. The balance heat from chiller after rejecting 75 TR in Geothermal Energy Piles is rejected in the cooling tower. The cooling tower is designed for wet bulb of 27.2 Deg C with Inlet temp of 36.5 Deg C and return of 31 Deg C to condenser. In winters the Air Cooled chiller will operate (in case cooling desired) and the pumping system will bring



cooled water from the cooling tower into the Energy Piles. The ambient used will be at night with the Closed circuit cooling tower operating in temperatures ranging from 10 Deg C to 20 Deg C.

### **COMMISSIONING**

Once all of the ground loop and plant room pipework has been completed and leak tested, it was possible to proceed with commissioning of the GSHP. All of the shipping restraints and hold down bolts are to be removed from the heat pump. The ground loop was circulated whilst by-passing the heat pump, and all air vented from the system. The ground loop and load side were then circulated through the heat pump. Following this, the load and ground side strainers were inspected, cleaned and reinstalled prior to heat pump operation. Checks were made on the phase connection to ensure the correct pump and compressor rotations. In these circumstances it was helpful that both the heat pump and the pump motor controllers were provided with phase reversal protection. Given that the local electrical power supplies can be of varying quality, it is also useful that the Chiller is supplied with a phase failure protection module that checks for under and over voltage, frequency drift, and phase reversal. This protects the heat pump compressors from operating under adverse electrical conditions.

Once it is clear that the heat pump and the aqua stat controls are functioning correctly, it is possible to carry out a series of simple commissioning tests. Using sensors the entering and leaving temperatures on both the load side and ground side are measured, with one or two compressors operating. From these temperature differences it was possible to confirm that the desired flow rates were being achieved.

To demonstrate the energy delivery of the heat pump, an accurate digital thermometer was placed in the load side buffer tank. The chiller is to be run in Cooling mode until the buffer tank achieved maximum temperature, and the elapsed heat pump run time was recorded.

**Annexure - II**  
**List of Approved Makes**

S. No	Equipment/Material	Approved Manufacturer Name
1.	Condenser water Pumps and Pressurized Expansion Tank, Air Separator	Xylem Armstrong Grundfos
2.	Closed Circuit Cooling Tower	Evapco Baltimore Rosemex Nihon Spindle
3.	M.S. Pipe and G.I Pipe	Jindal Hissar Jindal Star Tata Steel
4.	HDPE Pipe & Fitting	Palconn
5.	Geo Exchange Control Center	Rosemex/ KES
6.	Butterfly Valve (Manual and Motorized)	Audco Jayhiwa Advance AIP VTM Kitz
7.	Balancing Valve	Advance VTM Jayhiwa AIP
8.	Ball Valve	VTM KITZ Zoloto
9.	Check Valve	Advance Valve Honeywell Kitz VTM AIP
10.	Pressure Gauge & Thermometer	Emerald Fiebig H Guru
11.	Pot & Y Strainers	Emerald VTM
12.	Fire Sealant	Birla 3 M Hilti Promat
13.	Flexible Pipe Connection	Cori Dunlop Easyflex Flexionics Resistoflex

S. No	Equipment/Material	Approved Manufacturer Name
14.	Electrical Panel	Sterling & Wilson Adlec Control System Advance Panels & Switchgear Ambit Switchgear Pvt. Ltd. SPC Electrotech
15.	Air Circuit Breakers / Moulded Case Circuit Breaker / MPCB / Contactors	Siemens Schneider Electric L&T ABB
16.	Final Distribution Boards / MCB/RCCB	Siemens Schneider Electric ABB L&T Hager Legrand
17.	Control Transformer / Potential Transformers (Epoxy Cast Resin)	Automatic Electric Gilbert & Maxwell Precise Pragati Matrix Kappa
18.	Indicating Lamps LED type and Push Button	Schneider Electric Siemens L&T (ESBEE) Teknik Vaishno Kaycee
19.	Digital Meters	Siemens Schneider Electric L&T Automatic Electric
20.	LT Cables	Polycab KEI Batra Henlay RPG Cables RR Kabel
21.	Termination kits	3M Raychem
22.	Double Compression Cable Glands with earthing links	Dowells Comet
23.	Bimetallic Cable Lugs	Dowells Comet Cosmos
24.	PVC Insulated HFFR Wires	Polycab KEI, Batra Henlay Finolex Bonton L&T

S. No	Equipment/Material	Approved Manufacturer Name
25.	Terminal Blocks	Connect well Elmex Wago
26.	Cable Trays	Ricco Profab Indeana Engineering
27.	Accessories for Supporting system	Hilti Fisher
28.	Insulating Mats	DL Miller & Co. Premier Polyfilm Ltd RMG Polyvinyl India Ltd Jyoti
29.	Metal Conduit & Accessories	BEC AKG
30.	Accessories for Metal Conduits	Sharma Sales Super Sales
31.	PVC / PVC FRLS Conduit & Accessories	BEC AKG Polypack Precision
32.	Busbar	Hindalco
33.	Timers	Siemens ABB Hager Schneider Legrand L&T
33.	Starter	Schneider ABB Siemens Kirloskar Allen Bradley L&T

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### **ANNEXURE-III**

### **TECHNICAL SPECIFICATIONS**

#### **1.0 CONDENSER WATER PUMPS**

The scope of work shall comprise of Supply, installation, testing & commissioning of water application pumps of the capacity & type indicated on drawings as well as Bill of Quantity. The contractor shall submit Pump performance curves and power consumption with operating points clearly indicated in the technical submittal prior to supplying equipment to site.

Pump casing shall be close-grained cast iron of heavy section, horizontally/vertically split, making possible complete servicing of rotating parts without breaking piping or motor connections. Motor to pump connection shall be of the flexible coupling type. Suction passages shall be volute in form, promoting smooth entry to impeller and increased efficiency. Impeller shall be bronze or gun metal, or Stainless Steel (cast grade CF8) double suction, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. Impeller rings shall be secured from relative movement by tongue and groove fittings. Shaft shall be high tensile strength steel, protected by gunmetal sleeves extending through stuffing boxes. Stuffing boxes shall be extra deep, water sealed with renewable bushes. Shaft shall be supported in ball /journal bearings, grease lubricated, contained in easily removable housing. Pumps shall be fitted with mechanical seals, an air valve, two grease lubricators, drain plug and water seal drain connections. The casing shall be provided with NPT threaded companion flanges with gaskets and hardware. Back pull out end suction pumps may be used upto 1000 USGPM flow rate or 15 HP motor rating or suction pressure not exceeding 8 Kg/cm<sup>2</sup>. Double suction split casing pumps shall be used for ratings beyond above.

Pump impeller shall be fully enclosed type and of Stainless Steel (cast grade CF8)/Bronze construction which will be keyed and secured to the pump shaft by stainless steel/bronze fittings. Impeller rings shall be secured from relative movement by tongue and groove fittings. Shaft shall be grease lubricated and supported on ball /journal bearings in easily removable housing.

The Motor shall be energy efficient type (IE-2) with minimum 90% efficiency, totally enclosed, fan-cooled, Class-F insulation, RPM not exceeding 1440 and suitable for 415 ± 10% volts, 3 phase, 50 hertz AC power supply. Motor rating shall have minimum of 10% margin on rated power or sufficient to meet the input power requirement at duty point. Motor to pump connection shall be of the flexible coupling type.

Mechanical Seal shall be provided on pumps which will be with stainless steel spring, EPDM elastomer and facilitate easy replacement. Factory installed seal vent line piped from the seal area to the pump suction connection shall also be provided.

The base shall extend over entire length covering pump, motor & shaft and constructed from cast iron or welded steel. Flexible/spacer type coupling shall be protected by a wire-mesh guard mounted on the base.

In split casing pumps, the casing shall be split radially to allow removal of the rotating element without disturbing the pipe connections. Impeller shall be double suction, enclosed type and hydraulically balanced. Pumps shall be fitted with mechanical seals, an air valve, two grease lubricators, drain plug and water seal drain connections.

The pumps shall be installed over a MS structure or cement-concrete foundation. Manufacturer shall include necessary vibration isolation mechanism to ensure there is no transmission of vibration to adjacent floors. Anchor bolts and sleeves and necessary vibration isolation pads shall be included. Upon installation of the complete system and before testing,

the pump shall be lubricated in accordance with the manufacturer's instructions. Split casing pumps shall be aligned with a dial indicator within 0.05 mm tolerance prior to testing.

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After commissioning, the pumps shall be finished with final coat of spray paint. Paint that have scratched/damaged during shipment or erection shall be cleaned, wire brushed, spot primed and then coated with spray paint.

Prior to handover, pump performance and power consumption will be tested using filed devices and verified against submittal made during technical document approval. Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested at factory as per relevant BIS codes or equivalent codes .

#### **1.1 Installation & Commissioning**

All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to VFD output and it shall test all inputs, outputs and program execution specific to this application.

The system manufacturer through its trained representative shall provide commissioning support of the packaged pumping system. This shall include verification of proper installation, system initiation, adjustment and fine tuning. Commissioning shall not be considered complete until the sequence of operation, including all alarms, has been sufficiently demonstrated to the owner or owner's designated representative.

The contractor shall provide on-site training for owner's personnel. This shall also cover maintenance and operation training of all system components.

**2.0 CLOSED CIRCUIT COOLING TOWERS****2.1 General**

Furnish and install factory assembled, induced draft, axial fan, closed circuit cooling tower(s) with vertical air discharge, conforming in all aspects to the specifications and schedules as shown on the plans. The closed circuit cooling tower(s) shall be approved makes having prior experience of regeneration of geothermal Energy piles using the same.

**2.2 Cooling Capacity**

The closed-circuit cooling tower(s) shall be warranted by the manufacturer as per the BOQ. The thermal performance shall be certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201. A manufacturer's performance guarantee or performance bond without CTI Certification will not be accepted.

