

07 CHAPTER SPECIFICATIONS - ELECTRICAL

1.0 INTENT OF SPECIFICATIONS/SCOPE

- 1.1 This specification along with specific job requirements (if any) is intended to cover the design, engineering, supply, installation, testing and commissioning of entire electrical facilities/ equipment and items and accessories including consumable against lump sum price for entire treatment plant/facility as indicated here in and elsewhere covered in the scope of this tender.
- 1.2 It is not intended to cover all aspect of system design but to indicate the basic requirements only. Contractor shall ensure that detailed design and installation is carried out as per good engineering practices and shall meet requirements of safety, reliability, ease of maintenance & operation, aesthetics, scope for future expansion (if specified elsewhere in tender under scope of work or project description) and maximum interchangeability of the equipment.

“Scope of Schedule of Item” as mentioned herein are minimum and suggestive but not conclusive and binding. The contractor shall furnish all, but not limited to equipment, materials, accessories, and service as required fulfilling the performance of proposed new plant.
- 1.3 Bidder must quote the price according to intent, besides content of the of the tender. Engineer’s/ Consultant’s interpretation of the meaning of the specifications, drawings shall be final who shall have the right to accept or reject any material or work which in his assessment is not complete to meet the intent of this specification and/or applicable standards.
- 1.4 The equipment and accessories shall be complete in all respects and any device not included in this specification but essential for proper operation of the plant shall be deemed to be within the scope of this specification whether specifically mentioned or not.
- 1.5 Some parts of the total work may have tie ups with the existing system. Hence any commercial or technical implications thereof must be duly taken care of even if not mentioned/considered in this tender.
- 1.6 It is the responsibility of Bidder to visit and assess the site conditions for the purpose of this work.
- 1.7 Bidder shall also ensure to take care of existing works/piping/cabling, if any, during execution and ensure no damage is done and obstruction be resolved in consultation with engineer in-charge at no extra cost. In case of any damage, it is the responsibility of bidder to rectify the problem to the satisfaction of engineer in-charge at no extra cost.
- 1.8 The equipment items shall be supplied only as per approved vendor list for major items enclosed herewith as part of this tender document. Bidder shall furnish necessary technical catalogue and details and obtain approval for the make of items he proposes to procure before placement of order. The decision of Engineer-in-charge in the matter is final and binding. Approval for makes of items not mentioned in the approved list of vendors will also be required to be obtained from Engineer-in-charge before procuring the same.
- 1.9 Compliance with this specification and/or review of any of the vendor documents shall not relieve the vendor of his responsibility towards his contractual obligation with regard to the completeness and satisfactory operation of the plant.

2.0 SCOPE OF WORK

Design, Engineering, Supply, Installation, Testing and Commissioning of the entire electrical facilities including electrical equipment, control devices, fittings, cables/wires, conduits, hardware and consumable and also including all relevant works like termination, cable jointing, earth excavation/backfilling, structural works for equipment support, Hot dip galvanized ladder/perforated type medium duty (minimum 610 g/m² galvanizing) cable trays as per IS: 2629/FRP/GRP cable tray as per NEMA FG1 specification with minimum factor of safety 1.5 or higher as specified elsewhere, all allied civil works etc.

In outdoor areas cables shall be mostly laid on overhead cable trays (min. 3m clear height and for road crossing for vehicle / truck movement without obstruction shall be min. 5m clear height or higher as required) or in cable trench with proper support angle, clamp etc. and covered with precast cover for outdoor area. For outdoor area, cables laid direct buried in ground are not permitted. Where as in indoor areas, cables shall be laid in trenches/walls/ceilings/structures through suitable trays. Overhead cable tray (outdoors) shall be erected with minimum 5m clearance or higher as required at road crossing for vehicle/ truck movement without obstruction.

Installation of the contract work including furnishing labour (Skilled/Unskilled) and supervisory personnel inclusive of the services of an experienced engineer, having authorized and valid supervisory license is included in the scope of work/services.

All installation are to carried out as per the statutory requirements of local Electrical Inspectorate/IE rules/CEA Regulations/applicable IS Code/code of practices and obtaining statutory clearance from Electrical Inspectorate shall be in the scope of executing contractor including for Genset (Diesel/Gas) as applicable.

Electrical equipment shall meet the requirements of Indian Electricity Rules, CEA Notification, CPWD guidelines, State Regulations as amended up to date and relevant IS/IEC Codes of Practice. In addition, other rules and regulations as applicable to the work shall be followed. In case of any discrepancy, the most restrictive rule shall be binding.

2.1 SCOPE OF SCHEDULE OF ITEMS

“Scope of Schedule of Items” as mentioned here in are suggestive but not conclusive and binding. The contractor shall furnish all, and not limited to below equipment, materials and accessories and service, as required to fulfill the performance of proposed new plant. The general requirements as under.

Sr. No.	Item Description
1	11 kV, Two pole structure with DO type air break isolator/DO fuses/LA/ relevant insulators (Disc/Pin/Post) etc. of adequate rating along with required foundations, fencing, gates etc. (Minimum 1 Set with HT Breaker Panel or Min. 3 Sets or more as required to meet site and statutory requirement. For distance of power supply company metering / GOD structure and client GOD structure / HT Breaker or from client GOD structure to client HT Breker panel exceeding beyond stipulated distance and if outddor type RMU panel or such required as per electrical inspector / statutory requirement, same shall be provided by bidder at no extra cost.)
2A	11kV Outdoor type, 630Amps. 21 kA for 3 second, SF6 type extensible and motorized One way(i.e one LBS and One VCB) smart Ring Main Unit (RMU) complete with VCB and FPI as per IS / Specification.
2B	11kV, 500 MVA, HT 3 breaker (1 incoming + 2 outgoing) or higher as per system requirement, indoor HV VCB switchgear panel with internal arc protection equal to short circuit current of the system i.e. 26 kA for 1 second and complete with numerical protection relays. HV panel shall be as per IEC: 62271-200/IEEE 1584/IEC 60439.

3	<p>11/0.433kV Dyn11, ONAN, Oil Filled type, outdoor type transformers energy efficiency level 2 as per IS: 1180 Part 1 (latest version), continuous duty with On load (on circuit) tap changer mechanism with RTCC panel as specified elsewhere, Buchloz relay and other standard fittings/accessories, each of required rating to cater to the entire treatment plant load @ 80% loading. Required foundations, chain link fencing, gates etc. shall also be provided.</p> <p>The transformer shall be sized considering the diversity and load factor and voltage drop as specified in design basis/specifications elsewhere.</p> <p>Transformer sizing shall be restricted preferably to 2500kVA maximum. If transformer required is > 2500 kVA, then load shall be segregated optimally and transformers of lesser ratings (2 working + 1 standby of same capacity) feeding two PCC/PMCC shall be provided. Separate HV breaker feeders shall be provided for each transformer. Alternatively 2 working transformers and one common stand by transformer with common change over panel also is acceptable only if both PCC/PMCC being fed are in the same room.</p> <p>kVA rating to be specified by the Bidder along with necessary load calculations for plant peak load considering 100% stand by unit. Transformer sizing shall be based on motor rated PF i.e. without APFC/Fixed PF improvement capacitors.</p>
4	<p>3 phase Aluminium Sandwich type bus duct IP 65, 65kA, design ambient of 50 °C with all accessories including copper flexibles at termination of equipment and GI supporting structure for transformer ratings 1000 kVA and above, one for each incomer.</p>
5	<p>LV/MV panels (PCC/PMCC/MCC)</p>
5a	<p>PCC/PMCC: 415V, 3 phase, 4 wire, minimum 50kA (1 second) or higher as per fault level requirement, PCC/PMCC (at main LV room) with necessary incomers (as required for each incoming supply - for each transformer/grid, DG set etc.), bus coupler(s) (between grid incomers, other/additional bus couplers if required as per design), with electrical/mechanical interlocks etc. and with fixed capacitor bank and 7% detuned reactor with thermostat at each grid incomer (minimum 3% of transformer rating, timer interlocked and in break up of approximately 50%, 25%, 15%, 10% of total, each with separate/MCB (D curve)/MCCB and interlock contact and as per tender specifications / SLD) and required outgoing power feeders, starter feeders, spare feeders etc. Power feeder for each MCC panel shall be taken from both the buses.</p> <p>Incomer and bus coupler ACB/MCCB ampere rating shall be with minimum 20% margin over the required ampere rating based on rated current of transformer.</p> <p>Please note the following minimum requirement for the LV panel:</p> <ul style="list-style-type: none"> • The fixed capacitor/reactor and associated switchgear must be located on the front side of the LV panel compartment to facilitate ease of maintenance. • The LV panel for the pump starter must be of a two-door design. The upper compartment shall house the main power MCCB, and the lower compartment shall house the soft starter. • Control cable wiring for auxiliary items, such as thermostats, heaters, sockets, and panel lights, must be installed with proper cable dressing. Plastic tags or temporary installations are strictly prohibited. • For All motor starters and outgoing power feeders equipped with MFMs, separate ammeters and voltmeters are required. • Sufficient space must be provided within the panel for MCBs and protection relays. • The rear side of the LV panel must have a single door; double doors are not permitted. • Each feeder shall be labeled with a nameplate of stainless steel (SS)

	<p>material, featuring white font on a black background. The nameplate shall be affixed using rivets. The minimum width of the nameplate shall be 2 cm, and the length shall be determined as required.</p> <ul style="list-style-type: none"> • The pump starter wiring must be configured so that the ON, OFF, and trip indications are displayed only when the main MCCB/ACB is ON. • A specialized high-temperature rated cable shall be used for panel heater wiring. • Each compartment within the panel shall be equipped with a dedicated lamp and controlling MCB. • Sufficient internal space shall be provided within all starter panels and feeders to facilitate ease of maintenance. • EDO-type ACBs, incorporating UVT features, shall be used. Their displays must also remain ON when energized without a load. • The LV panel shall provide the capability to operate all actuator-operated valves/gates from their respective panel starters. • All covers and doors shall be equipped with recessed neoprene gaskets, or a superior long-life sealing solution, to ensure extended operational lifespan. • Separate double-pole (DP) MCBs shall be provided for auxiliary items such as cooling fans, heaters, and thermostats.
5b	<p>MCC PANEL</p> <p>Bidder/Contractor shall consider to provide MCCs to be housed in MCC room at other suitable location in plant as per their design. All MCC panel shall be provided with two incomers (one incomer as standby) with electrical and mechanical interlocking between the two.</p> <p>Panels forming part of the various Mechanical Equipment to be supplied by the Contractor and which are considered part of the respective equipment, are not included in the above.</p> <p>Outdoor starter/control panels/power panels wherever provided shall be with canopy and double door. Panel shall be fabricated from SS 304 and all hardware, hinges supporting structure etc shall be of SS.</p>
5c	<p>MPDB/PDB/MLDB/LDB (MCB type TPN, LDB, typically 4/6/8 way per phase, up to 20A single pole per way). Outdoor PDB/LDB shall be with double door and with canopy.</p>
6	<p>Automatic (Dynamic) power factor improvement capacitor panel(APFC panels) to maintain minimum power factor as per specifications. 7% detuned reactor with thermostat, 440V shall be provided in series with 525V capacitor if working VFD load is more than 50% of total load. KVAR rating of capacitor shall be suitable for reactor rating. Minimum 20% margin to be considered above required capacitor as per calculation.</p> <p>At PCC/PMCC, 2 Nos. APFC panels shall be provided as a minimum, one on each bus of PCC/PMCC, with minimum 70% of rated design each or higher as required. Additionally APFC panel can also be considered at MCC level.</p> <p>Please note the following minimum requirement for the APFC panel:</p> <ul style="list-style-type: none"> • The APFC panel should be designed to accommodate the following capacitor ratings: 5 Kvar, 10 Kvar, 15 Kvar, 20 Kvar, 25 Kvar & 50 Kvar.
7	<p>LV motors, IE3 class, S1 duty; for Crane/Hoist application S4 duty; for Submersible Pumps - equivalent to IE2 class, S1 duty.</p>
8	<p>Local start/stop push button control station (Polycarbonate enclosure), IP 65</p>
9	<p>Indoor and Outdoor illumination system to achieve average lux level as mentioned elsewhere in this electrical specifications. Indoor and outdoor lighting fixtures shall be LED type only. Lighting poles shall be GI Octagonal type. Welding sockets with necessary cabling/wiring, MDBs/LDBs, poles, fixtures etc.</p>
10	<p>HV/LV Power/Control Cables: (multi-stranded conductor, with extruded inner sheath)</p> <p>a) 11kV XLPE (E), Aluminum conductor, armoured power cable;</p> <p>b) 1.1kV, XLPE/PVC insulated, Alu. conductor, armoured power cable of</p>

	<p>suitable size and cores. Aluminium power cable for 6 sq mm and above sizes only and for 2.5 sq mm, 4 sq. mm only multi-strand Copper cable shall be used;</p> <p>c) 1.1kV, PVC/XLPE insulated, multi-strand Copper conductor, armoured, Control Cable of 2.5 sq mm suitable number cores for LCS, ammeter etc. minimum 1 no. or 20% spare cores to be provided;</p> <p>d) 1.1kV PVC/XLPE insulated, Copper, 4 core armoured cable of required size (Minimum 2.5 sq mm or higher as required as per load requirement) for lighting cable.</p> <p>e) Other cables as required.</p> <p>Note: Copper Cable shall be provided between each transformer to PCC / PMCC Panel Incomer.</p>
11	Complete earthing system with maintenance free earth electrodes, chemical earthing Pits, earthing strip (hot dip galvanized GI/Copper), Lightning arrestor etc.
12	Cable glands (double compression Ni plated Brass glands), sockets, steel, other erection hardware and accessories etc.
13	Supply/fabrication/erection/painting of MS structural steel as required for cable trays as per IS: 2629/supports/hangers/cleats etc. to complete entire electrical works. Cable trays shall be hot dip galvanized (medium duty minimum 610 g/m ² galvanizing). Alternately cable trays of FRP (GRP) cable tray as per NEMA FG1 of suitable size and strength can be accepted. Hardware used shall be hot dip galvanized/SS.
14	Any other internal wiring / point wiring / electrification work and including required switches, plug points, power sockets / points, etc.; industrial power sockets, fans, exhaust fans, safety accessories, etc.
15	DG Set of required rating to cater to 100% capacity for treatment plant (CWPH,WTP,ZLD) of the working load of entire plant @ 80% loading along with AMF panel to operate entire plant load on DG Set in case of power failure. (AMF Cum Synchronizing panel is strictly not permitted) Every DG set must work individually.
16	Surge protection shall be provided on power system equipment fed from overhead line systems. Usually this shall apply to HV overhead supplies feeding to sites. In this case the surge protection shall be provided by the contractor at incoming and outgoing of HV panel. Surge protection shall be provided at incomer of each LV panel (PMCC/MCC).
17	Any other work as required to complete the work in all respects.

Note: It is not the intent to specify herein completely, all details pertaining to design, shop testing, installation, field testing and commissioning. However, these shall conform in all respects to high standards of engineering design and workmanship, meeting the requirements of all applicable codes and standards including local statutory requirements. The scope shall include all the specified accessories/items as well as other any required items/accessories, whether specified or not, for satisfactory/safe operation of the entire electrical system and for meeting all statutory requirements.