**2.3 Corrosion Resistant Constructions**

Unless otherwise noted in this specification, all steel panels and structural members shall be constructed of heavy-gauge G-235 (Z700 metric) hot-dip galvanized steel, with all sheared edges given a protective coating of zinc-rich compound.

When X-scribed to the steel substrate it shall be able to withstand 2000 hours of 5% salt spray per ASTM B117 without blistering, chipping, or loss of adhesion. When X-scribed to the steel substrate it shall be able to withstand 2000 hours of exposure to acidic (pH=4.0) and alkaline (pH=11.0) water solutions at 95°F (35°C) without signs of chemical attack.

Shall withstand 2000 hours of ultraviolet radiation equivalent to 120,000 hours of noontime sun exposure without loss of functional properties. Shall withstand 200 thermal shock cycles between -25°F and +180°F (-32°C and 82°C) without loss of adhesion or other deterioration.

Shall withstand 2000 hours of exposure to 60 psi (42,184 kg/m<sup>2</sup>) water jet without signs of wear or erosion.

**2.4 Construction Details**

The closed circuit cooling tower shall be constructed of heavy-gauge steel utilizing double-brake flanges for maximum strength and rigidity and reliable sealing of water-tight joints. All sheared edges shall be protected with a coating of zinc-rich compound.

The closed circuit cooling tower shall include a coil casing section consisting of spray water distribution system, and drift eliminators, as indicated by the manufacturer. PVC drift eliminators shall be removable in easily handled sections. They shall incorporate a minimum of three changes in air direction.

**2.5 Coil Assembly**

The cooling coil shall be detachable type (convenient for maintenance and efficient design for best drainage) fabricated of stainless steel at the manufacturer's own facility. The cooling coil shall be pneumatically tested at 275 psig (2,865 kPa). The cooling coil shall be designed for low pressure drop with sloping tubes for free drainage of fluid

**2.6 Water distribution System**

Water shall be distributed evenly over the coil at a minimum flow rate of 4.5 gpm/ft<sup>2</sup> (3.1 l/s-m<sup>2</sup>) to ensure complete wetting of the coil at all times. The distribution system shall consist of large-diameter, non-clog, distribution nozzles spaced across the coil face area allowing quick removal of individual nozzles or complete branches for cleaning or flushing.



**7.24 Push Button Station**

The closed circuit cooling tower shall include a close-coupled, centrifugal pump equipped with a mechanical seal, mounted on the basin and piped to the suction strainer and water distribution system. It shall be installed so that it can be drained when the basin is drained. The pump assembly shall include a metering valve and bleed line to control the bleed rate from the pump discharge to the overflow connection. The pump motor shall be totally enclosed fan cooled (TEFC) type suitable for 415 volts, 3 phase, 50 Hz electrical service.

**2.8 Basin Assembly**

The combination basin/fan section shall be constructed of heavy-gauge G-235 (Z700 metric) galvanized steel. The basin shall be provided with large area lift out strainers with perforated openings sized smaller than the water distribution nozzles.

**2.9 Fan and Motor**

The fans and motors shall be factory installed at the top of the unit in the wet air stream to provide greater reliability and ease of maintenance. Fans shall be mounted on a steel fan shaft supported by heavy-duty self-aligning, re lubricatable bearings with cast iron.

Fan motor(s) shall be totally enclosed fan cooled (TEFC) type with a 1.15 service factor, suitable for 415 volts, 3 phase, 50 Hz electrical service and shall be mounted on an easily adjusted, heavy-duty motor base. V-belt drives shall be designed for not less than 150% of motor nameplate horsepower.

The fan, fan shaft, bearings, supports, and fan motor shall be warranted against defects in materials and workmanship for a period of one year from date of shipment.

**2.10 Sound**

To maintain the quality of the local environment, the maximum sound pressure levels (dB) measured 50 ft (15,240 mm) from the closed circuit cooling tower operating at full fan speed shall not exceed the sound levels detailed below 68 dba.

**2.11 Testing**

Capacity of the cooling tower shall be computed from the measurements of the 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 consumptions for cooling towers shall be computed from measurements of incoming voltage and input current.

**3.0 Manifolds**

The Manifold for ground-source geothermal loops offers an alternative method of piping parallel earth loops, bringing circuits to a common manifold station without labor-intensive fusion welding. Manifolds provide significant installation, commissioning, and operational advantages. With  $\frac{3}{4}$ " or 1" balancing valves with flow meters and shutoff ball valves, it allows easy individual circuit balancing leading to lower pumping costs and greater system efficiency. Shutoff ball valves installed on the return manifold allows for easy individual circuit purging while minimizing purge pump size. Couplings are used for connecting to polyethylene piping, either directly to the manifold or to the balancing valves and shutoff valves, making the ground earth loop installation completely free of fusion joints. The Manifold for ground-source geothermal loops, with automatic air vents, dual-scale temperature gages, fill/drain valves, supply and return manifolds, brass end caps with insulation, wall brackets with mounting hardware and labels.

The Manifold is used for controlling water flow in geothermal energy piles. Each sub header of the geothermal loops is connected to the manifold, thus making it possible to control water flow or heat supply to each energy piles individually through reverse return.

**7.24 Push Button Station**

The manifold consists of a supply and return manifold. The supply manifold includes possibility for individual shut-off of each circuit and as an option also flowmeter. The return manifold is equipped with integrated pre-setting valves securing optimal hydraulic balance in the system.

**Construction details**

The manifold modules shall be designed to prevent condensation. Polymer construction with an air gap insulating the medium from outside humidity reduces the effects of exterior corrosion. The manifold is reversible providing installation flexibility for easy connection to the earth loops with respect to the heat pump.

Two brass end caps and four tie-rods compress the modules to ensure proper sealing. The seal between the modules isolates the internal fluid duct and the single air chambers. The bracket can be mounted to a wall before mounting the manifold to allow for easy connection to the earth loops.

**4.0 Pressurized Expansion Tank**

Expansion tank duly coated with anti-rusting painting, suitable for total volume of water in chilled water circuits along with necessary accessories such as centrifugal air separator, pumps etc. in order to keep chilled water system under (+) pressure and to prevent entrapment of pressure and to prevent entrapment of air in the system. The tank shall be precharged steel expansion tank with replaceable heavy duty butyl rubber bladder. The tank shall have 50 MM system connection and 20 mm drain and charging valve connection to facilitate the on site charging of the tank to meet system requirement. The tank shall be fitted with lifting rings and a floor mounting skirt for vertical installation.

The tank and air separator must be constructed in accordance with section VIII of the ASME Boiler and pressure vessel (Unfired) code and stamped 125 PSI working pressure. The complete system shall be sourced from single manufacturer and supplied and installed with all accessories and safety fixtures and safety fixtures required for proper functioning of the complete hydronic system.

**4.1. AIR SEPARATOR**

The Air Separator shall be designed, constructed, and stamped in accordance with Section VIII, Division I of the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors. The Air Separator shall be rated for 125 PSI maximum working pressure. The Air Separator body shall be made of cast iron or carbon steel. The Air Separator shall have a maximum temperature rating of 350°F (177°C). The Air Separator body shall be three times the nominal inlet/outlet pipe diameter. The Air Separator shall include threaded blow down connection to allow for sediment to be regularly cleaned out of the unit. The Air Separator shall include a threaded air removal connection on top of the unit so an air vent or expansion/compression tank can be connected, allowing collected air to be removed from the unit. The Unit shall have Flanged or Grooved inlet and outlet connections tangential to the vessel shell.

**5.0 SOFTNER**

Softeners shall be vertical up flow type, designed to give required hardness. Softener shall be provided with suitable grade of cation exchange resins in quantity to be indicated by the contractor at the time of tendering.

Softener vessel shall be bobbin wound polyester fiberglass multi-layer vessel with dished ends and self-supporting arrangement. The vessel shall have a minimum thickness suitable for pressure as given in the schedule of quantities as per manufactures recommendations.

The vessel shall have minimum two pressure type manhole covers, efficient under drain system comprising of sufficient numbers of PP strainers, raw water distributor at the top and



## 7.24 Push Button Station

one number (PVC) regenerate distributor at required level. The strainer plate shall be accessible as per manufacturer's design..

Softener shall have a set of face piping of non-corrosive uPVC of 10kg/sqcm with injection moulded fittings and solvent weld joints comprising of inlet, outlet and backwash regeneration and rise complete with valves and piping, 100 mm dial bourden type gunmetal pressure gauges with gunmetal isolation cock and connecting piping on inlet and outlet, sampling cock on raw water inlet and softened water outlet, drain connection with valve.

One set of regeneration assembly comprising of power valve, ejector, brine suction valve and all necessary piping. One orifice board for indicating wash and rinse rate to be filtered in drain sump. One charge of supporting gravel, sand and "Cation" resin in requisite quantity. One water testing kit with instructions for testing water samples.

6 **PIPING**

## 6.1 Scope

The scope of this section comprises the supply and laying of pipes, pipe fittings and valves, testing and balancing of all water and refrigerant piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards.

## 6.2 Pipe Sizes

Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes have been indicated on the Drawings, these are for Contractor's guidance only and shall not relieve contractor of responsibility for providing smooth noiseless balanced circulation of fluids.

## 6.3 Chilled, Hot and Condensing Water Piping

Following material shall be used for pipes and fittings.

Pipes Nominal size (mm)	Material Specification
<150	IS 1239 Part-1
200 and above	IS 3589 Gr. FE 410 (8mm thick)
Fittings Nominal size (mm)	Material Specification
<40	Socket welded, ASTM A105 construction as per ANSI B16.11
50-150	Butt welded, ASTM A234 Gr. WPB as per ANSI B16.11
>200	Site fabricated from IS 3589 Gr. FE 410 (8mm thick)
Flanges Nominal size (mm)	Material Specification
< 150	IS 2062 Gr.A construction as per ANSI B16.5
> 200	IS 2062 Gr.A, construction as per ANSI B16.5

All jointing in the pipe system shall generally be by welding, unless otherwise mentioned, or directed at site. All welding shall be done by qualified welders and shall strictly conform to BIS Code of practice for manual metal arc, welding of Mild Steel.

Out of three weld one butt weld of each welder shall be fully radiographed for testing purposes. Upon approval of welding joints the concerned welder shall be allowed to carry further welding of pipes. Rest of the welds shall have 100% visual inspection.

- b. All welded joints (except pipe welded end-to-end) shall be made by use of one-piece welding flanges, caps, nozzles, elbows, branch outlets and tees of approved make. Cut

## 7.24 Push Button Station

samples shall be submitted for approval, if directed. All such fittings etc., shall be of a type which maintain full wall-thickness at all points, simple radius and fillets, and proper bevels or shoulders at ends. All job welding shall be done by the electric arc welding process in accordance with the following:

All joints shall have 45 degree bevel type, pipe mill-bevelled or machine-bevelled by the contractor.

All scale and oxide shall be removed with hammer, chisel or file and bevel left smooth and clean.

Pipe lengths shall line up straight with abutting pipe ends concentric.

Both conductors from the welding machine shall be extended to locations at which welding work is being done. The leads from welding machine to location of welding work shall be held together with tape or other approved means so as to prevent induced current in structural steel, in piping or in other metals within the building. The ground lead shall be connected to length of pipe through joints in pipe, structural steel of building or steel pipe supports.

- c. All pipes and their steel supports shall be thoroughly cleaned and given one primary coat of red oxide paint before being installed. For vibration isolators premoulded polyurethane pipe sections of 160 Kg/m<sup>3</sup> density with adhesive shall be fixed between pipe and MS support. 10 mm thick MS 'U' clamp with resistoflex shall be fixed on the pipe so that the pipe is kept in position. All welded piping shall be subject to the approval at site. All supports exposed to ambient shall be painted with two coats of epoxy. For condenser water piping running exposed to ambient, 2 coats of Epoxy paint shall be applied over piping. Then One coat of zinc chromate primer shall be applied. Finally colour painting shall be provided as per specification in identification of services.
- d. Fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type. These shall form part of piping and are not separately identified in Schedule of Quantities.
- a. Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

## 6.4 Cold Water and Drain Piping

- a. All pipes to be used for cold water (makeup), drain, condensate drain and fittings shall be GI / U-PVC as indicated in SOQ.
- b. All jointing in the pipe system shall be by screwed joints and/or by screwed flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.
- c. All pipes supports shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed.
- d. Fittings shall be galvanized steel 'medium class' malleable casting of pressure rating suitable for the piping system. Supply of flanges shall include bolts, nuts, gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections, or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping and are not separately identified in Schedule of Quantities.

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- e. Gate valves, globe valves, check valves and strainers shall be similar to those specified for chilled, condensing and hot water piping.
- f. For proper drainage of AHU Condensate, 'U' trap shall be provided in the drain piping.
- g. All condensate drain piping shall be insulated and painted as per the section "Insulation" as indicated in Schedule of Quantities.

## 6.5 GEO EXCHANGE HDPE WATER PIPING

Following material shall be used for pipes and fittings.

Pipes Nominal size (mm)	Material Specification
<150	IS 4984
	ASTM - D 2610
	ASTM - D2683
	ASTM - D2657

- a. All jointing in the pipe system shall generally be by thermal fusing, unless otherwise mentioned, or directed at site. All thermal fusing shall be done by qualified person and shall strictly conform to IS Code of practice for HDPE pipes.
- b. Fittings shall be HDPE of pressure rating suitable for the piping system. Fittings used on piping shall be of the fused type. These shall form part of piping and are separately identified in Schedule of Quantities.

## 6.5.1 Geo Exchange/Vertical Loop Installation

- i. Vertical Bores shall be drilled to sufficient depths to ensure the entire length as specified of U Tube to be inserted. At times this may require the bore to be drilled a few feet more than the U Tube Length.
- ii. Vertical Bores shall be drilled so that the resulting bore diameter is 1 inch larger than the U Tube width if the thermal conductivity of the back fill or grout is less than 80% of the natural soil conductivity.
- iii. Spacers shall be provided at regular intervals during lowering of U Tube to maintain gap between the two tubes throughout the depth of the bore.
- iv. All U Tube Joints shall be visually inspected for integrity as specified by the pipe manufacturer (alignment of joints, proper head roll back) and shall be filled with water and shall be pressure checked for leakages before insertion in Bore.
- v. The bore hole annulus shall be backfilled or grouted to ensure there are no air voids. In consolidated formations, this will require the bore to be filled from the bottom to the top with a termie tube.
- vi. The upper 20 ft of every bore annulus shall be grouted with a material having low permeability to inhibit surface water penetration into the formation.
- vii. The U Tubes are to be connected to the headers and the assembly is to be purged at a flow rate that ensures that the velocity in all sections of piping exceeds 2 ft per second.
- viii. After purging the assembly should be pressurised to 60 psig at the isolation valves and maintain pressure for one hour to check integrity of all joints made at site with header.

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- ix. Any joint made at site in U – Tube at connection point to the header for any variation in length of the supplied U Tube are to be thermally fused joints. Fused transition fittings with reinforced threads shall be used to adapt to metal or reinforced connection fittings. Barbed fittings are not an acceptable transition to polyethelene pipes. All joints made at site are to be assessable at time of pressure testing.
- x. All HDPE pipes in open are to be provided with protective covering to reduce scope of damage to the pipes.

## 6.6 Piping Installation

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

Pipe shall be cut only with hack saw blades and welding rods shall not be used for this purpose. All the pipes shall be cleaned and applied with one coat of Zinc chromate primer.

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

All pipes in HVAC plant room shall be supported with pipes and channels from floor only with necessary PUF pipe supports and resistoflex sheet.

- c. Pipe supports shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black. Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following :

Pipe size	Spacing between supports	Rod Size
Upto 12 mm	1.5 Meter	10 mm
15 to 25 mm	2.0 meter	10 mm
30 to 150 mm	2.0 meter	10 mm
Over 150 mm	2.5 meter	12.5 mm

- d. Vertical pipes passing through floors shall be plumb and parallel to wall. Pipes shall be supported on alternate floor. MS cleats shall be welded on pipes and rest on MS channel placed on the floor with 15 mm thick resistoflex pads between the cleat and channel. U clamps with resistoflex sheet shall be provided to keep the pipe in position.
- e. Bull heading in water/refrigerant piping shall be avoided.
- f. Pipe sleeves atleast 3 mm thick, 50 mm / 100 mm larger in diameter than condenser / chilled water pipes respectively shall be provided wherever pipes pass through **retaining** wall and slab. Annular space shall be filled with fibreglass and finished with retainer rings welded on the ends of the sleeve.



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- g. Wherever pipes pass through the brick or masonry / slab openings, the gaps shall be sealed with **fire sealant** such as fire barrier caulks.
- h. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 20 gage metal sheet shall be provided between the insulation and the clamp, saddle or roller, extending atleast 15 cm on both sides of the clamp, saddles or roller.
- j. All piping work shall be carried out in a workmen like manner, causing minimum disturbance to the existing services, buildings and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipes, supports, and pressure testing for each area shall be carried out in one stretch.
- k. Cut-outs in the floor slabs for installing the various pipes are indicated in the Drawings. Contractor shall carefully examine the cut-outs provided and clearly point out where the cut-outs shown in the Drawings do not meet with the requirements.
- l. The Contractor shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.
- m. All pipes shall be accurately cut to the required size in accordance with relevant BIS Codes, edges bevelled and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.
- n. Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided no more than 30 meters centres, or where-ever shown in Approved-for-Construction shop drawings, to facilitate future cleaning of all welded pipes.
- o. All buried pipes shall be cleaned and coated with zinc chromate primer and bitumen paint, and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters and wrapped with three layers of fibre glass tissue, each layer laid in bitumen.
- q. Auto purge valves shall be provided at all highest points in the piping system for venting air. Air valves shall be 15 mm pipe size with screwed joints.
- Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.
- r. Whenever services like piping, ducting and cabling are passing through floor slab, shaft or fire zone wall, opening around services shall be closed with fire retardant material. Contractor shall use either fire compound or fire barriers for this purpose. Fire compound shall be in form of powder and shall be mixed with water in proportion suggested by OEM. Mixed compound shall be poured in shuttering and grid of 30 x 30 x 1.2mm angles placed as 150mm center to center. Minimum thickness of pour shall be 100mm and shall be for fire integrity of 120minutes. Angles shall be securely welded to building re-bars ( if left during construction) or fastened to concrete floor.
- Fire barrier shall be in form of high density rock wool slabs with surface treated for fire retardation. Minimum thickness of the slab shall be 100mm and shall be for fire integrity of 120 minutes. Slabs shall be tightly friction fitted in the shaft to cover all open spaces.

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Measurement will be on area basis of applied projected area (in m<sup>2</sup> / ft<sup>2</sup>).

## 6.7 Pressure Gauges and Thermometer

- a. Pressure gages shall be stainless steel and shall be provided at suction and at discharge of each pump, at chilled water supply and return at each air handling unit, at each chillers and condenser, and as shown on the Drawings and included in Schedule of Quantities. Care shall be taken to protect pressure gages during testing.

Pressure gage sockets on insulated pipes and accessories shall be extended upto insulation to avoid damage of insulation for replacement of gages. Pressure gauges shall be provided with ball valve and syphon tube.

- b. Thermometers shall be stainless steel and shall be provided at chilled water supply and return at each air handling unit, at each chiller and condenser, and as shown on Drawings and included in Schedule of Quantities.
- c. Thermometers on CHW lines shall be with long stem. Thermometer socket shall be extended upto insulation thickness so that the thermometer shall be removable without damaging the insulation.