3.0 SPECIFICATIONS OF ELECTRICAL WORKS (GENERAL)

General

Following clauses specify general electrical requirements and standard of workmanship for the equipment and installations. General specification clauses shall apply where appropriate except where particularly redefined in the Special Specification Clauses.

3.1 Equipment Selection

The general basic requirements for design and selection of equipment shall be for

- Safety of Personnel and Equipment
- Adequate Operational Reliability

- Ease of Installation, Operations and Parts
- Interchangeability of Equipment and parts
- Robust and Economical Design

The offered equipment shall be brand new with state of the art technology and proven field track record. No prototype equipment shall be offered.

Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply.

Vendor shall give a notice of at least one year to the end user/owner of equipment before phasing out the product/spares to enable the end user for replacement of order for spares and services.

3.2 CODES AND STANDARDS

The electrical equipment and complete installation offered shall comply with the relevant Indian Standards/Codes of Practices, this specifications, statutory regulations and sound engineering practices.

The complete system shall conform to the latest revisions of the following.

- The Indian Electricity Act & Rules
- The Indian Electricity (Supply) Act, 1948
- Regulations laid down by local statutory authorities and CEA/Electrical Inspectorate.
- The requirement of State Electricity Board/ Electricity Regulation Committee.
- Fire advisory Committee Insurance Act/Fire Insurance Regulations
- Indian Petroleum rules and any other regulations laid down by the Chief Controller of Explosives
- The factory act and any other regulations laid down by factory inspectorate

3.2.1 Obtaining approvals on behalf of Client from statutory authorities for materials, plant design/ drawings and complete installation shall be the responsibility of the contractor including all required liasoning (All statutory fees shall be paid by client). The contractor shall get the drawings, layouts of HV sub station, Genset (Diesel/Gas operated etc.) etc. approved from local electric supply company and Chief Electrical Inspector, as applicable. The contractor also shall arrange to get the installation inspected by CEI and carryout modifications/rectification as required by CEI, prior to commissioning of substation/electrical equipment.

3.2.2 Wherever Indian Standards do not exist, the relevant IEC, British or German (VDE)/IEEE/ NEMA standards shall apply. Any other Standard which is considered equivalent to or superior than applicable Indian Standards may also be acceptable. The tenderer however, shall have to substantiate equivalence or superiority.

3.3 Voltage Regulation

During starting of heavy equipment, the voltage may drop by a maximum of 15% for period of up to 45-60 seconds depending upon the duty of the driving equipment and maximum 5% at the load terminal during running condition. All the electrical equipment shall, therefore, be suitable for trouble free and uninterrupted operation even during such voltage variation at the time of starting of heavy equipment.

3.4 Site/Ambient Conditions

All electrical equipment and installation shall be designed for the tropical climatic conditions and be suitable continuous operation under the site conditions as described below for design purpose.

Maximum Ambient Temperature	:	50 °C
Minimum Ambient Temperature	:	5 °C
Design Ambient temperature	:	50 °C (unless otherwise specified for specific components/equipment)
Relative Humidity	:	94%

Climate : Tropical, Dusty, Corrosive

If not specifically mentioned, an altitude not exceeding 1000m above mean sea level shall be taken into consideration for design purpose.

Where the equipment is installed outside and exposed to direct sunrise, these shall be suitable for operation at higher ambient temperature and rigorous weather conditions under which they are required to operate.

3.5 Design Basis

The distribution system shall be designed in accordance with project specifications and shall ensure continuity/reliability of supply, flexibility of operation and safety.

All components of the Electrical System shall be sized to suit the maximum load under the most severe operating conditions. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and additional margin shall be taken into account for intermittent service loads, if any.

The basic design data to be considered as follows.

Incoming Supply Conditions	11kV \pm 10%
Frequency	50 Hz \pm 5%
Voltage and Frequency Combined variation	\pm 10%
Fault Level at 11 kV	500 MVA symmetrical (1 second) or higher as per system requirement/power supply company requirement.
System Grounding	Solidly earthed
Fault Level at 415V (Design)	50kA symmetrical (1 second) or higher as per fault level requirement,
Control Voltage Circuit	LV panels: 230V AC via control voltage/constant voltage transformer HV panels up to 4 breakers: Power pack suitable for number of operations as per specifications. HV panels with 5 or more breakers: 110V DC, 100 AH (minimum or higher as required) for HV panel via battery and battery charger with DCDB with battery backup of minimum 2 hours.
HV Cabling	3C XLPE, 11 kV (E) Aluminium, armoured, extruded inner sheath.
LV Cabling	Alu. multistrand conductor XLPE/PVC insulated, extruded inner sheath cable except for motor upto and including 3.7kW for which to use 3C x 2.5 sqmm, Cu multistrand conductor, XLPE/PVC insulated cables subject to voltage drop within specified limits. Cables having Aluminium conductor shall not be less than 6 sq mm.
Control/LCS Ammeter Cables	Multicore 1.5/2.5 sq mm Cu stranded conductor, XLPE/ PVC
LDB to Switch Board and Power Sockets	Multistrand Copper flexible, 2C, minimum 2.5 sq. mm for switchboard and 4 sq. mm of power socket or higher as per requirement
Earthing	Earth pit: Maintenance free Cu plate/GI pipe electrode (Chemical type) as per IS: 3043/specifications and with Copper strip/hot dip galvanized strip.
Induction Motor	Squirrel cage induction motor, TEFC, IP 55, continuous duty (S1) rating and S4 rating for Crane/ Hoist applications, class F insulation with temperature rise limited to class B, energy efficient design of IE3 class as per IS: 12615 (2018)/IEC:60034 amended up to date. However, motors operating with VFD shall be totally compliant and

	shall have vacuum impregnated, double insulation winding with Class H insulation and with temperature rise limited to class F of inverter duty
LV Panel Design (PCC/PMCC/MCC)	Fuse less design shall be used as per CPWD guidelines/specifications. Incomer rating of LV panel shall be with minimum 20% margin over maximum working load. ACB/VFD/Soft starter cubicles shall be in single front execution only. VFD panel shall be standalone panel or as mentioned in specifications. The derated current of VFD/Soft starter for 50 °C continuous operating temperature shall be equal to or greater than 110% of the full load current as specified in IS: 12615 for squirrel cage induction motors or such type for dry well type pump set. For submersible pumps/DC or special motors the full load current shall be considered as per declared current by submersible pump/equipment manufacturer. All PMCC/MCC feeders including motor starter feeders shall be 3 phase, 4 wire system with busbar and feeder MCB/MCCB/ACB to be TPN/4P.
Soft Starter	DOL starting, soft starter derated current for 50 °C operating conditions \geq minimum 110% of rated motor current, with in-built or external bypass contactor, with in-line contactor and semi-conductor (fast acting) fuse protection, required protection parameters etc. Soft Starter shall be with inbuilt RS 485 and door mounted display unit.
Variable Frequency Drive (VFD)	VFD de-rated current for 50 °C operating conditions \geq minimum 110% of full load current of motor as specified in IS: 12615, with in-line contactor and semi-conductor (fast acting) fuse protection, required protection parameters etc. VFD shall be with inbuilt RS 485 and door mounted display unit.
Starting current for various types of starter application to be considered for design	DOL starter: Minimum 6 times the full load rated current. Star-Delta starter: Minimum 3.5 times full load rated current Soft starter: Minimum 3.5 times or higher full load rated current VFD Starter: Minimum 2 times or higher full load rated current
Load Factor	Main motors/process equipment/blower: 0.9, Auxiliary load (valve actuators, crane/hoist etc.): 0.4 & Lighting load: 1.0
Diversity Factor	Main motors/process equipment/blower: 1.0, Auxiliary load (valve actuators, crane/hoist etc.): 1.1 & Lighting load: 1.1
DG Set	DG set and alternator rating shall be designed as per guidelines given in technical specifications. Further in case of DG set rating exceeding 1000kVA, DG sets shall be minimum 2 Nos. i.e 2 x 50% capacity as a minimum or such multiples along with AMF panel. Additional 10% contingency shall be considered over and above the load requirement.

Note: The Bidder shall be responsible for assessing the voltage level requirement as per local supply regulations and based on their load requirement and in case of voltage level other than 11kV is required or envisaged as per local power supply company norms/local regulations. The Bidder shall be responsible to consider the same and all HV equipment (GOD structure, HV breaker panel, transformer incomer voltage level etc. as applicable) shall be provided suitable for this revised voltage level without any cost implication and shall be meeting all statutory requirements and all fault level and other design requirements, all clearances, safety requirement, accessories etc. shall be as per IS/CPWD/CEA guidelines.

- 3.6** Power shall be provided at any one point within the battery limit of the plot of plant / pumping station as applicable (generally being provided near the entry gate of the plant or as per the norms of power supply company). Power is expected through single circuit 11kV overhead line from the Local Power Supply Company to be terminated at Power Supply Company's Two Pole / GOD Structure with metering /

Breaker cum Metering Panel as applicable. The scope of bidder shall commence from this point onwards for transmitting power onwards to proposed plant's one way RMUs as specified in tender. Power from RMU transmitted through cables laid on overhead cable trays and terminated to Two Pole Structure with D.O. type HT isolator, fuses and lightning arrestors and Power from Two pole structure to fed to indoor 11 kV switch gear board located in substation. The scope of work also includes liasoning work for obtaining power from power supply company (PSC) on behalf of client. Bidder to also refer the requiremetns specified elsewhere in tender (scope of work / chapter 01 to 03 of Vol. 2 / BOQ as applicable).

In case of existing HV power at site, same shall be strengthened for additional demand for onward distribution of power from this point by bidder and shall also include required modifications in existing switch yard and provision of required additional two/four pole structures shall be provided to meet the statutory and design requirements and then conveyed to two pole structure of proposed plant and onwards to incomer of HV panel or to HT side of transformers as per requirement. The entire onwards power distribution from the supply company panel / GOD structure including required step up/down of voltage levels shall be in bidder's scope.

- 3.7 The HV switchgear shall comprise of Vacuum Circuit Breakers with required incoming and outgoing and shall feed proposed nos. of transformers of adequate rating for the proposed plant installed outdoor. The proposed transformers are connected by cables/bus ducts to the Main 415V power (cum motor) control centre (PCC/PMCC) at sub station building. This PCC/ PMCC shall in turn feed down stream MCC and PDB/MLDBs etc. for feeding various loads. The HT side of transformers shall be fed from outgoing of HT Breaker panel or in the case where transformer ratings are lower and within the limit as permitted by electrical inspector / statutory requirement (generally with single transformer rating of 400kVA or lower and for total / combined transformer rating within the substation of 800 kVA or below and as per latest prevailing rules/ guidelines of electrical inspector / power supply ompnay / statutory authority) direct from two / four pole structure.
- 3.8 The motors shall be suitable for outdoor installation with tropical insulation and weather proof to IP 55 as a minimum. All motors shall be started and stopped by push buttons at Local Control Stations located near respective motors. Starters shall be housed in PMCCs/MCCs with START/ STOP (Mushroom head stay put type with padlocking facility)/OVERLOAD reset push button and Auto-Off-Manual, local-remote selector switches. Motors of rating less than 7.5kW rating shall be provided with Direct-On-Line starting provision, motors of rating 7.5kW and above and less than 75kW rating shall be provided with fully automatic Star/Delta starters and motors rated 75kW and above shall be provided with soft starters unless specifically mentioned to operate with alternative menthods like VFD etc. as per process/operational requirement. Motors shall be energy efficient as per IE3 class as minimum. Motors when installed outdoor, shall be provided with FRP canopy of minimum 2mm thick.

All cables to be laid on overhead cable trays (min. 3m clear height and for road crossing for vehicle / truck movement without obstruction shall be min. 5m clear height or higher as required) or in cable trench with proper support angle, clamp etc. and covered with precast cover for outdoor area. For outdoor area, cables laid direct buried in ground are not permitted. WhereIn indoor areas, cables shall be laid in trenches through medium duty GI cable trays (minimum 610 g/m² galvanizing as per IS: 2629). Cables shall be so selected that voltage drop from PMCC/MCC to consumer end/upto motor does not exceed **5%** and subject to overall voltage drop from transformer outgoing/source to consumer end/motor shall not exceed **6%**. Accordingly the voltage drop for main power cables (feeding PMCC/PCC or feeding MCC) shall be generally sized for voltage drop not exceeding **0.5-1%** to meet the permissible overall voltage drop requirement of **6%**. Cables having Aluminium conductor shall not be less than 6 sq mm.

- 3.9 Cables shall be sized based on the rating of the transformer for PCC/PMCC, based rating of incomer ACB/MCCB for MCC, based on maximum continuous rated load current for outgoing feeder, after suitable derating within 10% overload capacity after derating and the voltage drop. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, resistance @ 70 °C maximum permissible temperature rise for cables, etc. shall be taken into account. The derated cable current shall be at least 10% higher over the rated load current. A **derating factor of 0.65** shall be used as a minimum or higher as per site conditions. Vendor will have to submit the calculations for the same.

3.10 Sub-Station/MCC Room

Sub-station or MCC room, wherever required shall be located in a safe area close to load centre. The building shall be sized to take care of present and future needs and to maintain adequate clearances between equipment for ease of maintenance. Clearance around equipment shall be maintained as per IE rules and equipment supplier's recommendations, whichever is higher. The recommended minimum clearances shall be as follows.

a) Front clearance for LV switch board panels	Single row of SWBD: 1500mm Two rows of SWBD: 1800-2000mm between two row of panels
b) Front clearance for HV switch board panels from wall	Minimum 2200mm or higher
c) Rear clearance for panels requiring maintenance from rear	1000mm from the outermost edge of panel to any wall/obstruction/projection of column
d) Rear clearance for panels not requiring back access/maintenance from rear	150-200mm
e) Side clearance from wall	750-1000mm
f) Clearance between two panels	Equal to the depth of panel

If battery banks are required/provided, same shall be located in a separate adequately ventilated room along with necessary exhaust system and water connection with sink. Floor of battery room and walls upto 1.0m height shall have acid/alkali resistant protective material coating/tiling.

Adequate safety equipment such as insulating mats, exit signs, shock/fire hazard charts, warning signs, first aid boxes, portable fire extinguishers etc. shall be provided in sub-station/MCC room as per statutory regulations.

- 3.11** Earthing system design and installation shall be generally as per IS: 3043. Earthing system shall be carried out by hot dip galvanized MS/Copper strips, electrodes by Copper/GI pipes. All earthing pits shall be maintenance free chemical type earthing pits with inner pipe minimum 40 mm dia. having 200-250 micron galvanising or Copper coated solid steel rod/flat strip type connection terminal 14mm dia with constant ohmic value surrounded by highly conductive corrosion resistant chemical compound with high charge dissipation suitable for electrical installation like transformers, DGs, lightning arresters, transformer neutrals, AC plant, Instrument control panels and sensitive computer system (like Automation, SCADA) with 3meter length of pipe with two nos. 25kg bag of back filling compound (earth enhancement material). All equipment shall have two separate and distinct earth points. Earth resistance shall not exceed one ohm at any point.(All equipment's earthing certificate must be submit to client with its earthing value.)