## 6.8 Valves

- a. Ball and butterfly valves conforming to the following specifications shall be provided as shown on Drawings :

Size	Construction	Ends	Type
15 to 40 mm	Forged Brass	Screwed	Ball
50 mm and over	Body Cast iron,	Wafer	Butterfly

Type and requirements shall be as indicated in Schedule of Quantities. Valves shall have non-rising spindles unless specified otherwise and shall be suitable for PN 16 (unless specified otherwise in SOQ) rating. Butterfly valve should be of wafer type long neck construction single stem design with centre lugs to ensure proper alignment of pipe flanges. Mount valve onto flanges only after flanges have been welded to pipes using a tool piece and cooled down to room temperature to prevent damage to resilient seat. The rubber liner should be fully supported by the valve flanges. Appropriate dimensions and thickness of Flanges and Bolts, as per the Flange Tables *ANSI B16.5* should be used. The flanges should be properly aligned with each other so that bolts are exactly perpendicular to the flanges. Evenly tighten the flange bolts to secure the valves. Counter flanges with nut-bolts and gaskets shall be provided by valve manufacturer.

- b. Butterfly valves shall perform the function of isolating valves and shall be suitable for PN 16 (unless specified otherwise in SOQ) rating. Butterfly valves shall have Epoxy Coated cast iron body with Integrally moulded EPDM liner of replaceable type. The liner shall be integrally moulded on hard backup ring and shall be suitable for PN 16 (unless specified otherwise in SOQ) rating. All butterfly valves shall be provided with locking devices. Valves 250 mm and above dia shall be gear driven.
- c. Automatic balancing valves shall automatically control flow rates within  $\pm 5\%$  accuracy. Valve control mechanism shall consist of a stainless steel cartridge with a ported cup and coil / helical spring to avoid corrosion. Four operating ranges shall be available with the minimum range requiring less than 14 kPa to actuate the



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- mechanism. Manufacturer shall provide independent laboratory tests verifying assurance of performance.
- d. Balancing cum control valves shall be sized based on flow rates and pressure drops across cooling coil.
  - e. Manual double regulating balancing valves shall be provided at chiller, condenser, various tapp-offs and each AHU outlet line as indicated in Schedule of Quantities. These valves shall have built-in pressure-drop measuring facility to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation. To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a computerized balancing instrument which shall enable the operator to read the flow directly without the use of diagrams or tables. In addition to measuring flow rate, differential pressure and temperature, computerized balancing instrument shall have a computer programme to provide the following functions:
    - i. To balance the HVAC installation and calculate the necessary valve settings, based on system measurements.
    - ii. To store the results of balancing.
    - iii. To log measured values from a valve (differential pressure, flowrate or temperature).
    - iv. To printout saved data in computerized measurement protocol (CMP) consisting of :
      - Name and size of Balancing Valve (BV)
      - Presetting position of BV
      - P at BV
      - Flow at BV
      - Design Flow
  - f. The supply of flanges shall form part of piping (not separately identified in Schedule of Quantities) and shall also include supply of bolts, washers, nuts and suitable asbestos fibre / rubber insertion gaskets (minimum 3 mm thick). Flanges shall be as per ANSI B16.5.
  - g. All ball valves and ball valves with Y strainer shall be brass forged body construction with chrome plated brass ball and handle of stainless steel constructions. These are separately identified in Schedule of Quantities.
  - h. Non return valves shall be dual plate check valve provided as shown on the Drawings, and identified in Schedule of Quantities conforming to relevant Codes and in accordance with the following Specifications :

Size	Construction	Ends
40 to 300 mm	<b>Body:</b> Grey Cast iron (Epoxy Coated), <i>CI IS 210 Gr. FG 260</i> <b>Plates:</b> CF-8 (SS-304), <b>Hinge/Stop Pin:</b> SS-410 <b>Spring(s):</b> SS-316. <b>Seal:</b> EPDM	Flanged



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350 mm to 500 mm	<b>Body:</b> Grey Cast iron (Epoxy Coated), <i>CI IS 210 Gr. FG 260</i> <b>Plates:</b> SS-409. <b>Hinge/Stop Pin:</b> SS-410 <b>Spring(s):</b> SS-316. <b>Seal:</b> EPDM	Flanged
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The bearing shall be PTFE material. Valves shall be PN 16 (unless specified otherwise in SOQ) rating.

## 6.9 Strainers

- a. Strainers shall be 'Y' type or Pot Strainer suitable for PN 16 (unless specified otherwise in SOQ) rating as shown on drawings and included in SOQ. 'Y' Strainer shall be fabricated out of MS 'C' class pipe two sizes higher than that of Strainer pipe size. Flanges as per *ANSI B16.5* shall be provided at inlet and outlet connectors. The body shall be hot dip galvanized. Permanent magnet shall be provided in the body of the Strainer to arrest MS particles. Filter element shall be of non magnetic 20 gage SS sheet with 3 mm perforation. Cartridge having five different type of filters made out of SS 304 with different mesh sizes shall be provided. These will be replaced so as to get good quality of water in system during commissioning. Strainers shall be provided at inlet of each Air Handling Unit and Pump as shown in drawings and included in SOQ.

Pot Strainers body shall be fabricated out of MS plate IS 2062. Thickness of sheet shall be as per size of the strainer chamfered pipes with flanges shall be provided at inlet /outlet connections of the strainer. The tangential entry of water shall create a centrifugal action and due to velocity shall separate sediments and deposit on the inner surface of Filter Element and at bottom of the Strainer. Butterfly valves shall be provided at inlet / outlet connections as shown in drawing and included in BOQ. The strainer body shall have two separate chambers properly sealed to avoid mixing of filtered and unfiltered water. A powerful magnet shall be provided in the body to arrest MS particles. Filter element of Pot Strainer shall be of non magnetic 18 gage SS sheet properly reinforced to avoid damage of the element. A cone with sufficiently large drain pipe with butterfly valve shall be provided at the bottom chamber to flush-out foreign particles. This arrangement shall avoid frequent opening of Pot Strainer for cleaning of filter element. Gage connection shall be provided at inlet and outlet connection.

Pot strainers shall be provided with automatic backwash system if called for in SOQ. This shall be with heavy duty reduction gear motor provided at top of upper lid. During backwash, motorised drain valve shall be opened along with vent cock. Power supply cabling with tray shall be included in cost of pot strainer. Entire operation shall be through BAS A set of MS flanges with tongue and groove arrangement and neoprene rubber gasket shall be provided on the top cover and Pot Strainer flange with sufficient bolts and nuts to make the joint water tight. Bearing loaded top cover lifting and swinging arrangement shall be provided. The Pot strainer body shall be properly de-rusted and epoxy coated from inside and outside.

Size of various Pot Strainer, Filter Element and Thickness of MS sheet shall be as under:

Pipe size	Pot Dia	Pot HT	Element Dia	Element HT	MS Plate Thickness
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(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
50	300	400	200	240	6
80	350	450	250	250	6
100	450	500	300	280	6
125	500	600	330	340	8
150	540	700	360	390	8
200	610	815	400	470	8
250	800	955	550	510	8
300	1000	1105	750	580	8
350	1190	1300	895	678	12
400	1350	1500	1020	785	12
450	1518	1700	1060	890	12
500	1690	1800	1100	900	12
600	2000	2200	1500	1160	12

Each Port strainer shall be provided with a Manufacturer Test Certificate.

## 6.11 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 at least two times the maximum operating pressure, but not less than 10 kg per sq. cm gage 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. After regular flushing, as per 'f' above, all systems shall be chemically cleaned. Chemical cleaning shall be carried out in 3 stages. In first stage biological cleaning shall be done to remove algae, bacteria, SRB etc which produces slimes. Second stage is pre-cleaning in which loose rust, oil, and debris are removed. Chemical addition and hold up time shall be as per chemical supply agencies recommendations. Third stage is passivation, in which chemicals will be added and passivation film will be formed over inside surfaces of piping system. Type of chemical used and quantity of the same along with detailed method statement shall be submitted by contractor for consultants' approval before starting this activity.  
  
Before handover Owner's site representative shall be provided with certificate of cleaning of pipe systems, signed by the contractor.
- 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.

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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.

- j. The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, the 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.
- k. 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.

**6.12 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.

**6.13 Valve Identification**

Provide 30 mm dia brass valve tag, with embossed letters and number for each valve and attach the tag to valve handle by "S" hook or by suitable means. Contractor shall provide valve tag schedule and valve chart for each piping system, consisting of schematic drawing of piping layout, along with a valve list, showing and identifying each valve by number, service and location and describing its function.

The contractor shall frame under glass in the air-conditioning plant room or as directed by Owner's site representative two copies of valve chart. Two additional unmounted copies shall be supplied to the Owner's site representative.

Tags shall correspond with the valve schedule and record drawings. In back of house areas, where ceilings are installed and the valve or valve tag is not visible, a self adhering tag with the valve number shall be installed on the wall or directly under the ceiling. For public area ceiling valves, these tags are to be installed in the service corridor, leading to the public areas.

**6.14 Measurement for Piping**

Unless specified otherwise, measurement for piping for the project shall be on the basis of centre line measurements described herewith.

Piping shall be measured in units of length along the centre line of installed pipes including all pipe fittings, flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric and / or eccentric reducers, inspection pieces, expansion loops etc. The above accessories shall be measured as part of piping length along the centre line of installed pipes, and no special multiples of pipe lengths for accessories shall be permitted.

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The quoted rates for centre line linear measurements of piping shall include all wastage allowances, pipe supports including hangers, MS channel, PUF supports, nuts, check nuts, vibration isolator suspension where specified or required, and any other item required to complete the piping installation as per the Specifications. None of these items will be separately measured nor paid for.

However, all valves (gate / globe / check / balancing / purge / butterfly / drain etc), strainers, thermometers, pressure gages shall be separately counted and paid as per their individual unit rates, which shall also include their insulation as per Specifications. Piping measurements shall be taken before application of the insulation.

Contractor shall get pressure testing of pipes/measurements etc verified by the Owners representative at site.