- 3.12** Suitable rating automatic power factor improvement panel with integral capacitor bank shall be designed/provided at each main bus to improve and maintain lagging power factor of **0.99 or better** (maximum 1.0, leading power factor is not permissible) at in-comer of main LV panel. Capacitors shall be considered for VFD motor load also to improve power factor to 0.99. **Under no circumstance, the power factor shall be less than 0.96 lag at HV side/power supply company meter.**

Voltage and current harmonics at supply side of drive system at PCC (point of common coupling) shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations of the IEEE 519 2014 or latest edition.

Drive manufacturer shall provide necessary passive/active harmonic filter solution at point of coupling to comply with standards as specified above to limit total harmonic distortion (THD). However for turbo blowers with VFD the passive filter solution shall be provided along with blower for blower VFD installed within blower skid/blower panel. Passive filter shall be preferably of the same make as VFD or shall be as recommended and vetted by VFD manufacturer.

- 3.13** Adequate numbers of small and welding power outlets to be provided at appropriate places. Appropriate numbers of Welding receptacles shall be provided at suitable locations such that it ensures accessibility with 50meter length of trailing cable at any point within battery limits of the plant. The welding receptacles shall be industrial heavy duty type rated for 415V, 63A, 5 pin, 3 phase, 4 wire system complete with scraping earthing facilities, necessary interlocks and associated plugs. Housing shall be of Polycarbonate. The receptacles shall be weatherproof type and additionally flameproof type for hazardous areas.
- 3.14** Lighting design shall conform to relevant international codes and standards, IES hand book and shall take into consideration the requirements from point of view of safety and ease in operation & maintenance. A maintenance factor of 0.8 shall be assumed for lighting illumination level calculations for normal areas. Co-efficient of utilization shall be calculated as per fixture type and areas. It shall be the Bidder's responsibility to demonstrate the illumination levels as specified in these specifications elsewhere using lux meter and rectify by providing additional lighting fixtures, if necessary, in case if illuminations levels are found to be below the specified levels. Dark patches and uneven illumination shall be avoided. **Indoor and Outdoor lighting shall be carried out by LED light fittings.**

3.15 Drawings/Documents

Execution Drawings/Documents

Following and besides that what ever drawing required detailed design drawings/documents are to be prepared in line with recommended specifications/details and submitted to Engineer-in-charge in a timely manner to allow for review and approval as a minimum.

- a) List of Drives/Loads with Quantity (Working, Standby and Total)/Rating/Type of Starter/ Specifications along with Power Load Statement
- b) Transformer, DG Set, Capacitor Sizing Calculations and Fault Level Calculations
- c) SLD, Power and Control Diagram of Complete Electrical System
- d) Wiring/Schematic Drawings for Complete Electrical System (HV Panels, LV Panels, LVDB, Lighting Panels, PDBs etc.)
- e) Overall Cable Layout and Unit Wise Cable Tray Layout
- f) Earthing Layout with Earthing Calculations
- g) Transformer & DG foundation Drawings, Substation Layout Drawings with Fencing Details
- h) Equipment Layout Drawings
- i) Internal Lighting Layout with Calculations
- j) External Lighting Layout with Calculations
- k) Cable Schedule with Voltage Drop Calculation/Sizing Calculations
- l) Interconnection Schedule
- m) GA Drawings for All Equipment including Sectional Drawings wherever necessary and specifying Recommended Installation, Weight and Clearance Requirements etc.
- n) Filled in Data Sheets
- o) Schedule of Quantities along with Brief Specifications
- p) Design/Sizing Calculations for Equipment as Applicable
- q) O and M manual for All Equipment

As-Built Drawings/Documents

All above final documents and drawings incorporating modifications, if any, done during erection/commissioning shall be furnished in number of sets as specified in scope of work after completion of work.

3.16 HV Supply

The Contractor shall ascertain the details of availability of HV supply from local electric supply company as applicable for site location wherever HV supply is to be availed and procure the equipment accordingly. It is the responsibility of the Bidder to liaison and complete the formalities of procuring power from Power Supply Company/Utility/Discom. The Client shall pay the charges for obtaining the

above connection whereas necessary liaison for the same shall be done by the Bidder/Contractor in consultation with Engineer-in-charge.

3.17 Condition of Operation

The equipment offered shall be suitable for continuous operations under high ambient temperature of 50 °C, which shall also be considered as design temperature for selection/sizing of equipment, unless otherwise specified.

All electrical equipment installed in hazardous areas, where applicable, shall be selected as per IS: 5571 and DGMS regulations, where applicable, and shall meet the requirements of relevant IS, IEC or NEC standards. Area classification drawings shall be prepared by the Contractor indicating the zone of hazardous area and the gas group. A hazard source list shall be prepared by the Contractor including the list of all flammable materials handled along with their properties like flash point, ignition temperature, explosive limits etc. Motors for digester mixing and within hazardous area shall be weather and explosion proof suitable for the hazard class. Electrical equipment for hazardous areas shall have test certificates issued by recognized independent test house (CMRI/BASEEFA/UL/FM or equivalent) and have valid statutory approvals as applicable for specified locations.

The Contractor shall submit layout drawings, showing the location of switch board and other equipment proposed to be installed for the approval of Engineer-in-charge.

3.18 Standards and Codes

- Applicable standards govern the materials and workmanship in the manufacture of all Equipment/ items of Electrical Equipment.

Codes	Description
IS: 731, BS 137, IEC 383	Pin & Disc Insulator
IS: 2544, IS: 5350, BS 3297, IEC 168	Porcelain post insulators for systems with nominal voltage greater than 1000V
IS: 5621	Hollow insulators for use in electrical equipment
IS: 398 Part I and II (1996)	ACSR conductor
IS: 9920 Part 1 to 4 (2002)	Specification for High Voltage Switches for rated voltage above 1kV and less than 52kV (First Revision)
IS: 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1000V
IS: 9385 (1983)	Governing specifications for GOAB switch
IS: 3070	Lighting arresters for alternating current systems
IS: 15086	Surge arresters
IS: 8828	Electrical Accessories -Circuit Breakers for Over Current Protection for Household and Similar Installations
IEC 60529	Enclosure degree of protection IP 5X
IS: 3231	Electrical relays for power system protection
IS: 4047, IEC 408	Air Break Switches
IS: 2208, IEC 259-1	Fuses
IS: 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2419	Dimensions for panel mounted indicating and recording electrical instruments
IS: 2705	Current transformers
IS: 3156	Voltage transformers

IS: 2026, IEC 60076	Power transformers
IS: 11171	Specification for Dry-Type Power Transformers.
IS: 335	New insulating oils
IS: 1180 Part 1 (2021)	Outdoor Type Oil Immersed Distribution Transformers Up to and including 2500kVA, 33kV Specification
IS: 8468	On-load tap changers
IS: 2099	Bushings for alternating voltages above 1000V
IS: 6600	Guide for loading of oil immersed transformers
IS: 4237	Switchgear General Requirements
IS: 13947 IEC 60947-1 and IEC 60947-2	Low-voltage switchgear and control gear
IS: 375	Panel Wiring
IS: 3427	AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1kV and Up to and Including 52kV
IS: 2516	Moulded Case Circuit Breakers
IS: 3842	Application guide for electrical relays for ac systems
IS: 13925	Shunt capacitors for ac power systems having a rated voltage above 1000 V
IEC 60831 (1 and 2)	Shunt capacitor of the self- healing type for AC systems having rated voltage up-to and including 1000V
IEC 61921	Power capacitors –Low voltage power factor correction banks
IS: 16636	Automatic Power Factor Correction (APFC panels for voltage rating up to and including 1000V)
IS: 2959, IEC 158-1	Contactors
IS: 1822, IEC 292	Starters
EN 50081-1, 50082-2 and 60204-1	Microprocessor Soft Starter
IEC 61800 and/or IEEE 519	Harmonics Control & Reactive Compensation Of Static Power Converters
IEC 721-3-3, Class 3C1	Maximum Corrosion Level of the Cooling Air
IEC 721-3-3 Class 3C2	Maximum Corrosion Level of the Chemical Gases
UL 508C	Solid state thermal protection of AC Drive
IS: 722	Specification for AC Electricity Meters
IS: 12615 (2018)	Energy efficient induction motors-three phase squirrel cage
IS: 15999 (Part 1)	Rotating electrical machines: Part 1 Rating and performance
IS: 15999 (Part 2)	Rotating electrical machines: Part 2 Method of tests, standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
IS: 12065	Permissible limits of noise level for rotating electrical machines
IS: 2253	Designation types of construction and mounting arrangement of rotating electrical machines
IS: 8789	Values of performance characteristics for three phase induction motors
IS: 9283	Motors for submersible pump sets
IS: 9334	Electric motor operated actuators
IS 8130	Conductors for insulated electric cables and flexible cords
IEC 228	Conductors of Insulated Cables
IEC 230	Impulse tests on cables and their accessories

IEC 502	Extruded solid dielectric-insulated power cables for rated voltage from 1kV up to 30kV.
IEC 540	Test methods for insulations and sheaths of electric cables and chords
IEC 229	Test on cable over sheaths which have special protective functions and are applied by extrusion.
IEC 287	Calculations of continuous current rating of cables (100% load factor).
IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 61537	Cable management -Cable tray systems and cable ladder systems
IS: 1554 Part I	PVC insulated (heavy duty) LT electric cables up to 1.1kV
IS: 7098 Part I	XLPE Insulated LT Electric cables (heavy duty) up to 1.1kV
IS: 7098 Part II	XLPE insulated PVC sheathed cable for voltage from 3.3kV up to 33kV
IS: 5831 (1984)	PVC insulation & sheath of electrical cables
IS: 694	PVC Insulated cables for working voltage up to and including 1100 V
IS: 1255	Code of practice for installation and maintenance of power cables up to and including 33kV rating
IS: 3975	Mild steel wires, formed wires and tapes for armouring of cables
IEC 885(2) – 1987 Part-I)	Electrical test methods for electric cables partial discharge test
IS: 10810	Methods of test for cables
IEC 811	Common test methods for insulating and sheathing materials of electric cables
IEC 230	Impulse test on cables & other accessories
IEC 859	Cable termination for gas insulated switchgear
IS: 3961	Recommended current ratings for cables
IS: 3043	Code of practice for earthing
IS: 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS: 2633	Methods for testing uniformity of coating of zinc coated articles
IS: 1897	Copper strip for electrical purposes – Specification
IS: 2309	Code of practice for protection of buildings and allied structures against lightning
IS: 732	Code of practice for electrical wiring installations
IS: 1646	Code of practice for fire safety of buildings (General) Electrical installation
IS: 2509	Rigid non-metallic conduits for electrical wiring
IS: 6946	Flexible (Pliable) non-metallic conduits for electrical installation
IS: 9537	Conduits for electrical installations
IS: 3854	Switches for domestic purpose
IS : 3415	Fittings for rigid non-metallic conduits
IS: 3837	Accessories for rigid steel conduits for electrical wiring
IS: 14927	Cable trunking and ducting systems for electrical installation
IS: 4648	Guide for electrical layout in residential building Indian electricity act and rules
IS: 1293	3 pin plugs and sockets
IS: 4795	Holders for Indicator Lamps for Electronic and Telecommunication Equipment
IS: 3646	Code of practice for interior illumination

IS: 1913	1969 General and Safety requirements for Electric lighting fittings
IS: 1239, IS: 2713	GI Lighting Poles
IS: 1944	Code of practice for lighting of public thoroughfare
IS: 374	Electric ceiling type fans and regulators
IS: 1293	Plugs and socket-outlets of rated voltage up to and including 250 volts and rated current up to 16 amperes – Specification
IS: 6665	Code of practice for industrial lighting
IS: 8224	Electric lighting fittings for division 2 areas
IS: 9583	Emergency lighting units
IS: 9974	High pressure sodium vapour lamps
IEC 62305	Protection against lightning -Part 4: Electrical and electronic systems within structures
IS: 1271	Thermal evaluation and classification of electrical insulation
IS: 1544	Cotton calico
IS: 1868	Anodic Coatings on Aluminium and its Alloys – Specification
IS: 2190	Selection, Installation and Maintenance of First-aid Fire Extinguishers — code of practice
IS: 2546	Specification for galvanized mild steel fire bucket
IS: 5572	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation
IS: 9677	Guide for limits of temperature-rise of the windings of electrical equipment when tested by different methods
IS: 9678	Methods of measuring temperature rise of electrical equipment
IS: 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
IS: 15652	Insulating mats for electrical purposes – Specification
IS: 5424	Rubber mat
IS: 4770	Rubber Gloves -Electrical Purposes – Specification
IS: 2551	Danger notice plates
ISO 3046	Diesel Engine
IS: 4722, BS 2613	Alternator
IS: 16101	General lighting LED and LED modules
IS: 16102 (Part 1)	Self ballasted LED lamps for general lighting service-Safety Requirement
IS: 16102 (Part 2)	Self ballasted LED lamps for general lighting service-Performance Requirement
IS: 16103 (Part 1)	LED modules for General lighting-Safety Requirement
IS: 16103 (Part 2)	LED modules for General lighting-Performance Requirement
IS: 16107 (Part-10)	Luminaries Performance-General Requirement
IS: 16108	Photo biological safety of lamps and lamp systems
IS: 10601	Dimensions of terminals of HV switchgear and control gear
IS: 12729	General requirements of switchgear and control gear for voltages exceeding 1000V
IEC 1330	High voltage/low voltage prefabricated substations
IEC 60694	Common clauses for MV switchgear standards
IEC 6081	Monitoring and control

IS: 8686	Specification for static protective relays
IEC 376	Filling of SF6 gas in RMU

- Use the latest issue of Standards. All revisions/ammendments issued in any and all standards shall automatically apply.
- It is essential that the electrical power distribution system will comply in all respects with the relevant statutory and regulatory instruments of state of Gujarat/as applicable state and that of India.
- The relevant, state and national, statutory and regulatory instruments for electrical installations are, The Indian Electricity Rules 1956, The Electricity Act 2003, CEA regulations, State Electricity Act 2003, ECBC (Energy conservation & building code), fire prevention and life safety measurement act 2013.

Safety and Security

- The design should include all reasonable precautions and provisions for the safety of operating and maintenance personnel.
- Electrical works design life shall be Minimum 15 years.

4.0 EQUIPMENT/TECHNICAL SPECIFICATIONS

All equipment shall be new and supplied by the reputed and approved manufacturers' only. All equipment shall be complete with all necessary weather and anticorrosion protection including tropicalization to prevent damage due to climate, harsh atmosphere, dust and corrosive vapours.

Certain minimum requirement for the major equipments shall be as follows.

❖ 11kV SWITCHYARD (TWO POLE/FOUR POLE STEEL STRUCTURE)

Two pole structures shall be erected in switchyard to receive 11 kV power supply from power supply company (DISCOM) with following minimum equipment.

- a) 11 kV MS pole structure with ISMB, ISMC, hardware etc. including grouting of MS poles in RCC grout blocks/foundation works.
- b) Vertical 150 mm dia. GI pipe for cable support.
- c) Chain links fencing with gate.

The minimum Factor of Safety for supports shall be as per CEA (Measures relating to Safety and Electricity Supply), Regulations as and when these are notified by the authority. The supports shall be suitable for the wind loads as per relevant IS.

Following equipment/accessories shall be required for each 11 kV two pole structure as minimum and other as per drawings/statutory requirements at site shall be provided. All required sub assemblies and accessories shall be suitable for environmental and atmospheric conditions as well as pollution levels of the location(s) where such switchyards are to be built. For locations where pollution levels are high or for critical locations anti-fog type insulators are to be used invariably.

Sr. No.	Particulars	Quantity
1	11kV Porcelain glazed disc insulator with hardware/polymer composite insulators.	3 Nos.
2	11kV, 10kA single pole gapless lightning arrestor (LA) with all required fitting accessories/hardware. LA shall be with surge counter and monitor.	3 Nos.
3	11kV, 9kV LA clamp with nut bolt.	3 Set
4	11kV, 10kV LA jumper wire.	3 Nos.
5	11kV, 400A, 3 pole gang operated air break (GOAB) heavy duty switch with gang operated mechanism & earth switch and all required fitting accessories/hardware. Insulators shall be as per expected environmental and pollution conditions.	3 Nos.
6	11kV, DO fuse assemblies with 400A fuse element with fuse barrel, fiber barrel insulated operating rod and all required fitting accessories/hardware.	3 Nos.
7	11kV, 10kA insulator for 11 kV GOAB switch, DO fuse etc. porcelain glazed disc insulator with hardware/polymer composite insulators.	15 Nos.
8	Fiber operating insulated rod with mechanism and handle suitable for 11 kV GOAB switch.	1 Set
9	ACSR (Mink/Dog/Panther) conductor with required clamps, connectors and hardware etc.	30 RMT or as actual
10	25mm X 6mm thick Copper earth strips in two parallel runs in required quantity i.e. from LA to earthing chambers.	As required
11	Required concrete foundation (grout blocks) etc.	Lot
12	Two/Four pole structure is to be painted with two coats of red oxide followed by two final coats of Alluminium paint as per IS, specifications and drawings.	Lot

Note: For ratings other than 11kV, equipment kV rating shall be changed to suit requirements as per system kV rating and all clearances, safety requirement, accessories etc. shall be as per IS/CPWD/CEA guidelines.

All members shall be fabricated to suit the mounting/fixing of GOD, LA, DOF, Disc/Pin/Post insulators, cable end termination kit/box etc. All members, nut-bolts, washer etc. used shall be hot dip galvanized.

All metallic supports shall be permanently and effectively earthed.

Earthing terminals shall be provided by welding 12mm size bolt/cleat of 50mm x 6mm size MS flat shall be fixed to each joist with a hole of 15mm dia. Fixing or joining of members shall be done by nuts and bolts. Suitable MS flat supports and cleats shall be fixed to ISMB poles for supporting/ fixing the earthing protection strip in the manner approved by the Client.

Vitreous enamelled caution boards or any other statutory requirements shall be provided in accordance with CEA (Measures relating to Safety and Electricity Supply).

Protective guards shall be used where overhead line crosses or is in proximity to any telecommunication line, or any other overhead lines, and in populated localities. Every guard wire shall be connected to earth wherever its electrical continuity is broken.

DP structure/accessories shall meet all statutory requirement laid down in I. E. Act/CEA regulations.

Structure

Pole structure shall be of rolled steel of minimum ISMB 150mm X 75mm size and minimum 9 meters in length with 400mm X 400mm X 6mm thick base plate welded at bottom end of the poles of structure.

Mild steel cross members of minimum ISMC100mm X 50mm size channels of required length and numbers shall be provided with cross bracing angles ISA of 50mm X 50mm X 6mm size of required length. Clamps, cleats etc. shall be fabricated from minimum 50mm X 6mm size MS flats as per actual requirement. All bolts, nuts, washers etc. shall be of minimum 15mm dia.

Welding at site should be avoided as far as possible. In case, welding becomes necessary, the joint shall be covered with cold galvanizing paint.

All MS parts shall be painted with two coats of red oxide followed by two coats of Aluminium paint. All MS part shall be hot dip galvanized as per IS: 2629. Alternatively All cross members and clamps shall be hot dip galvanised after fabrication.

11kV GOAB Switch

The GOAB switch shall be triple pole construction suitable for vertical/horizontal mounting. Each pole shall consist galvanized steel base, insulators, Copper alloy male and female contacts, arcing horns of adequate section to break magnetizing current of transformer, MS square coupling rod of adequate length for rocking operation, required length of GI pipe for operation from ground level and operating handle, for smooth operation. Jumper shall be EC grade braided Copper of appropriate size to complete the current path from moving post to fix post.

Disconnecter and earthing switches, including their operating mechanism shall be designed such that they cannot come out of their open and closed positions by gravity, wind pressure, vibrations, reasonable shocks or accidental touching of the connecting rods of their operating mechanism.

Isolators shall be provided with provision of locking in open and closed positions. The switch shall be single throw-single break or single throw-double break.

The insulators shall be post type, high quality brown porcelain, highly glazed/polymer insulator and shall be of appropriate voltage rating, suitable for atmospheric conditions specified. Grading rings may be provided to obtain uniform voltage stress distribution, where required.

All poles of the switch shall be gang operated by a common operating mechanism such that all poles close or open simultaneously. The operating mechanism shall be positive type and shall be provided with two earthing terminals. Operating handle shall also be provided with an "equalizing braid" earth connection to prevent unequal potential between structure and rod during faults.

11kV Drop Out Fuse

The DO fuse assembly set shall be single pole construction suitable for 11 kV supply and suitable for vertical mounting. Each pole shall consist galvanized steel base, insulators, Copper alloy DO top and bottom contacts and fuse carrier top and bottom contacts, epoxy extruded fiber fuse carrier. The assembly shall be mounted on pole structure, complete with fuse elements of required ampere rating. The fuse link shall consist of iron channel base, stack insulator per phase, fuse carrier Bakelite tube, non-ferrous metal parts and spring loaded phosphor-bronze contacts. The insulator shall comply with impulse voltage test in accordance with relevant IS.

Technical Requirement for GOAB Switch and DO Fuse Set

Rated Voltage	12 kV
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Rated Current for DO Fuse Set	250/400 Amp	Lightning Arrestor
Rated Current for GOAB Switch	400 Amp	
Impulse Withstand Voltage to Earth	60 kV	
Impulse Withstand Voltage Across the Terminals	75 kV	
Power Frequency Withstand Voltage to Earth	28 kV	
Power Frequency Withstand Voltage Across the Terminals	32 kV	
Rated Short Time Current for 1 Second	10 kA	

arrester shall be for 11 kV rating furnished complete with insulating base and anchoring hardware for mounting on steel structure. The arrestors shall be metal oxide gapless type comprising of a stack of zinc oxide valve elements as per IS: 3070.

The arrestors shall be single phase, single pole suitable for outdoor installation under atmospheric conditions as specified elsewhere.

The arrester shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes. Insulators shall be wet process porcelain, brown glazed and free from imperfection. All metal parts and hardware shall be hot dip galvanized.

Independent Copper earthing shall be provided for LA.

Technical Requirement for Lightning Arrestor

Rated Voltage	9 kV
Rated Current	400 Amp
Creepage Distance	Total: 300mm & Protected: 140mm
Type	Station Class
(1) 1 Minute Power Frequency Withstand Test Voltage	28 kV
(2) Impulse Withstand Test Voltage	75 kV
Minimum prospective for 0.2 Second Symmetrical Fault Current	21.86 kA
(1) Top Connection Arrangement	(1) ACSR Conductor
(2) Bottom Connection Arrangement	(2) Hot dip galvanized strip/ galvanized stranded steel wire
Nominal Discharge Current	10 kA

Conductor

Aluminium conductor steel reinforced (ACSR) or equivalent all aluminium alloy conductors (AAAC), all aluminium conductor (AAC) as per site environmental and pollution conditions shall be used. ACSR shall be hard drawn from 99.5% pure electrolytic aluminium rods with 60% IACS conductivity. The vendor shall specify the conductivity. The aluminium shall have resistivity of $0.028264 \Omega \text{ mm}^2/\text{m}$ at 20°C temperature. Thermal conductivity shall be $0.563 \text{ calories}/\text{cm}^\circ\text{C}$ and density shall be $2.703 \text{ gram}/\text{cm}^3$ shall be as per typical drawing and as per IS: 398.

The size of conductor shall depend upon the voltage regulation, factor of safety, power to be transmitted, length of line, line voltage and mechanical strength desired.

Suitable insulating paint shall be applied on bare conductors in coastal areas to prevent corrosion.

Stay Arrangement

To prevent tilting of a pole from its normal position due to abnormal wind pressure and deviation of alignment, the pole shall be kept in position by stays.

Galvanized iron stay wires and stay rods of adequate size shall be used. The individual wire used to form “stranded stay-wire” shall have minimum tensile strength complying with relevant IS. For double pole structure, for stays along the line, two in each direction or as required depending on the angle of deviation shall be provided. When two or more stays are provided on the same pole, each stay shall be grouted entirely separate from the other. The angle between the pole and stay wire shall be about 45° and in no case it shall be less than 30° .

Stays shall be anchored either by providing base plates, iron angle or rail.

Stay wires shall be connected to the pole with a Porcelain Guy Strain Insulator. The standard guy strain insulators shall be as per relevant IS. The porcelain insulator shall be inserted in the stay wire at a height of minimum 3

meter vertically above the ground level. The strain insulators shall be free from defects, thoroughly vitrified and smoothly glazed.

Wooden insulators shall not be used for stay/guy wire.

❖ 11kV HV SWITCHGEAR (VCB) PANEL

Design Criteria

The switchgear system shall be capable of continuous operation at specified rating under the design conditions specified here in.

The switchgears will be located indoor/outdoor area as per requirement.

The de-rating of complete panel including bus bar section shall be done at **50 °C ambient design temperature** if it is designed at lower ambient temperature. The maximum temperature in any part of the equipment at specified rating shall not exceed 85 °C.

Applicable standards for HV panels shall be, IEC 62271/100-200, IEEE 1584, IEC 60947, IEC 60439, IS: 13118-191.

Specific Requirements

The switchgear shall be metal-clad, extensible on both sides, floor mounted, draw-out type with fuse-less design and suitable for Local/Remote operation (Both control and monitoring). Enclosure shall conform to the degree of protection IP 4X and IP 5X for metering section.

The minimum thickness of sheet steel used shall be 2mm CRCA steel/Al Zn and gland plate of 3mm thick.

The switch gear assembly shall comprise continuous, dead-front, line-up of free standing, vertical cubicles. Each cubicle shall have front hinged door with latches and removable back cover. All covers and doors shall be provided with recessed neoprene gaskets. All doors shall have pad locking arrangement. The swing of the door shall be more than 90 degree.

The design shall be such that failure of one equipment shall not affect the adjacent units.

Each cubicle shall be separated from adjacent one, by grounded sheet steel barrier and bus sealing arrangement.

All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.

Each breaker shall be provided with 6 way, 3 position, spring return to neutral, angular movement, Trip-Neutral-Close (TNC) switch with lockable pistol grip type handle.

Each breaker shall be provided with 4 way, 2 position, angular movement with lever type handle Local-Remote selector switch.

Each switchgear cubicle shall be provided with thermostat controlled space heater and 3 pin 15 Amp plug point and light point operated at 230V 50 Hz AC.

Bus connections from bus compartment to breaker compartment, breaker compartment to cable compartment, and bus compartment to adjacent panels shall be through sealed resin cast bushing assembly.

Each breaker cubicle shall be provided with 'service' and 'test' position limit switches having at least 4 NO and 4 NC contacts. The swing of the door shall be more than 90 degree.

Enclosure for HT VCB panel must be closed door application. And regarding all latest safety features. At the time of power failure all start, stop, spring charged etc. function must be operated out side of panel door. No case operator will put his hand in the panel/VCB for any operation for on or off condition.

Bus and Bus Taps

Bus bars shall be of uniform cross section throughout the entire length of panel and suitable for carrying rated current continuously and short circuit current for specified duration without overheating.

The main bus bar and connections shall be of high conductivity Copper. **Copper bus bars shall be sized for maximum 1.4 A/mm² current density.**

All bus bars, jumper connection shall be fully insulated for working voltage with adequate phase /ground clearances and shall be sleeved with R,Y,B colour coded PVC heat shrinkable sleeves. Bus bars, links, live parts etc. shall have non-flammable epoxy cast-resin shrouds. All jointing hardware shall have nylon caps.

No paper/cotton based insulation shall be used anywhere in the panel.

Safety shutter, phase barrier, bus bar seal-off bushing plate, support insulators etc. shall be of non-flammable high tracking fibre glass/epoxy insulation system.

All buses and connections shall be supported and braced to withstand dynamic electro-magnetic stresses due to maximum short circuit current and also to take care of any thermal expansion.

Circuit Breaker

Circuit breaker shall be triple pole, single throw, vacuum type, electrically operated (on/off), electrical draw out (EDO) type.

Circuit breaker shall have Service, Test and Disconnected (Isolated) positions with positive indication for each position.

Circuit breakers of identical rating shall be physically and electrically interchangeable.

Circuit breaker shall have manual spring charge as well as motor wound charging facility with mechanical and electrical anti-pumping features and shunt trip. Motor wound mechanism spring charging shall take place automatically after each breaker's closing operation. The motor shall be suitable for operation with voltage variation from 85% to 110% of rated voltage.

Mechanical safety interlock shall be provided to prevent following.

- a) Circuit breaker from being raked in or out of the service position when the breaker is closed.
- b) Raking in the circuit breaker unless the control plug is fully engaged.
- c) Closing and opening of the breaker in an intermediate position between 'Service' and 'Test' and between 'Test' and 'Disconnected' position.

Automatic safety shutters shall be provided to fully cover the female primary contacts when the breaker is withdrawn from service position.

The manual trip device shall be located on the front door and indicators with shrouds will be visible from front door even when breaker is closed.

Each breaker shall be provided with following.

- a) Auxiliary switch with 6 NO + 6 NC contacts, mounted on the draw-out portion of the switchgear.
- b) Position/cell switch with minimum 3 NO + 1 NC contacts, one each for Test and Service position.
- c) Auxiliary switch, with 4 NO + 4 NC contacts, mounted on the stationary portion of the switchgear and operated mechanically by a sliding lever from the breaker in Service position.
- d) Trip push button, mechanical ON-OFF indication, operation counter and mechanism charge/ discharge indicator.

Limit/auxiliary switches shall be convertible type i.e. facility for changing NO contact to NC and vice-versa. Switch contact shall be rated 10 A AC and 2A DC at operating voltage.

Each breaker shall be provided with suitable encased rollers.

The trip coils shall be operated satisfactorily at voltage between 70% and 110% of rated control supply voltage.

Each circuit breaker cubicle shall be provided with earthing facility. Earthing facilities shall be fully interlocked to prevent faulty operation e.g. earthing of live parts.

One set of earthing truck for cable earthing and bus earthing shall be supplied along with panel.