#### 6.15 CPVC pipes

All pipes inside the buildings and where specified, outside the building shall be CPVC pipes tubes conforming to Specific Gravity ASTM D 792 at 23oC should be 1.55 as specified. With Tensile Strength as per ASTM D 638 at 23oC should be 55N/mm<sup>2</sup>

All special fittings and accessories like internally or externally threaded brass adaptors, ball valves, globe valves, unions, diaphragm valves, butterfly valves, etc shall be made of CPVC by licensee.

The CPVC solvent cement used for installing CPVC piping systems shall conform to ASTM F493. Pipes from ½" upto 2" pipes and fittings, a single step medium bodied CPVC solvent cement should be used. For CPVC pipes and fittings upwards of 2", a primer shall be used followed by a heavy bodied solvent cement conforming to ASTM F493. PVC solvent cement should not be used.

Installation procedure :

All parameters pertaining to the installation of CPVC plumbing system such as cutting, joining, support spacing, expansion loops, insulation, type of support, special connections, etc. shall be as per the manufacturer's specifications.

All pipes shall be fixed in accordance with layout and alignment shown on the drawings. Care shall be taken to avoid air pockets.

Where shown on the drawings main pipe lines may be run in masonry trenches from the pump house to the buildings, filled up with sand and buried in ground as per architectural /landscape details.

#### 6.16 Testing of Joints

After laying and jointing, the pipes and fittings shall be inspected under working condition of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost.

The pipes and fittings after they are laid shall be tested to hydraulic pressure of 1.5 times the working pressure or at 7.5 Kg/Sqcm whichever is higher. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer. The draw of taps and stop cocks shall then be closed and specified hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped, the test pressure should be maintained without loss for at least two hours. The pipes and fittings shall

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be tested in sections as the work of laying proceeds, having the joints exposed for inspection during the testing.

The treated water shall be left in the pipe line for a period as directed but not exceeding 24 hours. Chlorine residual tests shall be taken at various points along the pipe line. The sterilization process shall be repeated until the samples of water taken from the pipeline are declared fit for human consumption by a recognised laboratory.

#### 6.17 cPVC Ball Valves:

The ball valve shall be of cPVC. The ball valve shall be as given below:

##### High Pressure:

Indicated by the abbreviation 'HP' for use on mains having pressure. These shall remain closed at a test pressure of 10.5 Kg/Sq.cm.

Sl. No.	Nominal Size of Ball Valve	15	20	25	32	40	50
		mm	mm	mm	mm	mm	mm
1.	Diameter of spherical float (mm)						
	High Pressure	127	152	203	229	254	305
	Low Pressure	114	127	178	203	203	254

The ball valves shall be of following nominal sizes 15mm, 20mm, 25mm, 32mm, 40mm and 50mm. The nominal size shall correspond with the nominal bore of the inlet shanks.

## 7. ELECTRICAL INSTALLATION

### 7.1 Scope

The scope of this section comprises of fabrication, supply, erection, testing and commissioning of Motor Control Centre (MCC), wiring and earthing of all air-conditioning equipment, components and accessories.

Note – Configuration of MCC panels shall be design to suit the requirement of system \ process. Necessary single line diagrams \ GA drawings shall be furnished by contractor for approval by consultant \ owner.

### 7.2 General

Work shall be carried out in accordance with the accompanying specifications and shall comply with the latest relevant Indian Standards and Electricity Rules and Regulations.

All motor control centres shall be suitable for operation on 3 Phase/single phase, 11,000/415/240 volts, 50 cycles, 4 wire system with neutral grounded at transformer. All MCCs be CPRI tested design and manufactured by a approved manufacturer. **CPRI certificate be made available.**

MCCs comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-8623. MCCs / starter panels for outdoor equipment shall be suitable for outdoor duty application.

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7.3 Constructional Features

The Motor Control Centre (MCC) shall be of 2 mm thick sheet steel cabinet and suitable for indoor installation, dead front, floor mounting/wall mounting type and shall be form 3b construction. The Distribution panels be totally enclosed, completely dust and vermin proof and be with hinged doors and folded covers, Neoprene gasket, padlocking arrangement and bolted back. All removable/ hinged doors and covers shall be grounded by flexible standard connectors. MCC shall be suitable for the climatic conditions as specified in Special Conditions. Steel sheets used in the construction of panels be 2 mm thick and be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding, slag shall be rounded off and welding pits wiped smooth with plumber metal. The general construction confirm to IS-8623-1977 (Part-1) for factory built assembled switchgear & control gear for voltage upto and including 1100 V AC.

All MCCs/panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws enter into holes tapped into an adequate thickness of metal or provided with wing nuts. Self threading screws not be used in the construction of Distribution panels. A base channel of 75 mm x 40 mm x 5 mm thick shall be provided at the bottom for floor mounted panels. Minimum **operating** clearance of 275 mm be provided between the floor of panels and the lowest operating height.

The MCC shall be of adequate size with a provision of spare feeders. Feeders be arranged in multi-tier. Knockout holes of appropriate size and number shall be provided in the Motor Control Centre in conformity with the location of cable/conduit connections. Removable sheet steel plates shall be provided at the top to make holes for additional cable entry at site if required. Every cabinet shall be provided with Trifoliate or engraved metal name plates. All panels shall be provided with circuit diagram mounted on inside of door shutter protected with Hylam sheet. All live accessible connections shall be shrouded and minimum clearance between phase and earth be 20 mm and phase to phase be 25 mm.

Panels with ACB shall necessarily have front and rear access as per requirement whereas panels with all MCCB breaker shall be provided with front access with sufficient clearance.

All control wiring shall be carried out by using PVC insulated copper conductor wires in conduits. Minimum size of control wiring be 1.5 sq mm. Minimum size of conductor for power wiring shall be 4 sq. mm 1100 volts grade PVC insulated copper conductor wires in conduit. All conductors shall be stranded.

7.5 Circuit Compartment

All components for each feeder shall be housed in a separate compartment and have steel sheets on top and bottom of compartment. Sheet steel hinged lockable door be duly interlocked with the breaker in the "ON" position. Safety interlocks be provided to prevent the breaker from being drawn-out when the breaker is in 'ON' position. The door not form an integral part of the draw-out portion of the panel. Sheet steel barriers shall be provided between the tiers in a vertical section.

All MCCs shall be provided with feeders of appropriate capacity as per Single Line Diagram. All MCCs shall be completely factory wired, ready for connection. All the terminals shall be of proper current rating and sized to suit individual feeder requirements. Each circuit be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits be distinctly marked with a small description of the service installed.

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

7.6 Instrument Accommodation

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Adequate space shall be provided for accommodating instruments, indicating lamps, control contactors and control MCBs. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker and bus bar 'ON' lamps shall be provided on all outgoing feeders.

**7.7 Bus Bar Connections**

Bus bar and interconnections shall be of high conductivity electrolytic grade aluminium/copper complying with requirement of IS : 5082 – 1981 and of rectangular cross section suitable for carrying the rated full load current and short circuit current and shall be extendable on either side. Copper conductor shall be used for busbar of rating 1000A and above. Bus bars and interconnections shall be insulated with heat shrinkable sleeve of 1.1 KV grade and shall be colour coded. Bus bars shall be supported on glass fiber reinforced thermosetting plastic insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. All bus bars shall be provided in a separate chamber and all connections shall be done by bolting. Additional cross sectional area to be added to the bus bar to compensate for the holes. All connections between bus bars and breakers shall be through solid copper / aluminium strips of proper size to carry full rated current and insulated with insulating sleeves. Maximum current density for the busbars be 0.8 A/sq.mm for aluminium and 1.4 A/sq.mm for copper busbars.

**Maximum allowable temperature for the Bus bar to be restricted to 85 deg C**

**7.8 Temperature – Rise Limit**

Unless otherwise specified, in the case of external surface of enclosures of bus bar compartment which shall be accessible but do not need to be touched during normal operation, an increase in the temperature rise limits of 25° C above ambient temperature be permissible for metal surface and of 15° C above ambient temperature for insulating surfaces as per IS 8623(Part-2) 1993.

**7.9 Cable Compartments**

Cable compartment of adequate size shall be provided in the panel for easy clamping of all incoming and outgoing cables entering from the top/bottom. Adequate supports be provided in cable compartment to support cables as per approved for construction shop drawing.

**7.10 Air Circuit Breaker (ACB)**

The ACB conform to the requirements of IEC 60947-2 / IS 13947-2 and shall be type tested & certified for compliance to standards from CPRI, ERDA/ any accredited international lab. The circuit breaker shall be suitable for 415 V  $\pm$  10%, 50 Hz supply system. Air Circuit Breakers be with moulded housing flush front, draw out type and shall be provided with a trip free manual operating mechanism or as indicated in drawings with mechanical "ON" "OFF" "TRIP" indications.

The ACB be 3/ 4 pole with modular construction, draw out, manually or electrically operated version as specified. The circuit breakers shall be for continuous rating and service short Circuit Breaking capacity (Ics) shall be as specified on the single line diagram and should be equal to the Ultimate breaking capacity(Icu) and short circuit withstand values(Icw) for 1 sec.

Circuit breakers shall be designed to 'close' and 'trip' without opening the circuit breaker compartment door. The operating handle and the mechanical trip push button shall be at the front of the breakers panel. Inspection of main contacts should be possible without using any tools. The ACB shall be provided with a door interlock. i.e. door should not be open when circuit breaker is closed and breaker should not be closed when door is open.

All current carrying parts shall be silver plated and suitable arcing contacts with proper arc chutes shall be provided to protect the main contacts. The ACB have double



## 7.24 Push Button Station

insulation (Class-II) with moving and fixed contacts totally enclosed for enhanced safety and in accessibility to live parts. All electrical closing breaker be with electrical motor wound stored energy spring closing mechanism with mechanical indicator to provide ON/OFF status of the ACB.