For each breaker feeder following DI and DO shall be considered.

DI

Breaker ON

Breaker Trip

Breaker Test Position

Breaker Service Position

DC Fail

Local/Remote Selection

Vibration Sensor Feedback: 6 Nos. (if applicable for motor feeder)

DO

Breaker On

Breaker OFF

RTD Input

Winding and Bearing Temperature: 8 Nos (if applicable for motor feeder)

Protection and Measurement

Protective Scheme Requirement

Main protective relay shall be microprocessor based, current and voltage based/monitoring numerical relays with combined protections and with communication facility as listed in the table given below. Relay shall have minimum 5 logic input and output each, with fault (Minimum 10) and event record (Minimum 100). Front USB port for local downloading of fault, event records.

Auxiliary relays, timers switches etc. required to make the scheme complete shall be considered as part of the scope of work.

All CT-PT wires shall be brought to test terminal blocks before connecting to circuits.

The circuits of various protections shall be connected to master trip relays through auxiliary relays (flag indicated).

Auxiliary relays shall be provided for each transformer fault. Connection of the relay shall be through links to facilitate maintenance.

For control supply distribution, panel to panel, separate set of terminal blocks shall be provided. All items/accessories required for above in each panel and in incoming panels shall be provided by the supplier.

All relays shall be self/hand-reset type with digital/flag indication. NO/NC contacts for relays shall be as per requirement of approved protection, annunciation and interlock schemes. Wherever required, Vendor/Supplier shall provide auxiliary relays for contact multiplication.

Annunciation facia shall be mounted on the panel and details shall be finalized during drawing approval stage.

Emergency stay-put type off push button/mechanism are to be considered.

DC supply fails alarm and indication is to be considered.

Draw-out type line PTs, shall be provided on all incomers with suitable 110V AC secondary two winding transformer for metering and protection separately of minimum burden 100/200 VA or higher as required.

Incomer of HV breaker shall be with following as a minimum.

Sr. No.	Relay	Indication and Monitoring	Digital Type Meter
1	PT Fuse Failure Relay	Phase Indication (R, Y ,B)	PF Meter & Ammeter and ASS
2	Numerical Relay with RS 485 Communication with Combined Protection with Configurable Digital Input and Digital Output (Minimum 5 each), Fault Record (Minimum 10) and Event Record (Minimum 100), for the following.	Breaker ON, OFF, Trip	Voltmeter and VSS
2.1	IDMT and Instantaneous 3 O/C + 1 E/F (50, 51, 50N, 51N)	DC Supply ON, AC Supply ON	MFM with Communication Port Equivalent to Schneider (Conzerv) EM 6400NG with RS 485 (Cl. 0.5s)
2.2	Under Voltage and Over Voltage with Time Delay (27/59)	Spring Charge	
2.3	Trip Circuit Supervision (95)	Test and Service Position	
2.4	Circuit Breaker Protection/Failure (50 BF)	Trip Circuit Healthy	
2.5	Anti-Pumping Relay	Minimum 12 Window Annunciation Panel	

3	Master Trip Relay (High Speed Trip Relay) with Hand Reset Contact (2 NO and 2 NC contact)		
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Outgoing (Transformer) HV breaker shall be with following as a minimum.

Sr. No.	Relay	Indication and Monitoring	Digital Type Meter
1	Numerical Relay with RS 485 Communication with Combined Protection with Configurable Digital Input and Digital Output (Minimum 5 each), Fault Record (Minimum 10) and Event Record (Minimum 100), for the following.	Breaker ON, OFF, Trip	PF Meter & Ammeter and ASS
1.1	IDMT and Instantaneous 3 O/C + 1 E/F (50, 51, 50N, 51N), Thermal Overload (49)	DC Supply ON	MFM with Communication Port Equivalent to Schneider (Conzerv) EM 6400NG with RS 485 (Cl. 0.5s)
1.2	Trip Circuit Supervision (95)	Spring Charge	
1.3	Circuit Breaker Protection/Failure (50BF)	Test and Service Position	
1.4	Anti-Pumping	Trip Circuit Healthy	
2	Auxiliary Relay for WTI, OTI, Bucholz Alarm Indication and Trip	12 Window Annunciation Panel or Higher as Required.	
3	Master Trip Relay (High Speed Trip Relay) with Hand Reset Contact (2 NO and 2 NC Contact)		
4	Restricted Earth Fault (REF) and Differential Earth Fault Protection Relay for Transformer Rating 2000 kVA and Above		

CBCT shall be provided for Sensitive Earth Fault (SEF) for transformer feeder.

Outgoing (Motor Feeder) HV Breaker shall be with following as a minimum.

Sr. No.	Relay	Indication and Monitoring	Meter
1	Numerical Relay with RS 485 communication with Combined Protection with Configurable Digital Input and Digital Output (Minimum 5 each), Fault Record (Minimum 10) and Event Record (Minimum 100), for the following.	Breaker ON, OFF, Trip	PF Meter & Ammeter and ASS
1.1	IDMT and Instantaneous 3 O/C + 1 E/F (50, 51, 50N, 51N), Thermal Overload (49), Negative Phase Sequence Overcurrent (46), Locked Rotor during Start-up (51S), Under Current/Loss of Load (37), Start/Stalled Protection/Motor Re-Acceleration (48/51 LR), Number of Starts Limitation (66), RTD Temperature Monitoring (38/49T)	DC Supply ON,	MFM with Communication Port Equivalent to Schneider (Conzerv) EM 6400NG with RS 485 (Cl. 0.5s)

1.2	Trip Circuit Supervision (95)	Spring Charge	
1.3	Circuit Breaker Protection/Failure (50BF)	Test and Service Position,	
1.4	Anti-Pumping Relay	Trip Circuit Healthy	
2	Master Trip Relay (High Speed Trip Relay) with Hand Reset Contact (2 NO and 2 NC Contact)	Minimum 12 Window Annunciation Panel or Higher as Required.	

CBCT shall be provided for SEF for outgoing feeder for cable protection.

Numerical protection relay for motor feeder shall be MiCOM 220 with RS 485 of Schneider or Equivalent of any approved make.

Relays and Meters

MFM shall be microprocessor based numerical and communicable type with RS 485 port. Communication link shall be provided between MFM and numerical relays for further communication to PLC/SCADA.

All instantaneous current protection relays shall be of 3 pole type.

Relays shall be rated for operation on 110V DC secondary voltage and 1A secondary current. Number and rating of relay contacts shall suit the job requirements.

All relays shall furnish, install and coordinate to suit the protection and interlock requirement of VCB panel.

Relay shall be low burden, provided with RS 485 computer communication port for monitoring and operation from Remote location/PLC with suitable Software.

Current Transformer

Current transformers shall be cast resin type and shall be as per IS: 2705 (Part 1 to 4).

CTs shall have shorting link on secondary side to facilitate insertion of meters on secondary side without opening CT circuits.

Accuracy class of the current transformers shall be as under.

- Class PS for differential and restricted earth fault relaying.
- Class 5P10 for other relaying.
- Class 0.5 for MFM.
- ISF < 5 for metering.

The CTs shall be capable for safely withstanding the short circuit stresses corresponding to the fault level as indicated and shall be able to meet short-time requirement specified.

All CT secondary shall be earthed through separate switch link on terminal block.

CT terminals and their polarities shall be clearly marked.

Voltage Transformer

Voltage transformer shall be provided in separate cubicle.

PTs, connection, insulation levels shall be similar to rating of associated breaker.

VA burden shall be selected based on requirement for meters, closing, tripping and indicating circuit.

Voltage transformer shall be cast-resin, draw-out type, dual core (for secondary) for metering and protection separately and shall have an accuracy class 0.5 and 3P for metering and protection respectively. Voltage transformer mounted on breaker carriage is not acceptable.

The PTs shall be of shell type single phase construction with HRC fuses at both ends and plug-in connection on primary side.

High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position.

Control MCB of suitable rating shall be provided on the secondary side to prevent overload. The PTs shall be capable of operating continuously at 110% of the rated voltage without any damage. When star-star connection is required in non-effective or under grounded system, the PTs shall be suitable for continuous operation with a persistent phase to ground fault.

Indication and Monitoring Instruments

Control cabinet, mounted on top of breaker cabinet, provided with suitable anti-vibration facilities and one number heavy duty spring return type TRIP-NORMAL-CLOSE control switch with pistol grip lockable handle.

Indicating lights to be provided in front of compartments as a minimum.

Green	:	Breaker Open
Red	:	Breaker Closed
Amber	:	Auto Trip
White	:	Trip Circuit Healthy
Yellow	:	Breaker Test Position
Blue	:	Breaker Service Position
DC supply ON	:	White

Indicating lamps shall be 20 mm dia LED type with series resistance. Lamp and lens shall be replaceable from the front.

All indicating instruments shall conform to IS: 1248 (1983) and IS: 2419 (1979) and shall be capable of withstanding system fault current taking into account CT saturation, back connected and located in the upper part of the panel.

Meters

Indicating instruments shall be minimum 96 sq.mm. dial flush mounted digital type with accuracy class 0.5 minimum.

Digital type Multi Function Meter shall be three line display of accuracy class 0.5s for incomer and outgoing and suitable for measuring and digitally displaying following parameters. kVA, kW, kWh, kVAh, kVAR, kVARh, A, V, PF, frequency, Harmonic, MD measurement and control (MD control only in incomer feeder). Minimum 2 nos. digital output shall be available.

Each meter will be provided with at least two output signals of 4-20 mA and communication port (RS 485) for all above parameters for monitoring and operation from Remote location/PLC with suitable Software.

Meter selector switches shall maintain firm contact, stay put type with knob handle. Ammeter selector switches shall be four-position type having make before break contacts to prevent open circuit of CT secondary. Digital Power factor meter shall be provided separately for Incoming and Outgoing Feeder.

Annunciation

It shall be static type suitable to work on AC supply as specified.

Hooter and bell for trip and alarm indication respectively.

Test, accept and reset facilities (with push button) shall be provided on each panel.

Suitable audio-visual indication shall be provided on DC failure. Audio alarm with reset facility shall be provided.

Visual indication shall be given panel wise.

Spare annunciation points shall be wired up to terminal blocks. 20% spare facia shall be provided.

Sequence shall be as follows.

	VISUAL	AUDIO
On Occurring of Fault	Flashing	On
On Accepting	Steady On	Off
On Reset (Fault Cleared)	Off	Off
On Reset (Fault Persists)	Steady On	Off

Warning and emergency points shall be as per the list approved during detailed engineering stage. One common point shall be provided to indicate operation of annunciation system of the complete panel (in case of any trouble in the panel in tie feeder, bus coupler, incomer etc.). Remote and annunciation facia window details shall be finalized during detailed engineering.

A common audible alarm for each switchgear line up shall be provided to alert the Operator that circuit breaker has tripped. Means shall be provided for silencing the audible alarm whilst leaving it free to sound when any other alarm is initiated but the associated alarm indications shall continue until cancelled.

Secondary Wiring

Switchgear panel shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and interlocking schemes.

Control MCB of suitable rating shall be provided to permit individual circuit isolation from bus/ wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.

Wiring shall be done with flexible, 650V grade; FRLS PVC insulated wires with stranded Copper conductors of 1.5 mm² for control current circuits and voltage circuits. All power wiring like space heater supply etc. shall be carried out with min. 2.5 mm² PVC insulated Copper conductor wire.

Each wire shall be identified at both ends with dependent and cross addressing permanent markers bearing wire numbers. Trip circuit shall have red colour ferrule.

Wire termination shall be made with crimping type ring connectors with insulating sleeves. Wires shall not be spliced between terminals.

The wires shall run preferably through PVC channel with cover adequately supported along its run to prevent sagging due to flexibility or vibration. The control and power wires shall be routed through separate channels.

Inter panel wiring PVC channel shall be furnished for wiring between switchgear cubicles. All wiring required for interlocking between the cubicles of any switchgear shall be furnished and installed. Wherever wires are passing through cutouts or openings, they shall be protected by providing suitable grommet or gasket around the openings. Inter panel wiring at shipping sections shall be through terminal blocks placed suitably at intersection points.

The colour of wire shall be taken as follows.

AC System	:	Black
DC System	:	Grey
Earthing System	:	Green
CT and PT Wiring System	:	Red, Yellow, Blue Color Code

Terminal Blocks

Terminal blocks shall be 660V grade box clamp type with 10 mm² marking strips.

Terminal for PT secondary lead shall be disconnecting link type. Power wiring circuits and PT secondary wiring circuits shall be terminated by bolt type terminal blocks and rest by screw type terminal blocks.

Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Multi connection terminal strip to be used if required.

Wiring shall be so arranged that an external cable can be connected to consecutive terminals.

Terminal blocks for external/space heater wiring shall be separate from inter panel wiring.

All control wire shall be terminated with ring type insulated lug only.

The terminal block shall be grouped according to circuit functions and individual terminals in each block shall be serially numbered in accordance with the drawings. Such numbering shall be legible, permanent and indelible.

Communication port of meters and relays of individual breaker panel shall be looped together and brought out at External Terminal Connector/Block using instrument signal cable 1 pair, annealed Tinned Copper conductor flexible cable.

All spare contacts of Breaker, CT, Relay, Annunciator etc. shall be wired upto external TB.

Cable Termination

Switchgear panel shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection with suitable size gland plates with knock out plates for specified HV cable connection.

The design of cable box shall be such that any type of jointing methods such as heat shrinkable/push on type/cold shrinkable type termination can be adopted.

Ground Bus

A ground bus shall be minimum 40mm x 6mm Tinned Copper or higher as per requirement, shall extend the full length of the switchgear panel in all compartments including cable compartments etc.

Each stationary unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw-out PT unit shall be grounded through heavy multiple contacts.

CT and PT secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing other.

All hinged doors shall be grounded using silver plated and braided copper flexible of adequate size.

Name Plates

Name plate shall be provided as per standard.

Space Heaters and Plug Sockets

Each cubicle shall be provided with thermostat controlled space heaters and 5/15A, 6 pin plug socket, panel illumination lamp. Cubicle heater, plug/socket circuits shall have individual MCBs. 230V AC supply for HV panel shall be taken from LV panel in the plant/pumping station.

Auxiliary Power and Control Supply

- a) Control voltage shall be for
 - Closing, Tripping Coil : 110V DC
 - Indication Circuit : 110V AC
 - Spring charging motor, panel space heater, 3 pin socket and panel illumination : 230V AC
- b) Bus wires of adequate (minimum 4 sq. mm. Copper) capacity shall be provided to distribute the incoming supplies to different cubicles.
- c) DP MCB shall be provided at switchgear for the incoming supplies 230V AC supply and 110V DC supply (as applicable).
- d) Battery backup/power pack unit (1 No.) shall be provided for switchgear panel for 110V AC/110V DC for closing and trip circuit suitable for minimum two successive open and close operations after failure of power. Power pack connected on 110V AC PT supply OR 110V DC, shall be minimum 100 Ah capacity or higher as required.
- e) Battery and Battery Charger and DCDB shall be provided if specified in the scope of work/SOQ.

Tropical Protection

- All equipment, accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- Screens of stainless steel shall be furnished on all ventilating louvers to prevent entrance of insects.