The auxiliary contacts blocks shall be so located as to be accessible from the front. The auxiliary contacts in the trip circuits close before the main contacts have closed. All other contacts close simultaneously with the main contacts. The auxiliary contacts in the trip circuits open after the main contacts open. Minimum 4 NO and 4 NC auxiliary contacts be provided on each breaker.

Rated insulation voltage be 1000 volts AC.

## 7.10.1 Cradle

The cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. The movements be free from jerks, easy to operate and be on steel balls/rollers and not on flat surfaces.

There shall be 4 distinct and separate position of the circuit breaker on the cradle. Racking Interlock in Connected/Test/Disconnected Position.

Service Position : Main Isolating contacts and control contacts of the breaker are engaged.

Test Position : Main Isolating contacts are isolated but control contacts are still engaged.

Isolated Position : Both main isolating and control contacts are isolated.

There shall be provision for locking the breaker in any or all of the first three positions.

The following safety features be incorporated :

- a. Withdrawal or engagement of Circuit breaker not be possible unless it is in open condition.
- b. Operation of Circuit breaker not be possible unless it is fully in service, test or drawn out position.
- c. All modules shall be provided with safety shutters operated automatically by movement of the carriage to cover exposed live parts when the module is withdrawn.
- d. All Switchgear module front covers have provision for locking.
- e. Switchgear operating handles shall be provided with arrangement for locking in 'OFF' position.

## 7.10.2 Protections

The breaker should be equipped with micro-controller based , communicable type release with RS 485 port for communication to offer accurate and versatile protection with complete flexibility and offer complete over current protection to the electrical system in the following four zones :

- Long time protection.
- Short time protection with intentional delay.
- Instantaneous protection.
- Ground fault protection.

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The protection release generally have following features and settings **however for exact selection of protection releases shall be made based on project requirement.**

a. True RMS Sensing

The release sample the current at the rate of 16 times per cycle to monitor the actual load current waveform flowing in the system and monitor the true RMS value of the load current. It take into account the effect of harmonics also.

b. Thermal Memory

When the breaker reclose after tripping on overload, then the thermal stresses caused by the overload if not dissipated completely, get stored in the memory of the release and this thermal memory ensure reduced tripping time in case of subsequent overloads. Realistic Hot/Cold curves take into account the integrated heating effects to offer closer protection to the system.

c. Defined time-current characteristics :

A variety of pick-up and time delay settings shall be available to define the current thresholds and the delays to be set independently for different protection zones thereby achieving a close-to-ideal protection curve.

d. Trip Indication

Individual fault indication for each type of fault should be provided by LEDs for faster fault diagnosis.

e. Self powered

The release draw its power from the main breaker CTs and require no external power supply for its operation.

f. Zone Selective Interlocking

The release shall be suitable for communication between breakers to enable zone selective interlocking. This feature shall be provided for both short circuit and ground fault protection zones to offer intelligent discrimination between breakers. This feature enables faster clearance of fault conditions, thereby reducing the thermal and dynamic stresses produced during fault conditions and thus minimises the damage to the system. To implement ZSI manufacturer should supply all related equipment like power supply, wiring etc.

On-Line change of settings should be possible. It should be possible to carry out testing of release without tripping the breaker.

g. The release meet the EMI / EMC requirements.

h. The setting range of release shall be generally as follows :

SETTING RANGE OF RELEASE		
Type of Protection	PICK-UP CURRENT	TIME DELAY

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Long Time	0.4 to 1.0 times $I_n$ ( $I_r$ )  Steps : 0.4, 0.5, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00.  Operating Limit : 1.05 to 1.2 times $I_r$	0.5 to 30 sec at 6 $I_r$  Steps 0.5, 1, 2, 4, 6, 8, 12, 18, 24 and 30 secs  Tolerance : Corresponding to $\pm 10\%$ of current.
Short Time	2 to 10 times $I_r$  Steps : 2, 3, 4, 5, 6, 7, 8, 9 & 10  Tolerance : $\pm 10\%$	20 ms to 600 ms Steps 20, 60, 100, 160, 200, 260, 300, 400, 500 and 600 ms Tolerance : $\pm 10\%$ or 20ms whichever is higher
Instantaneous	2 to 12 times $I_n$ Steps : 2, 3, 4, 6, 8, 10, 12 Tolerance : $\pm 10\%$	
Ground Fault	0.2 to 0.6 time $I_n$  Steps : 0.2, 0.3, 0.4, 0.5, 0.6  Tolerance : $\pm 10\%$	100 ms to 400 ms  Steps : 100, 200, 300, 400ms Tolerance : $\pm 10\%$ or 20 ms whichever is higher.

All **incomer** ACBs have following additional protections other than mentioned above.

- Under and over voltage
- Under and over frequency
- Restricted Earth Fault protection
- Trip Circuit supervision with PS class CT's.
- Undercurrent, ( for DG set only)
- Reverse power ( for DG set only)
- Phase sequence reversal ( for DG set only)
- Load shedding and reconnection thru programmable contacts.
- Release should display the Contact wear indication.

The release should provide local indication of actual %age loading at any instant. The release should be able to communicate on MODBUS RTU protocol using inbuilt RS485/232/Ethernet port and shall be integral part of supply with trip unit. Parameters of the Protection Release should be changeable from Release as well as thru communication network. Release should have graphical LCD for display of power parameters. The release of incoming breakers should provide comprehensive metering with the following parameters

Phase currents (running, avg & max) – All parameters in single window.

Release should be able to capture short circuit current on which ACB has tripped. The last ten trips and alarms shall be stored in memory with the date & time stamping along with type of fault and alarm. The sensing CT Should be Rogowsky type with measurement precision of 1%.

Release should be self powered .

Release should have facility to select different type of IDMTL protection(DT,SIT,VIT,EIT,HVF) for better co-ordination with HT Breaker/Fuse.

Phase voltages (running, avg & max)

Energy & power parameters (active, reactive and apparent)

## 7.24 Push Button Station

PF

Frequency

Maximum Demand ( KVA &amp; KW)

Total Harmonics distortion

All O/G ACBs have following functions.**Protection**

The ACB control unit offer the following protection functions as standard:

Long-time (LT) protection with an adjustable current setting and time delay;

Short-time (ST) protection with an adjustable pick-up and time delay;

instantaneous (INST) protection with an adjustable pick-up and an OFF Position.

Current and time delay setting be indicated in amperes and seconds respectively On a digital display.

Earth-fault protection with an adjustable pick-up and time delay be provided if indicated on the appended single-line diagram.

**Measurements**

An ammeter with a digital display indicate the true rms values of the currents for each phase. Release acknowledge the current & time delay settings done by user on the LCD display.

A LED bargraph simultaneously display the load level on the three phases.

A maxi meter store in memory and display the maximum current value observed since the last reset. The data continue to be stored and displayed even after opening of the circuit breaker.

## 7.10.3 Safety Features

- I. The safety shutter prevent inadvertent contact with isolating contacts when breaker is withdrawn from the Cradle.
- II. It not be possible to interchange two circuit breakers of two different thermal ratings. For Draw-out breakers, an arrangement be provided to prevent rating mismatch between breaker and cradle.
- III. There shall be provision of positive earth connection between fixed and moving portion of the ACB either thru connector plug or sliding solid earth mechanism. Earthing bolts shall be provided on the cradle or body of fixed ACB.
- IV. The incoming panel accommodating ACB shall be provided with indicating lamps for ON-OFF positions, digital voltmeter and ammeter of size not less than 96 mm x 96 mm, selector switches, MCB for protection circuit and measuring instrument circuits.
- V. It shall be possible to bolt the draw out frame not only in connected position but also in TEST and DISCONNECTED position to prevent dislocation due to vibration and shocks.
- VI. Draw out breakers should not close unless in distinct Service/Test/Isolated positions.
- VII. The insulation material used conform to Glow wire test as per IEC60695.
- VIII. The ACB provide in built electrical and mechanical anti-pumping.

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- IX. All EDO ACB's have Ready to Close Contact to ensure that the ACB gets a command only when it is ready to close for applications of Remote Control, AMF, Synchronization and Auto Source Change Over Systems.

## 7.11 Module Case Circuit Breaker (MCCB)

The MCCB should be current limiting type with trip time of less than 10 msec under short circuit conditions. The MCCB should be either 3 or 4 poles. MCCB comply with the requirements of the relevant standards IS13947 - Part 2/IEC 60947-2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

MCCB comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses

The breaking capacity of MCCB be as specified in the Drawings. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCBs for motor application should be selected in line with Type-2 Co-ordination as per IEC-60947-2, 1989/IS 13947-2. The breaker as supplied to meet IP54 degree of protection.

## 7.11.1 Current Limiting &amp; Coordination

The MCCB employ maintenance free minimum let-through energies and capable of achieving discrimination up to the full short circuit capacity of the downstream MCCB. **The manufacturer provide both the discrimination tables and let-through energy curves for all.**

**Protection Functions**

MCCBs with ratings less than 100 A shall be equipped with Thermal-magnetic (**adjustable** thermal for overload and **fixed** magnetic for short-circuit protection) trip units

Microprocessor MCCBs with ratings 100A and above shall be equipped with microprocessor based trip units.

Microprocessor and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorized access to the settings

Microprocessor trip units comply with appendix F of IEC 60947-2 standard (measurement of RMS current values, electromagnetic compatibility, etc.)

Protection settings apply to all poles of circuit breaker.

All Microprocessor components withstand temperatures up to 125 °C

## 7.11.2 Testing

- a) Original test certificate of the MCCB as per IEC 60947-1 & 2 or IS13947 be furnished.
- b) Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.

## 7.11.3 Interlocking

Moulded, case circuit breakers be provided with the following interlocking devices for interlocking the door of a switch board.

- a) Handle interlock to prevent unnecessary manipulations of the breaker.

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b) Door interlock to prevent the door being opened when the breaker is in ON position.

c) Defeat-interlocking device to open the door even if the breaker is in ON position.