Painting

The HV panel shall be treated with seven tank process with cleaning of scale, grease, rust and foreign adhering matters and chemical de-rusting, sand blasting, degreasing, pickling in acid bath and phosphating as per IS: 6005 and primed.

After cleaning, the surfaces shall be given 2 coats of epoxy primer.

After seven tank process and primer coating, panel shall be powder coated with **RAL 7035** for inside and outside of the entire panel.

Inspection and Tests

The switchgear panel shall be completely assembled, wired, adjusted, inspected and tested at the factory/works as per relevant applicable standards.

Routine Tests

The tests shall include but not necessarily limited to the following for switchgear panel.

- a) Operation under simulated service condition to ensure accuracy of wiring, correctness of control scheme and proper functioning of the equipment.
- b) All wiring and current carrying part shall be given appropriate High Voltage test.
- c) Primary current and voltage shall be applied to all instrument transformers.
- d) Routine test shall be carried out on all equipment such as circuit breakers, instrument transformers, meters etc.
- e) Power frequency withstand insulation HV test for main circuits, auxiliary and control circuit as per relevant IS.

- f) Milli-volt drop test across main contacts of each phase of VCB and close and open time test for VCB shall also be a part of Routine Test.

Test Witness

Panel builder/integrator/manufacture shall perform all the tests as per IS/IEC Standards and specifications on all the panels (100% quantity of the project/tender lot) @ factory/works' in presence of Client/PMC/TPI.

Test Certificate

- a) Certified reports of all tests carried out at factory/works shall be furnished in four (4) copies for approval of the Client.
- b) The panel shall be dispatched from factory/works only after receipt of Client's written approval.
- c) The test reports shall furnish complete identification of panel such as serial number, rating, equipment designation as per drawings/documents etc. and date of tests carried out.

❖ 11 KV OUTDOOR RING MAIN UNIT

General

All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standards or any other standards ensuring equal or better quality.

The electrical installation shall meet the requirement of Indian Electricity Rules 1956 as amended up to date; relevant IS code of practice and Indian Electricity Act 1910 including all other applicable rules and regulations.

Scope

Design, engineer, manufacture, assembly, factory inspection and testing before supply at site, installation, testing & commissioning of RMU outdoor type SF6 filled, with various combinations of load break isolators and breakers including plate type earthing with 35mm GI earthing strip. The scope includes erection, testing and commissioning of complete RMU with associated equipment including civil work, supply & laying of 11kV cable, cable jointing kit, fencing etc. along with obtaining required permission of charging from the Electrical Inspector.

The insulation/dielectric media inside the stainless-steel welded tank should be SF6 gas. The RMU should be modular, extensible type on both sides with provision of attaching/ connecting with SNAP FIT arrangement without external bus bars additional load break switches and circuit breakers in future whenever required. However left side of RMU shall have metering panel on the left side and right side shall be free for extension on vice versa depending on site condition. Alternatively, extension shall be possible by adding trunking chambers and required accessories or by plug-in bushing type arrangement.

Ring main unit shall be capable of being monitored and controlled by the SCADA if & as required.

Each RMU shall be equipped with main-line load break switches and a fault passage indicator (FPI). Furthermore, to protect each of its lateral/transformer feeders, it shall be equipped with a corresponding set of circuit breakers and relay with provision of auxiliary supply.

Required configuration shall be as per SOQ/Site Requirement. Broadly it shall be as follows.

- a) 1 Way: 11kV Gas (SF6) insulated RMU with one 630A load break switch and one SF6 insulated VCB of suitable rating as per SOQ/site requirement.

The normal current rating of VCB shall be according to the load of the feeder along with suitable Relay. Any change in combination/configuration shall be executed with the prior approval of the Client/Consultant.

Technical Requirements

- Fixed type SF 6 gas insulated/vacuum circuit breakers.
- The RMU shall be: Compact with minimum space requirement i.e. small construction width;

maintenance free; able to operate in severe outdoor environmental conditions and climate; immune to electrical stress and disturbance; acceptable insulation properties; easy installation; safe, easy & reliable operation.

- The type of the 11kV circuit breakers shall be VCB and insulating medium for load break isolators, earth switch, 11kV buses and other associated equipment should be SF6 gas.
- Motorized operation of Load break switch and vacuum circuit breaker.
- Necessary current sensors/transformers for protection and metering (wherever required).
- All necessary dry (potential-free) contacts for indications relevant to RMU monitoring status and control (wherever required).
- Low gas pressure devices: 1.4 bar pressure & 1.4 bar pressure of SF6 gas in chamber of RMU is required.
- Live cable indicators: High Operator safety.
- Fully rated integral earthing switch on each device.
- Back up relay with auxiliary supply shall be provided.
- For indoor cable boxes should be front access and interlocked with earth switch. No rear/side access required. For outdoor RMU cable boxes shall be on front.
- Cable testing possible without disconnection of cables.
- Compact in dimension.
- Circuit breaker with back up relay with auxiliary supply shall be provided.
- Low pressure, sealed for life equipment, can operate at "0" bar pressure.
- Cable earthing switch on all switching device-standard, for Operator safety.
- Enclosure of outdoor RMU shall conform to the degree of protection IP 5X.

Technical Particulars

Vendor/Contractor shall furnish all guaranteed technical particulars as described in this specifications & data sheet.

The entire RMU shall be enclosed in a single compact metal clad, outdoor enclosure suitable for all weather conditions. The switchgear/steel gas tank shall be filled with SF6 as per IEC/IS standards relative pressure to ensure the insulation and breaking functions. The steel gas tank must be sealed for life and shall meet the "sealed pressure system" criteria in accordance with the IEC 298 standard. The RMU must be a system for which no handling of gas is required throughout its service life.

The RMU shall have a design such that in the event of an internal arc fault, the Operator shall be safe. This should be in accordance with IEC 298 and relevant test certificates shall be submitted @ time of inspection.

The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated below. Installation should be in normal indoor conditions in accordance with IEC60694.

RMU shall be tested for an internal arc rating of 26kA for 1 second for 11kV RMU. Suitable temperature rise test on the RMU shall be carried out and test reports shall be submitted @ time of inspection.

It shall be identified by an appropriately sized rating plate/label clearly indicating the functional units and their electrical characteristics.

The switchgear and switchboard shall be designed so that the position of the different devices and their operations are visible to the Operator on the front of the switchboard.

The entire system shall be totally encapsulated. There shall be no access to the exposed conductors in accordance with the standards. In effect, the switchboard shall be designed so as to prevent access to all live parts during operation without the use of tools.

The entire RMU is insulated by inert gas (SF₆) and shall be suitable for operating voltage up to 12 kV. Suitable absorption material shall be provided in the tank to absorb moisture from SF₆ gas. The SF₆ insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering an indication at different temperature ranges, having distinctive RED and GREEN zones for safe operation.

RMU must be routine tested for the following at factory.

- Micro-ohm test (Contact Resistance Test) for the assembly inside the tank.
- Circuit breaker analyser test so as to ensure the simultaneous closing of all poles for VCB.
- SF₆ gas leak test.
- Partial discharge test on the complete gas tank so as to be assured of the proper insulation level and high product life.
- High voltage withstand.
- Secondary test to ensure the proper functioning of the live line indicators, fault passage indicators and relays.
- As per IEC/IS standards mechanical operation of RMU switch must be carried out.

Sulphur Hex fluoride Gas (SF₆ GAS)

The SF₆ gas shall comply with IEC 376, 376-A and 376-B and shall be suitable in all respects for use in 11kV RMU under the operating conditions. The SF₆ shall be tested for purity, dew point air hydrolysable fluorides and water content as per IEC 376, 376-A and 376-B and test certificate shall be furnished to the Client/Consultant indicating all the tests as per IEC 376 for each lot of SF₆ Gas.

Dielectric Medium

SF₆ gas/VCB shall be used for the dielectric medium for 11kV RMU in accordance with IEC 376. Suitable absorption material shall be provided in the tank to absorb the moisture from the SF₆ gas/VCB and to regenerate the SF₆ gas/VCB following arc interruption. The SF₆ gas/ VCB insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go & no-go indication.

Structural and Mechanical Construction

The offered RMU should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is to be made of a cubicle sealed-for life with SF₆ gas/VCB and shall contain all high voltage components sealed off from the environment.

The overall design of the switchgear should be such that only front access is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

The unit should be constructed from minimum 2mm thick stainless-steel sheets. The design of the unit shall be such that it facilitates the unit being lifted by eyebolts or moved into position by rollers without any permanent damage or harm.

For outdoor RMU, a weather proofing process shall be carried out. Sheet metal must be grit blasted/thermally sprayed and polyurethane painted with about 80 micron thickness to achieve outdoor worthiness and corrosion proofness.

RMU enclosure must be shielded against solar irradiation and tested for ambient of 50⁰ C without de-rating of the equipment.

The cubicle shall have a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases are allowed to be exhausted out at the bottom/top/rear of the cubicle. A controlled direction of flow of the hot gas should be achieved.

The switchgear should have the minimum degree of protection (in accordance with IEC 60529).

- IP 67 for the tank with high voltage components
- IP 2X for the front covers of the mechanism
- IP 3X for the cable connection covers
- IP 54 for the outdoor enclosure

Metal Clad Enclosure

RMU shall be stainless steel enclosed type & tropicalized suitable for outdoor installation. RMU metal parts shall be of high thickness, high tensile steel which must be grit/short blasted, thermally sprayed with Zinc alloy, phosphate or should follow the 7 tank pre-treatment process and be subsequently painted with Polyurethane/PP based powder paint. The overall paint layer thickness shall be not less than 80 microns.

Relevant IE rules for clearances, safety and operation inside the enclosure shall be applicable. The enclosure shall be IP 54 and type tested for weather proof at ERDA/CPRI.

The equipment should also be designed to prevent ingress of vermin, accidental contact with live parts and to minimize the ingress of dust and dirt. The use of materials which may be liable to attack by termites and other insects should be avoided.

All live parts except for the cable connections in the cable compartments shall be insulated with SF₆ gas. The SF₆ gas tank shall be made of robotic or TIG or MIG welded stainless steel of thickness as per IEC tested/designed with the best weld quality so as to provide safety and to avoid leakage of gas. It should be provided with a pressure relief arrangement away from the Operator.

The cable termination chamber of isolators and circuit breakers both should be of front access type/round end type as per site requirement.

Any accidental over pressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the top or rear-bottom part of the tank or enclosure. Gas will be released to the rear of the switchboard away from the Operator and should be directed towards the bottom, into the trench to ensure safety of the Operating personnel. All the manual operations should be carried out on the front of the switchboard.

The rating of enclosure shall be suitable for operation on three phase, three wire, 11kV, 50 cycles AC system with short-time current rating of 26kA for 1 seconds for 11kV with RMU panels.

The enclosure should have two access doors one for the operation and relay monitoring and other for the cable access. Both the doors should have the locking facility to prevent the access to operating mechanism to avoid unauthorized operating of RMU and relay.

Enclosure for RMU must be closed door application. And regarding all latest safety features. At the time of power failure all start, stop, spring charged etc. function must be operated out side of panel door. No case operator will put his hand in the panel/VCB for any operation for on or off condition.

Isolators (Load Break Type)

The load break isolators for incoming and outgoing supply must be provided & be fully insulated by SF₆ gas. The load break isolators shall consist of 630A fault making/load breaking spring assisted ring switches, each with integral fault making earth switches. The switch shall be naturally interlocked to prevent the main and earth switch being switched "ON" at the same time. The selection of the main and earth switch is to be made by a lever on the facia, which is allowed to move only if the main or earth switch is in the "OFF" position. The load break isolators should have the facility for remote operation. Each load break switch shall be of the triple pole, simultaneously operated, automatic type with quick break contacts and with integral earthing arrangement.

The isolating distance between the OFF and ON position in the isolator should be sufficient to withstand dielectric test as per IS/IEC so as to have enough isolating distance for ensuring safety during D C injection for cable testing.

Load break switch should have the following.

- Motor operated 12kV, 630A load break switch and manually operated earthing switch with making capacity
- “Live cable” LED indicators through capacitor voltage dividers mounted on the bushings
- Mechanical ON/OFF/EARTH indication and interlocking between earth and on/off conditions
- Anti-reflex operating handle
- Cable testing facility without disconnecting the cable terminations, cable joints and terminal protectors on the bushings.

Cable terminations

Cable boxes suitable for minimum 1 x 3C x 300 sq. mm. XLPE cable with right angle cable termination protectors.

Earthing of Isolators and Breakers (Earth Switch): Necessary arrangement shall be provided at load break isolators breaker for selecting earth position. Mechanical interlocking system shall prevent RMU function from being operated from the “ON” to “Earth On” position without going through the “OFF” position.

RMU shade and Foundation

Agency must submit drawing for shade and foundation of RMU as per standard. Same must be approved by client.

Distribution Transformer (DT)/Feeder Breaker (Vacuum)

The VCB breaker for the controlling of DT/feeder breaker must be provided inside welded stainless steel SF 6 gas tank with the outdoor metal clad enclosure. The VCB circuit breaker must be spring assisted three positions with integral fault making earth switch. The selection of the main/earth switch lever on the facia, which is allowed to move only if the main or earth switches is in the off position.

The manual operation of the circuit breaker shall not have an effect on the trip spring. This should only be discharged under a fault (electrical) trip; the following manual reset operation should recharge the trip spring and reset the circuit breaker mechanism in the main off position.

The circuit breaker shall be fitted with a mechanical flag, which shall operate in the event of a fault (electrical) trip occurring. The “tripped” flag should be an unambiguous colour differing from any other flag or mimic.

Both the circuit breaker and ring switches are operated by the same unidirectional handle. The protection on the circuit breaker shall comprise of the following components.

- 5P10 class protection CTs,
- Low burden trip coil and
- O/C & E/F relay with auxiliary supply (24V DC) shall be provided IDMT protection relays (Microprocessor based) 3 x over current and earth fault element shall be Definite time type relay. The relay should be housed within a pilot cable box accessible.

The nominal current rating of protection class CT shall be as specified in SOQ or actual requirement and accordingly suitable numerical relay shall have to be provided.

The minimum relay current setting range for O/C: 20% to 250% and E/F: 10 to 250% should be from 2% to 100%.

Any change in combination/configuration shall be executed with the prior approval of the Client/Consultant.

Vacuum Circuit Breaker should have the following.

- Motor operated 630A SF6 insulated vacuum circuit breaker and earthing switch with making capacity 50kA
- Mechanical tripped on fault indicator
- Auxiliary contacts 4 NO and 4 NC
- Anti-reflex operating handle
- “Live Cable” LED Indicators through capacitor voltage dividers mounted on the bushings
- O/C + E/F relay with auxiliary supply (24V DC) shall be provided.

- Shunt trip circuit for external tripsignal
- Mechanical ON/OFF/EARTH indication
- Cable boxes suitable for minimum 1 x 3C x 300 sq. mm XLPE cable with right angle cable termination/protectors/boots.

Bushings

The units are to be fitted with the standardized bushings that comply with IEC standards. All the bushings are the same height from the ground and are protected by a cable cover.

Cable Boxes

All the cable boxes shall be air insulated suitable for dry type cable terminations and should have front access. The cable boxes at each of the two ring switches should be suitable for accepting HV cable of minimum 3C x 300 sq. mm. size and circuit breaker cable suitable up to minimum 3C x 300 sq. mm. size. The cable boxes for an isolator in its standard design should have sufficient space for connecting two cables per phase.

Necessary right angle boot should be supplied to the cable terminations. The type of the right -angle boot should be cold applied insulating boot. In cable box bushing fitting required shall be 3 KN capacity.

Cable Testing Facility

It shall be possible to test the cable after opening the cable boxes. The cable boxes should open only after operation of the earth switch. Thus, ensuring the earthing of the cables prior to performing the cable testing with DC injection.

Voltage Indicator Lamps & Phase Comparators

RMU shall be equipped with a phase wise voltage indication to indicate whether or not there is voltage on each phase of cable. There should be a facility to check the synchronization of phases with the use of external device. It shall be possible for the each of the function of the RMU to be equipped with a permanent voltage indication as per IEC 601958 to indicate whether or not there is voltage on each phase cables. Indicator should be visible from outside without opening door.

Extensible Type

Each combination of RMU shall have the provision for extension both sides by load break isolators/breakers in future, with suitable accessories and necessary bus bar. The equipment shall be well designed to provide any kind of extension/trunking chamber for connecting and housing extensible bus bars. Extensible isolators and circuit breakers shall be individually housed in separate SF6 gas enclosures. Multiple devices inside single gas tank/enclosure will not be acceptable. In case of extensible circuit breakers, the breaker should be capable of necessary short circuit operations as per IEC at 26kA, and the breaker should have a rated current carrying capacity of 630A.

Wiring and Terminals

The wiring should be of high standard and should be able to withstand the tropical weather conditions. All the wiring and terminals (including take off terminals for future automation, DC, Control wiring), 20% Spare terminals shall be provided by the Vendor/Contractor. The wiring cable must be standard single-core non-sheathed, core marking (ferrules), stripped with non-notching tools and fitted with end sleeves, marked in accordance with the circuit diagram with printed adhesive marking strips.

The wiring shall be carried out using multi-strand copper conductor super flexible PVC insulated FRLS wires of 1100V grade for AC power, DC control and CT circuits. Suitable coloured wires shall be used for phase identification and interlocking type ferrules shall be provided at both ends of the wires for wire identification. Terminal should be suitably protected to eliminate sulphating. Connections and terminal should be able to withstand vibrations. The terminal blocks should be stud type for controls and disconnecting link type terminals for CT leads with suitable spring washer and lock nuts.

Flexible wires shall be used for wiring of devices on moving parts such as swinging panels (switch gear) or panel doors. Panel wiring shall be securely supported, neatly arranged readily accessible and connected to equipment terminals, terminal blocks and wiring gutters. The cables shall be uniformly bunched and tied by means of PVC belts and carried in a PVC carrying trough.

The position of PVC carrying trough and wires should not give any hindrance for fixing or removing relay casing, switches etc. Wire termination shall be made with solder-less crimping type of tinned copper lugs. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted with both ends of each wire. Ferrules shall fit tightly on the wire when disconnected. The wire number shown on the wiring shall be in accordance with the IS: 375.

All wires directly connected to trip circuits of breaker or devices shall be distinguished by addition of a red colour unlettered ferrule.

Inter-connections to adjacent panels (switch gear) shall be brought out to a separate set of terminal blocks located near the slots or holes to be provided at the top portion of the panel. Arrangements shall be made for easy connections to adjacent panels (switch gear) at site and wires for this purpose shall be provided and bunched inside the panel. The bus wire shall run at the top of the panel.

Terminal block with isolating links should be provided for bus wire. At least 20% of total terminals shall be provided as spare for further connections. Wiring shall be done for all the contacts available in the relay and other equipment and brought out to the terminal blocks for spare contacts. Colour code for wiring is preferable in the following colours.

- Voltage Circuits : Red, Yellow, Blue for phase and Black for Neutral
- CT Circuits : Similar to the above
- DC circuits : Grey for both positive and negative
- 250V AC circuits : Black for both phase and neutral
- Earthing : Green

The wiring shall be in accordance to the wiring diagram for proper functioning of the connected equipment. Terminal blocks shall not be less than 1100V grade and shall be piece-moulded type with insulation barriers.

The terminal shall hold the wires in the tight position by bolts and nuts with lock washers. The terminal blocks shall be arranged in vertical formation at an inclined angle with sufficient space between terminal blocks for easy wiring.

The terminals are to be marked with the terminal number in accordance with the circuit diagram and terminal diagram. The terminals should not have any function designation and are of the tension spring and plug-in type.

Earthing

RMU outdoor metal clad, switch gear, load break isolators, vacuum circuit breakers shall be equipped with an earth bus securely fixed along the base of the RMU.

The size of the earth bus shall be made of IEC/IS standards with tinned copper flat for RMU and MS flat for distribution transformer, earth spike and neutral earthing. Necessary terminal clamps and connectors shall be included in the scope of supply.

All metal parts of the switchgear which do not belong to main circuit and which can collect electric charges causing dangerous effect shall be connected to the earthing conductor made of Copper having cross section area of minimum 75 sq. mm. Each end of conductor shall be terminated by M 10/ equivalent quality and type of terminal for connection to earth system installation. Earth conductor location shall not obstruct access to cable terminations.

The following items are to be connected to the main earth conductor by rigid or copper conductors having a minimum cross section of 75mm (a) earthing switches, (b) cable sheath or screen (c) capacitors used in voltage control devices, if any.

The metallic cases of the relays, instruments and other panel mounted equipment shall be connected to the earth bus by independent copper wires of size shall be made of IEC/IS standards. The colour code of earthing wire

shall be green. Earthing wires shall be connected on the terminals with suitable clamp connectors and soldering shall not be permitted.

Two nos. of earthing with connecting Copper/Aluminium/GI strips of required size are to be provided as per IS: 3043.

Fault Passage Indicators(FPI)

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU. The FPI shall have LCD/LED display, automatic reset facility.

The sensors to be bushing/cable mounted. The number of FPI should be put in all the three phases of the outgoing branch of the RMUs.

FPI should have suitable connectivity with the FRTUs for the SCADA purpose if and as required. FPI has to give indication on short circuit and earth fault both.

FPI Indication should be visible from outside without opening of door.

The FPI inside the RMU may be non-communicable and hard wired to the TB for the signals.

Fault Passage indicator OK
Fault Passage indicator operated

The conventional practice is to have (N-1) FPI where N is nos. of LBS in a particular configuration of RMU.

Accessories and Spares

The following spares and accessories shall be supplied along with the main equipment. These shall be deemed to be included in the unit of RMU.

1. Charging lever for operating load break isolators & circuit breaker of RMU.
2. The pressure gauge indication: 1 number

Provision shall be made for padlocking the load break switches/circuit breaker, and the earthing switches in either open or closed position with lock & masterkey.

Name Plate

RMU and its associated equipment shall be provided with a name plate legible and indelibly marked with at least the following information.

- a. Name of manufacturer
- b. Type, design and serial number
- c. Rated voltage and current
- d. Rated frequency
- e. Rated symmetrical breaking capacity
- f. Rated making capacity
- g. Rated short time current and its duration
- h. Month and Year of supply
- i. Rated lightning impulse withstand voltage
- j. Feeder name (Incoming and Outgoing), DTs Structure name, 11000 Volts Dangers etc.
- k. Name of Client

Tests

Acceptance and Routine Tests

All acceptance and routine tests as stipulated in the latest IEC shall be carried out by the Vendor in the presence of Client/Consultant. The partial discharge shall be carried out as routine test on each completely assembled

RMU gas tank and not on a sample basis. As this test checks and guarantees for the high insulation level and thus the complete life of switch gear.

Type Test

The vendor shall submit copy of type test certificate as confirming to relevant ISS/IEC of latest issue obtained from International/National Government Laboratory/Recognized Laboratory @ the time of inspection for review & acceptance by the Client/Consultant.

Pre Commissioning Tests @ Site

All the pre-commissioning tests will be carried out in the presence of the Engineer-in-charge of the Client and necessary drawing manual and periodical test tools shall be arranged to enable conducting such tests.

During the above tests the Vendor/Contractor's engineer should be present @ site till the RMU is put in to service.

Inspection

The inspection may be carried out by the Client at final stage of manufacture i.e. pre dispatch. Inspection and acceptance of any equipment under this specification by the Client shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.

The supplier shall keep the Client informed in advance, about the manufacturing programme so that arrangement can be made for inspection. The Client reserves the right to insist for witnessing the acceptance/routine testing of the bought out items. The Client has rights to inspect the supplier's premises for each and every consignment for type & routine test.

No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested/unless the same is waived by the Client in writing.

Documentation and Drawings

All drawings shall conform to relevant International Standards Organization (ISO)/IEC standards/ specifications. The Vendor/contractor shall submit following drawings & documents of the equipment, illustrative and descriptive literature in quadruplicate for various items in the RMU.

- I. General Arrangement Drawings & Schematic Diagram
- II. Instruction & Operation/Maintenance Manuals
- III. Catalogues & List of Spares recommended
- IV. Drawings of equipment, relays, control wiring circuit, etc.
- V. Foundation drawings of RMU and relevant civil work etc.
- VI. Single line diagram of RMU.
- VII. Data sheet as specified in relevant section.
- VIII.

Quality Assurance Plan

The Vendor/Contractor shall invariably furnish following information.

- I. Statement giving list of important raw materials including but not limited to
 - a) Contact material
 - b) Insulation
 - c) Sealing material
 - d) Contactor, limit switches etc. in control cabinet.

Name of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials & copies of test certificates.

- II. Information and copies of test certificates as in (I) above in respect of bought out accessories & raw materials.
- III. Quality control tests and inspections.

- IV. Special features provided in the equipment to make it maintenancefree.
- V. Quality Assurance Plan (QAP) points for Client/Consultant's inspection.

❖ DISTRIBUTION TRANSFORMERS

Scope

The scope covers the detailed requirements regarding supply, installation, testing, commissioning of transformers required for the indoor/outdoor installation in substation, meeting the requirements specified in the data sheet.

Associated civil works i.e. RCC pedestal/platform and fire wall as required for installation of transformers are also included in the scope.

Standards and Compliances

The transformer shall comply with IS: 2026 (Part I to V) and IS: 1180 Part I (2021) (latest editions) and shall be suitable for service under voltage and frequency fluctuation conditions as permissible under Indian Electricity Act. Transformers shall meet the requirements of governing standards and loading requirements in accordance with IS: 6600.

General Construction

Transformers shall be capable of operating continuously and without adverse effects of overheating under all specified conditions of operation including variation in system of $\pm 10\%$ voltage and $\pm 3\%$ frequency or $\pm 10\%$ combined voltage and frequency unless otherwise specified.

Transformer shall be indoor or outdoor type as specified. Unless otherwise specified the transformer in addition shall have thermal and dynamic ability to withstand external short circuit as per clause 9 of IS: 2026 Part I (1977).

Transformer shall be designed for frequent direct on line starting of motors having an equivalent rating in kVA up to CMR of the transformer and shall be capable of withstanding the forces arising from the starting currents of these motors.

Transformer shall be supplied with first filling of oil and 10% extra oil in non returnable drums conforming to IS: 335. The BDV of oil shall confirm to IS/IEE standards at the time of delivery at site and also at the time of commissioning.

Transformer shall be considered with OLTC and RTCC.

For transformer rated 2000kVA and above, neutral CTs for stand by Earth Fault and REF protection shall be provided along with differential protection. Neutral CTs shall be provided before bifurcation of neutral.

Creepage distance of 31 kV/mm is to be considered.

All hard ware shall be hot dipped GI.

The Maximum Total Losses and % Impedance for transformer ratings up to and including 2500kVA shall be as per **Energy Efficiency Level 2** as clearly specified in Table 3 (For and Up to 200kVA Ratings) and Table 6 (From 250kVA to 2500kVA Ratings) of IS: 1180 Part I (2021).

For transformer ratings above 2500kVA the maximum permissible losses and % impedance shall be as per CBIP Manual/Publication (Latest Version) and are indicated under as reference.

Transformer Rating	Maximum Permissible Load Losses with IS Tolerance	Maximum Permissible No Load Losses with IS Tolerance	% Impedance Voltage with IS Tolerance
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3150kVA	20kW	2.9kW	6.25%
4000kVA	27kW	3.2 kW	7.15%

Taps and Tap Change Gear/Device

Tap changing device to be provided for voltage variation on HV side and shall be either off circuit type or on load type as specified in SOQ/tender.

On Load Tap Change Gear (OLTC)

OLTC shall be with +5% to –15% taps in steps of 1.25% on HV winding of transformer. It shall have following technical features.

OLTC gear shall be designed to complete successfully tap changes for current equal to 120% of current at minimum tap position of the transformer. Also, OLTC over loading capability shall be compatible with that of transformer specified in IS/IEC specifications “Guide for loading of oil immersed transformers”. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. OLTC gear shall withstand through fault currents without injury.

When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

Oil in compartments which contain making and breaking contacts of OLTC shall not mix with oil in other compartments of the the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by pipe to separate oil conservator or to segregated compartment within the main transformer conservator. An oil surge relay shall be installed in above pipe. The conservator shall be provided with prismatic oil level gauge.

Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valved pipe connections. Any gas leaving these compartments shall pass through the oil surge relay before entering the conservator.

Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection window with view glass.

OLTC driving mechanism and its associated control equipment shall be mounted in outdoor, weather proof cabinet conforming to degree of enclosure i. e. protection IP 55. The finish shall match with that of the transformer on which it is mounted. The cabinet shall include following.

- Driving motor (415V, 3 Phase, 50Hz, AC squirrel cage),
- Mechanically and electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs,
- Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa will be provided in transformer marshalling box and one number outgoing feeder extending to OLTC driving motor cabinet, with appropriate provision for receiving the same,
- Control switch: Raise/Off/Lower (spring return to normal type) or independent push buttons,
- Emergency “OFF” push button (maintained type),
- Remote/Local selector switch (maintained contact type),
- Mechanical tap position indicator,
- Limit switches to prevent motor over-travel in either direction or final mechanical stops,
- Appropriate scheme/device to permit only one tap change at a time on manual operation,
- Emergency manual operating device (hand crank or hand wheel),
- A five digit operation counter,
- Space heaters with thermostat and MCB,
- Control transformers with MPCB/MCBs on primary and secondary sides for each supply,

- Interior lighting fixture with lamp, door switch/ON-OFF switch and MCB,
- Gasketed and hinged door with locking arrangement,
- Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables,
- Necessary relays, contactors, current transformers etc. and
- Transducers or any other appropriate device for remote tap position indication.

Control Requirements for OLTC

The following electrical control features shall be provided.

- Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- Only one tap change from each taps change command even if the command is maintained.
- Cut off of electrical control when manual operation is resorted to.
- Cut off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- Cut off of electrical control when it tends to operate the tap beyond its extreme position.

Remote Control Equipment

OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote control room. It shall conform to degree of enclosure protection IP 42 or better and shall comprise the following.