The MCCB shall be current limiting type and comprise of quick make – Break switching mechanism. MCCBs shall be capable of defined variable overload adjustment. All MCCBs rated 100 Amps and above have adjustable over load & short circuit pick-up.

All MCCB with microprocessor based release unit, the protection be adjustable Overload, Short circuit and earth fault protection with time delay.

The trip command override all other commands.

## 7.12 Motor Protection Circuit Breaker (MPCB)

Motor circuit breakers conform to the general recommendations of standard IEC 947 -1,2 and 4 (VDE 660, 0113 NF EN 60 947-1-2-4, BS 4752) and to standards UL 508 and CSA C22-2 N°14.

The devices shall be in utilization category A, conforming to IEC 947-2 and AC3 conforming to IEC 947-4. MPCB have a rated operational and insulation voltage of 690V AC (50 Hz) and MPCB shall be suitable for isolation conforming to standard IEC 60947-2 and have a rated impulse withstand voltage (Uimp) of 6 kV. The motor circuit breakers shall be designed to be mounted vertically or horizontally without de-rating. Power supply be from the top or from the bottom. In order to ensure maximum safety, the contacts shall be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers. The operating mechanism of the motor circuit breakers must have snap action opening and closing with free tripping of the control devices. All the poles close, open, and trip simultaneously. The motor circuit breakers accept a padlocking device in the "isolated" position.

The motor circuit breakers shall be equipped with a "PUSH TO TRIP" device on the front enabling the correct operation of the mechanism and poles opening to be checked. The auxiliary contacts shall be front or side mounting, and both arrangements be possible. The front-mounting attachments not change the breaker surface area. Depending on its mounting direction the single pole contact block could be NO or NC. All the electrical auxiliaries and accessories shall be equipped with terminal blocks and shall be plug-in type. The motor circuit breakers have a combination with the downstream contactor enabling the provision of a perfectly co-ordinated motor-starter. This combination enable type 1 or type 2 co-ordination of the protective devices conforming to IEC 60947-4-1. Type 2 co-ordination be guaranteed by tables tested and certified by an official laboratory: LOVAG (or other official laboratory). The motor circuit breakers, depending on the type, could be equipped with a door-mounted operator which allow the device setting. The motor circuit breakers shall be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection. In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) be factory set to an average value of 12 Ir.

All the elements of the motor circuit breakers shall be designated to enable operation at an ambient temperature of 60°C without derating. The thermal trips shall be adjustable on the front by a rotary selector. The adjustment of the protection shall be simultaneous for all poles. Phase unbalance and phase loss detection shall be available. Temperature compensation (-20°C to +60°C)

## 7.13 Miniature Circuit Breaker (MCB)

Miniature Circuit Breaker comply with IS-8828-1996/IEC898-1995. Miniature circuit breakers shall be quick make and break type for 240/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity not be less than 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current



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Limiting type (Class-3). MCBs shall be classified (B,C,D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer. The MCB have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer publish the values. MCB ensure complete electrical isolation & downstream circuit or equipment when the MCB is switched OFF.

The housing shall be heat resistant and having a high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP, TPN and 4 Pole miniature circuit breakers have a common trip bar independent to the external operating handle.

## 7.14 Painting

All sheet steel work undergo a process of degreasing, pickling in acid, cold rinsing, phosphating, passivating (seven tank processing) and then painted with electrostatic paint (Powder coating). The shade of colour of panel inside/outside shall be as indicated in datasheets & relevant BIS code.

## 7.15 Labels

Engraved PVC labels shall be provided on all incoming and outgoing feeder. Circuit diagram showing the arrangements of the circuit inside the control panel shall be pasted on inside of the panel door and covered with transparent plastic sheet.

## 7.16 Meters

- i. All voltmeters and indicating lamps shall be through MCB's.
- ii. Meters and indicating instruments be plug type.
- iii. All CT's connection for meters shall be through Test Terminal Block (TTB).
- iv. CT ratio and burdens shall be as specified on the Single line diagram.

## 7.17 Current Transformers

Current transformers be provided for Control panels carrying current in excess of 60 amps. All phase be provided with current transformers of suitable VA burden with 5 amps secondaries for operation of associated metering.

The CTs conform to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast, robust to withstand thermal and dynamic stresses during short circuits. Metering CTs, have inbuilt busbar mounting arrangement. Secondary terminals of CTs be brought out suitable to a terminal block which be easily accessible for testing and terminal connections. The secondary terminal should be covered with insulation cap/cover so that there should not be any possibility of touching the live terminal. The protection CTs be of accuracy class 5P20 and measurement CTs be of accuracy class I.

## 7.18 Selector Switch

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

## 7.19 Contactor

Contactors shall be built into a high strength thermoplastic body and shall be provided with an arc shield for quick arc extinguishing. Silver alloy tips shall be provided to ensure a high degree of reliability and endurance under continuous operation. The magnet system consist of laminated yoke and armature to ensure clean operation without hum or chatter.

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Starters contactors have 3 main and 2 Nos. NO / NC auxiliary contacts and shall be air break type suitable for making and breaking contact at minimum power factor of 0.35. For design consideration of contactors the starting current of connected motor shall be assumed to be 6 times the full load current of the motor in case of direct-on-line starters and 3 times the full load current of the motor in case of Star Delta and Reduced Voltage Starters. The insulation for contactor coils be of Class "E".

Coil shall be tape wound vacuum impregnated and be housed in a thermostatic bobbin, suitable for tropical conditions and withstand voltage fluctuations. Coil be suitable for 220/415±10% volts AC, 50 cycles AC supply.

**7.20 Thermal Overload Relay**

Thermal over load relay have built in phase failure sensitive tripping mechanism to prevent against single phasing as well as on overloading. The relay operate on the differential system of protection to safeguard against three phase overload, single phasing and unbalanced voltage conditions.

Auto-manual conversion facility shall be provided to convert from auto-reset mode to manual-reset mode and vice-versa at site. Ambient temperature compensation shall be provided for variation in ambient temperature from -5° C to +55°C.

All overload relays shall be of three element, positive acting ambient temperature compensated time lagged thermal over load relays with adjustable setting. Relays shall be directly connected for motors upto 35 HP capacity. C.T. operated relays be provided for motors above 35 HP capacity. Heater circuit contactors may not be provided with overload relays.

**7.21 Time Delay Relays**

Time delay relays shall be adjustable type with time delay adjustment from 0-180 seconds and have one set of auxiliary contacts for indicating lamp connection.

**7.22 Indicating Lamp and Metering**

All meters and indicating lamps be in accordance with relevant IS standard specification. The meters shall be flush mounted type. The indicating lamp shall be of LED type. Each MCC and control panel be provided with voltmeter 0-500 volts with three way and off selector switch, CT operated ammeter of suitable range with three nos. CTS of suitable ratio with three way and off selector switch, phase indicating lamps, and other indicating lamps as called for. All indicating lamp be backed up with 5 amps MCB.

**7.23 Toggle switch**

Toggle switches, where required, shall be in conformity with relevant IS Codes and be of 5 amps rating.

Push button stations shall be provided for manual starting and stopping of motors / equipment Green and Red colour push buttons shall be provided for 'Starting' and 'Stopping' operations. 'Start' or 'Stop' indicating flaps shall be provided for push buttons. Push Buttons shall be suitable for panel mounting and accessible from front without opening door, Lock lever be provided for 'Stop' push buttons. The push button contacts be suitable for 6 amps current capacity.

**7.25 Conduits**

Conduits and Accessories conform to latest edition of Indian Standards IS-9537 part 1 & 2. 16/14 (16 gauge upto 32mm diameter & 14 gauge above 32 mm diameter) gauge screwed GI or MS conduits to be used. Joints between conduits and accessories shall be



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securely made by standard accessories, as per IS-2667, IS-3837 and IS-5133 to ensure earth continuity. All conduit accessories shall be threaded type only.

Only approved make of conduits and accessories be used.

Conduits shall be delivered to the site of construction in original bundles and each length of conduit bear the label of the manufacturer.

**Note.** : Whatever materials required to be billed by the Contractor should come on site with proper Challan Numbers and quantity mentioned in each such Challan..

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into metallic Conduits are given below :

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	5	10	14	--	--
2.5	5	8	12	--	--
4	3	7	10	--	--
6	2	5	8	--	--
10	--	3	5	6	--
16	--	2	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into rigid non-metallic or PVC Conduits are given below :

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	7	12	16	--	--
2.5	5	10	14	--	--
4	4	8	12	--	--
6	3	6	8	--	--
10	--	4	5	6	--
16	--	3	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

#### 7.26 Cables

1100V grade Cables of sizes 25 sq. mm. and above shall be XLPE FRLS insulated aluminium conductor armoured type and PVC insulated Copper conductor armoured cables for sizes 16 sq. mm. and below. All cables shall be conforming to IS Codes. Cables shall be suitable for laying in trenches, ducts, and on cable trays as required. Cables shall be termite resistant. Cable glands shall be heavy duty double compression brass glands. Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables.

The equipment inside plant room shall be connected to the control panel by means of suitable cables of adequate size. An isolator shall be provided near each motor/equipment (mounted within 10 ~ 15 mtr distance on nearest wall or self supported on floor ) wherever the motor/equipment is separated from the supply panel through a partition barrier or through ceiling construction. PVC insulated copper conductor wires shall be used inside the control panel for connecting different components and all the wires inside the control panel shall be neatly dressed and plastic beads shall be provided at both the ends for easy identification of control wiring.

Cables shall be cross linked polyethylene (XLPE) insulated PVC inner sheathed and FRLS PVC outer sheath of 1100 volts grade. Cables shall be suitable for laying in trenches, ducts, and on cable trays as required. Cables shall be termite resistant. Cable glands shall be double compression glands. Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables. All conductors shall be stranded.

Cabling for following equipment shall be fire survival type.

1. Basement smoke exhaust fan
2. Jet fans
3. Smoke evacuation fan
4. Staircase, lift, lobby pressurization tank
5. Make-up air fan for emergency duty

#### 7.27 Fire Survival Armoured Cable

Fire Survival armoured cable, LPCB / BRE-GLOBAL / ERDA approved, with class -2, annealed copper / or aluminum conductor having glass mica fire barrier tape extruded with cross linkable low smoke zero halogen insulation. The inner & outer sheath shall be LSZH. The basic design shall be as per BS: 7846 & BS: 5839-1 (Latest edition).

The cable should meet fire performance circuit integrity test as per BS 8434-2 / BS 6387 CWZ.

#### 7.28 Fire Survival Un- Armoured Cable

Fire Survival Un-armoured cable, LPCB / BRE-GLOBAL / ERDA approved, with class -2, annealed copper or aluminum conductor having glass mica fire barrier tape extruded with cross linkable low smoke zero halogen insulation. The outer sheath shall be LSZH. The basic design shall be as per BS: 7629 & BS: 5839-1 (Latest edition).

The cable should meet fire performance circuit integrity test as per BS 8434-2 / BS 6387 CWZ.

Cabling shall be of the following sizes as minimum :

i.	From 30 HP to 35 HP motors	2 nos. 3 x 16 sq. mm aluminium conductor armoured cable.
ii.	From 40 HP to 50 HP motors	2 Nos. 3 x 25 sq. mm. aluminium conductor armoured cable.
iii.	From 60 HP to 75 HP motors	1 No. 3 x 70 sq. mm aluminium conductor armoured cable.
iv.	100 HP motors	1 No. 3 x 150 sq. mm. aluminium conductor armoured cable
v.	150 HP motor	1 No. 3 x 240 sq. mm. aluminium conductor armoured cable.
vi.	250 HP motor	2 Nos. 3 x 240 sq. mm. aluminium conductor armoured cable.
vii.	400 HP motor	3 Nos. 3 x 240 sq. mm. aluminium conductor armoured cable.
viii.	600 HP motor	3 Nos. 3 x 400 sq. mm. aluminium conductor armoured cable.

**HVAC contractor shall submit cable schedule for all equipment for approval.**

#### 7.29 Cable Laying

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

##### 7.29.1 Laying of Cables on Cable Trays

The relative position of the cables, laid on the cable tray be preserved and the cables not cross each other. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius as recommended by the manufacturer's. All cables be laid with minimum one diameter gap and shall be clamped at every metre to the cable tray. Cables be tagged for identification with aluminum tag and clamped properly at every 20M. Tags be provided at both ends and all changes in directions both sides of wall and floor crossings. All cable be identified by embossing on the tag the size of the cable, place of origin and termination.

All cables passing through holes in floor or walls shall be sealed with fire retardant Sealant and shall be painted with fire retardant paint upto one meter on all joints, terminations and both sides of the wall crossings by "VIPER CABLE RETARD".

#### 7.29.2 Laying of Cables in Ground

The width of trench for laying single cable be minimum 350 mm. Where more than one cable is to be laid in horizontal formation, the width of the trench be workout by providing 200 mm gap between the cables, except where otherwise specified. There shall be clearance of 150 mm between the end cable and the side wall of the trench. The minimum depth of the cable trench no to be less than 750 mm for single layer of cables. When the cables are laid in more than one tier the depth of the trench shall be increased by 300 mm for each additional tier.

Excavation of trenches : 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 excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. The bottom of the trench shall be levelled and shall be made free from stone, brick bats etc. The trench then shall be provided with a layer of clean, dry sand cushion of not less than 100 mm in depth. Prior to laying of cables, the cores shall be tested for continuity and insulation resistance. The cable drum be properly mounted on jacks, at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum and the spindle is horizontal. Cable shall be pulled over rollers in the trench steadily and uniformly without jerks and strains. The entire drum length shall be laid in one stretch. However, where this is not possible the remainder of the cable be removed by 'Flaking' i.e. by making one long loop in the reverse direction. After the cable has been uncoiled and laid into the trench over the rollers, the cable shall be lifted off the rollers beginning from one end by helpers standing about 10 meters apart and laid in a reasonably straight line. Cable laid in trenches in a single tier formation have a cover of clean, dry sand of not less than 150 mm. 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 300 mm shall be provided over the initial bed before the second tier is laid. Finally the cables be protected by second class bricks before back filling the trench. The buried depth of uppermost layer of cable not be less than 750mm.

Back Filling : The trenches shall be back filled with excavated earth free from stones or other sharp edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 300 mm. Unless otherwise specified, a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench shall be left to allow for subsidence.

#### 7.30 Wire and Wire Sizes

1100 volts grade PVC insulated copper conductor wires in conduit shall be used.

For all single phase/ 3 phase wiring, 1100 volts grade PVC insulated copper conductor LSZH wires shall be used. The equipment inside plant room and AHU room shall be connected to the control panel by means of insulated copper conductor wires of adequate size in exposed conduits. Final connections to the equipment shall be through wiring enclosed in galvanized flexible conduits rigidly clamped at both ends and at regular intervals. An isolator shall be provided near each motor/equipment wherever the motor/equipment is separated from the supply panel through a partition barrier or through ceiling construction. PVC insulated copper conductor wires shall be used inside the control panel for connecting different components and all the wires inside the control panel shall be neatly dressed and plastic beads be provided at both the ends for easy identification of control wiring.

The minimum size of control wiring shall be 1.5 sq. mm PVC insulated stranded soft drawn copper conductor wires drawn through conduit to be provided for connecting equipment and control panels.

Power cabling shall be of the minimum following sizes:

- |      |   |  |
|------|---|--|
| i.   | Upto 5 HP motors/ 5 KW heaters                      | 3C x 4 sq. mm copper conductor PVC insulated cables.       |
| ii.  | From 6 HP to 10 HP motors<br>6 KW to 7.5 KW heaters | 3 x 6 sq. mm copper conductor PVC insulated cables.        |
| iii. | From 12.5 HP to 15 HP motors                        | 2 Nos. 3 x 6 sq. mm copper conductor PVC insulated cables. |
| iv.  | From 20 HP to 25 HP motors                          | 2 Nos. 3 x 10 sq. mm copper conductor PVC insulated cables |

#### Starters

Each motor shall be provided with a starter of suitable rating. Starters be in accordance with relevant IS Codes. All Star Delta Starters be fully automatic. **Motors up to 7.5 HP be provided by Direct On Line (DOL) starter, motors above 7.5 HP and up to 45 HP shall be provided by star/delta starter and motors above 45 HP shall be provided by soft starter.** All starters be with Type II coordination for breaker, contactor and over load relay.

All the switches, contactors, push button stations, indicating lamps be distinctly marked with a small description of the service installed. The following capacity contactors and overload relays shall be provided for different capacity motors or as per manufacturer's recommendation.

TYPE OF STARTER CAPACITY	CONTACTOR CURRENT RANGE	OVERLOAD RELAY
5 HP Motors	D O L	16 amps
7.5 HP motors	D O L	16 amps
10 HP Motors	Automatic Star Delta	25 amps
12.5 HP Motors	Automatic Star Delta	16 amps
15 HP Motors	Automatic Star Delta	25 amps
20 HP Motors	Automatic Star Delta	32 amps
25 HP Motors	Automatic Star Delta	32 amps
30 HP Motors	Automatic Star Delta	40 amps
35 HP Motors	Automatic Star Delta	40 amps
40 HP Motors	Automatic Star Delta	40 amps
50 HP Motors	VFD	70 amps
60 HP Motors	VFD	110 amps
75 HP Motors	VFD	110 amps
100 HP Motors	VFD	200 amps
125 HP Motors	VFD	200 amps
150 HP Motors	VFD	200 amps
150 HP Motors	VFD	300 amps
200 HP Motors	VFD	300 amps
250 HP Motors	VFD	400 amps
300 HP Motors	VFD	400 amps
400 HP Motors	VFD	600 amps
600 HP Motors	VFD	900 amps

Two speed motors when specified, be provided with DOL starter irrespective of it rating.

## 7.31 Cable Trays

Ladder and perforated type Cable Trays be of Hot dip Galvanized type and factory fabricated out of CRCA sheet with standard accessories like tee, bends, couplers etc. for different loads and number and size of cables as given below :

Cable trays be galvanized as per Specifications..

- a. 1500 mm wide  
Runners 25 x 100 x 25 x 3 mm  
Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C  
Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x 40 x 5mm GI angle.
- b. 1200 mm wide  
Runners 25 x 100 x 25 x 3 mm  
Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C  
Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x 40 x 5mm GI angle.
- c. 1000 mm wide  
Runners 25 x 100 x 25 x 3 mm  
Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C  
Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x 40 x 5mm GI angle.
- d. 750 mm wide  
Runners 20 x 75 x 20 x 2.5 mm  
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C  
Suspenders 2 Nos. 32 x 32 x 5 mm GI angle 1800 mm C/C with base support of 40x 40 x 5mm GI angle.
- e. 600 mm wide  
Runners 20 x 75 x 20 x 2.5 mm  
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C  
Suspenders 2 Nos. 32 x 32 x 5 mm GI angle 1800 mm C/C with base support of 40x 40 x 5mm GI angle.
- f. 450 mm wide  
Runners 20 x 75 x 20 x 2.5 mm  
Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C  
Suspenders 2 Nos. 25 x 25 x 4 mm GI angle 1800 mm C/C with base support of 40x 40 x 5mm GI angle.
- g. Supply and fixing of perforated type cable trays of the following sizes of pre-galvanized iron.
  - i. 600 x 40 x 40 x 2 mm thick
  - i. 450 x 40 x 40 x 2 mm thick
  - i. 300 x 40 x 40 x 2 mm thick
  - ii. 150 x 40 x 40 x 2 mm thick

**Note :** Suitable length of 10 mm dia GI rod suspenders at 1800 mm interval shall be included in the item for perforated type cable tray.