- Control switches: Raise/Off /Lower (spring return to normal type) or independent push buttons,
- If automatic operation is specified, auto/manual selector switch (maintained contact type) and other items as listed,
- If parallel operation is specified, master/independent/follower selector switch (maintained contact type) with, out of step annunciation,
- Tap position indicator,
- Facia type alarm annunciators with “accept”, “lamp test” facilities and hooter/buzzer for alarms as listed,
- Necessary auxiliary relays,
- Lamp indications for: Tap change in progress, Lower limit reached & Upper limit reached,
- Transformer cooler control apparatus (if applicable),
- Cable glands for power and control cables,
- 240 V rated panel space heater with thermostat,
- CFL type interior lighting fixture with lamp and door switch,
- MCBs,
- Terminal blocks,
- Internal wiring,
- Earthing terminal,
- Hook up for the remote operation of tap lower and raise operation and contact and
- signal for tap position indication to Client’s DCS shall be incorporated in the panel.

Automatic Control of OLTC

Automatic voltage regulator (AVR) for auto control of OLTC shall include following.

- Voltage setting device,
- Voltage sensing and voltage regulating devices,
- Line drop compensator with adjustable R and X elements,
- Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation,
- Adjustable dead band for voltage variation and
- Additional features as required when parallel operation with other transformers is specified.

Alarms

The following alarms shall be provided.

- AC supply failure,
- Drive motor auto tripped,
- Other protective purpose considered essential by the Contractor,
- Out of step operation when paralleled transformers supposed to operate on the same tap are operating at different taps,
- Tap change delayed,
- AVR failure (if AVR is specified),
- For the all specified above a “OLTC trouble” group alarm to be provided in DCS which is located in control room and
- Others, as specified.

Annunciation

Microprocessor based annunciation, minimum 6 window or higher as required shall be provided for following fascia.

- AC supply fail
- out of step relay operated
- tap changer motor trip
- tap change incomplete
- spare
- spare

Tests

1) Routine Tests

Routine tests as per IS: 8468 shall be performed on all OLTCs and motor drive mechanisms. Over and above, pressure and vacuum tests shall be conducted as per IEC: 60214.

2) Type Tests

Type tests as per IS: 8468 shall be carried out on OLTC and motor drive mechanism when called for. The Bidder shall indicate in his price schedule extra price, if any, for carrying out these tests. If type tests are not called for, type test reports for tests conducted on a similar or higher rating OLTC and motor drive mechanism shall be submitted for Client's approval.

Additional Requirements

Tap position indicators and OLTC control switch shall be supplied loose if Client decides to mount the same in the power transformer control panel.

The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

Fittings and Accessories

All transformers shall be supplied/fitted with following accessories as per relevant IS.

- Inspection cover,
- Buchholz relay with alarm and trip contacts (**for transformer ratings of 250kVA and above**),
- Marshalling box of IP 55 class of protection,
- Sampling valve with plug or cover plate,
- Magnetic oil level gauge and Plain oil level indicator with minimum mark,
- Conservator and conservator drain valve,

- Bi-directional rollers,
- Oil temperature indicator with alarm and trip contacts,
- Bottom drain and filter valve with plug or cover plate,
- Silica gel breather,
- Air release plug/device,
- Separate neutral bushing,
- Top oil filter valve,
- Jacking pads,
- Lifting lugs,
- Two earthing terminals,
- Thermometer pocket for OTI,
- Winding temperature indicator with alarm and trip contacts,
- Pressure relief valve(**for transformer ratings of 200kVA and above**),
- Rating and diagram plate,
- Neutral CTs (NCT) for REF and Back-up E/F protection, differential protection (**for transformer ratings of 2000kVA and above**),
- **OLTC and RTCC panel**
- Oil surge relay (**only for transformers with OLTC**) and
- Any other required as per IS: 1180/IS: 2026

Accommodation for Auxiliary Apparatus

Where specified, Neutral CTs to be provided for the protection such as, restricted earth fault, back up earth fault and differential protection.

Rating Plates and terminal Plates

The followings plates shall be fixed to transformer in a visible position.

- a) Rating Plate and Terminal marking plate shall be provided as per IS: 2026 Part:1/IS: 1180 Part:1 (2021).

Gas and Oil Actuated (Buchholz) Relay

Buchholz relay shall be provided with isolation valve on both the sides for transformers of capacity 250kVA and above.

The design of the relay mounting arrangements, the associated pipe work shall be such that mal-operation of the relays shall not take place under normal service. The pipe work shall be so arranged that all gas arising from the transformer shall pass through the gas and oil actuated relay.

The oil circuit through the relay shall not from a delivery path in parallel with any circulating oil pipe, nor shall it be tied into or connected through the pressure relief vent, Sharp bends in the pipe work shall be avoided.

All wiring connections, terminal boards, fuses and links etc. connected with gas actuated relays shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resistant insulation and the bared ends of stranded wire shall be sealed together to prevent seepage of oil entering connection boxes used for cables or wiring.

Cable Box/Bus Duct Box

Cable box shall not be mounted on the tank covers. It shall be feasible to remove the tank covers for inspection during maintenance etc. without recourse to breaking the joints or disturbing the cables already terminated. Necessary removable links in oil approachable through inspection cover in tank cover etc. after lowering oil shall be provided for test purpose. HV cable box shall be considered with disconnecting chamber.

Cable box entry shall be suitable for the size and number of run of cables. Gland plate shall be provided with required number/size of knockouts for cable terminations.

In case of bus duct, bus duct box of suitable type shall be provided.

In case of ACSR conductor connection on HV side, vertical bushing of suitable type and size shall be provided.

Parallel Operation

Transformers shall be suitable for parallel operation when explicitly mentioned in SOQ. For parallel operation of transformers, the transformers shall have identical percentage impedance, transformer (X/R) ratio, voltage ratio, vector group, phase sequence, polarity, phase angle etc. as minimum.

Tests

1) Tests at Works

All routine (Impedance voltage and load loss, no load loss and excitation current, applied voltage, induced voltage, resistance measurement, ratio tests, polarity and phase relation, insulation resistance leakage etc. tests) and other tests prescribed by IS: 1180 Part: 1 (2021) shall be carried out at the manufacturers' works' before dispatch of the transformers without any additional cost to the Client.

For all transformers **rated below 500kVA**, all routine tests as narrated above shall be carried out by the manufacturers' works' before dispatch of the transformers. Certified copies of test certificates shall be furnished to the Client/PMC/TPI for review and approval.

For all transformers **rated 500kVA and above**, all routine tests as narrated above shall be carried out in the presence of Client/PMC/TPI.

In addition to the prescribed routine tests, heat run/temperature rise test shall be invariably done on one transformer of each design for ratings of 2000kVA and above.

For transformers with ratings lower than 2000kVA, temperature rise test certificate of identically rated transformer carried out as type test shall be submitted for review and acceptance.

In case, heat run/temperature rise test is to be carried out on transformers below 2000 kVA ratings, it shall be clearly specified in SOQ of the tender.

A copy of the impulse test certificate done on the same type/design of the transformer shall be furnished in accordance with IS for purpose of record. If no impulse test was done in an earlier unit of the same design and capacity, one transformer will be subjected to impulse test in consultation with the Client/PMC/TPI at Vendor/Contractor's cost.

Copies of the certificates for pressure test, bushings test and type test for short circuit shall be supplied to the Client/PMC/TPI for review.

Further if specified explicitly in SOQ/tender, one transformer of each type, design and rating approved from the project (tender) lot shall be selected randomly and sent to **ERDA** for determination/varification of losses. Costs incurred for such a test shall be paid separately as per SOQ. If values of losses so determined by ERDA, do not match with allowable maximum losses of particular rating, as specified in IS: 1180, such transformer shall be outrightly rejected and the Contractor shall replace the transformer without any additional cost to the Client.

2) Tests at Site

In addition to tests at manufacturers' premises, all relevant pre commissioning checks and tests conforming to IS code of practice No. 10028 (Part II and III) shall be done before energization.

The following tests are to be particularly done before cable joints or connecting up the bus bar trunking.

- a) Insulation test between HV to earth and HV to MV with 5000V Megger.

- b) Insulation test between MV to earth with 500V Megger.
- c) Di-electrical strength Test on oil.
- d) Buchholz relay operation by simulation test when fitted.

All test result is to be recorded and reports should be submitted to the department.

Installation and Commissioning

Fire protection system for transformers shall be provided as per CEA (measures relating to safety and electric Supply) Regulations/IE Act/Electrical Inspector. Separation walls or fire barrier wall shall be provided between the transformers as per the requirement. An oil soak pit/common burnt oil pit of adequate capacity with necessary valves/suitable pumping facility to keep the pit empty shall be provided as per applicable Standards/IE ACT/Regulations/Notification.

The transformer shall be installed in accordance with IS: 10028 (Part II and III) code of practice for installation and maintenance of transformer. Necessary support channels shall be grouted in the flooring.

The transformer shall be moved to its location and shall be correctly positioned. Transformer wheels shall be either locked or provided with wheel stoppers.

Transformer oil supplied in drums shall be topped up into the transformer after duly testing/filtering up to the correct level required.

Drying out of transformer winding will be necessary when the dielectric strength of the oil is lower than the minimum value as per IS: 10028 or the transformer has not been energized within 12 months of leaving the works or where the radiator assembly is done at site.

The transformer shall be dried out/filtration done by one of the methods specified in IS: 10028. Drying out with centrifugal or vacuum type filters will, however, be preferred. The contractor shall carry out the process of drying without interruption and shall maintain a log sheet indicating time, oil temperature and insulation resistance. BDV test shall be carried out and records to be maintained.

❖ SWITCHYARD AND TRANSFORMER YARD WITH FENCING AND GATE

Fencing around the outdoor transformer substation/11 kV switchyard.

The fencing shall be at a distance of not less than 1.5 meter on all sides of the substation (pole structure and transformer plinths, as applicable) to ensure free movement all round.

Fencing shall be with GI chain links with proper MS angle supports. The posts shall be 75mm x 75mm x 6mm angle/channel of 3meter long. The post shall be 2.4 meter above finish ground level (FGL) and 0.6 meter below FGL, fixed in 1:4:8 cement concrete foundation of size 250mm x 250mm.

GI heavy duty chain link fencing panel of size 2meter width and 2meter height made from 50mm x 50mm angle frame and covering with GI wire chain mesh 75mm, 8 SWG. Cross support of GI flat of minimum 50mm x 6mm shall be provided diagonally in the frame. Frame shall be fixed to the post with heavy duty GI bolts.

A gate of minimum 3metre (2meter x 1.5meter) with GI heavy angle frame as above and with chain link fencing as per above details shall be provided with necessary access (road/pathway) for easy mobility of each transformers/vehicular movement and for ease of O and M of switchyard/transformer yard.

Minimum 2 hinges shall be provided on each side of the gate.

Two coats of Aluminium paint over a coat of Aluminium primer shall be applied on fencing post, fencing panel and gate. Final one coat of paint shall be applied after completion of work at site at the time of handing over.

Fencing and gates shall be installed as per site condition and actual requirement.

Fencing shall be earthed properly covering all rows on all sides. Fencing shall be connected to earthing grid through suitable size hot dip galvanized earth strip as specified else where.

Caution notice should be fixed one on the 2/4 pole structure and at suitable location near transformers and another on the gate.

The sub station shall be uniformly levelled after proper ramming. Brick soling of thickness 75mm including consolidating by proper ramming, providing 100mm thick layer of 1:3:6 cement concrete and then spreading 40 mm aggregate stone jelly of thickness 100mm.

The above shall be done for transformer yard and also 1 meter all around the fencing.

Transformer details like name of the manufacturer, rating, year of manufacture, date of charging etc. shall be painted on the fire wall at suitable location for clear visibility.

❖ LV SANDWICH TYPE ALUMINIUM BUSDUCTS

Scope

This specification covers the design, manufacture, testing, installation and commissioning of Aluminium sandwich type bus duct. The proposed bus duct will serve as interconnection between LV terminals of outdoor transformers to their respective LV PCC/PMCC switchgear panels.

Construction Requirement

Bus duct shall conform to IEC 61439 (1 and 6) and IS: 8623 (1 and 2) with latest amendments. Fault level of the bus duct shall be 65kA for 1 second. Design ambient temperature is 50 °C.

415V, 3 phase Alu. + 100% neutral Alu. + 50% internal earth Alu. + external earth, naturally cooled, totally enclosed sandwich type bus duct of Aluminium bus bar, GI enclosure, powder coated Siemens grey RAL7035, IP 65 suitable for outdoor application with suitable vertical and horizontal bends, adopter box, expansion joint, suitable hardware as per IEC/IS specifications. Wall frame assembly shall be used wherever bus duct penetrates the wall. Expansion joint shall be provided for every 30 meters and as per site/route requirement.

Bus duct < 4000 Amperes rated capacity shall be electrolytic Aluminum and for higher ampere ratings i.e. ≥ 4000 rating the same shall be electrolytic Copper.

The Bidders shall visit the site and assess total length of bus duct depending on actual site conditions and requirement.

Enclosure

Enclosure shall be made up to electro galvanized/hot dipped GI sheet of 1.6mm thick/2mm thick. The degree of protection shall be IP 65.

Enclosure shall be weather proof, dust tight suitable for outdoor installation.

Bus Bars

- Rating : As per incomer rating
- Material : Aluminium ETP grade with high conductivity (99.5% pure)
- Configuration : 3 Phase + 100% Neutral (Al.) + 50% Internal Earth (Al.) + External Earth (Al.)
- Rated Insulation Voltage: 1000V AC

Maximum operating temperature at any point of the bus shall not exceed 85 °C with the limiting ambient conditions of 50 °C. Eddy current heating shall be taken into account while designing the enclosure.

Bus bars shall be insulated with high strength, good quality insulating material/coating class F/class H as per site condition and shall be colour coded at the ends for easy identification of phases.

Adjacent bus bar sections shall be joined with separate sub assembly so that they can be inserted/removed easily without disturbing the sections.

Copper flexible shall be provided at all the terminating ends. i.e at transformer end and panel end.

Phase sequence of bus bars shall be matched according to the transformer phase sequence

Earthing

Internal earth shall be of Aluminium and cross section of the same shall be 50% of phase/neutral bus bar.

Integral earth shall be connected to nearest earth pit/earth bus bar as per site conditions.

External earth with 2 separate runs of Al of size 50mm X 6mm shall be provided throughout the length of the bus duct and enclosure, supporting structure etc shall be connected to earth/ground bus.

Plug in Boxes

Suitable plug in boxes shall be provided as per requirement.

Bus bar trunking shall be installed so that plugs are side mounted to permit practical use of all plug in openings.

All contact on joint and plug in opening should be silver plated copper.

It shall be possible to inspect the plug-in opening and bus bars prior to the installation of the plug in units.

Supporting Structures

Structure and foundation drawings duly certified by Bus duct OEM after joint site measurement shall be submitted for approval.

All supporting structures required for hanging and/or supporting the complete bus duct shall be included in the scope. This includes all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.

All steel members shall be hot dip galvanized. All hardware shall be of high strength steel with suitable treatment against corrosion.

The enclosure supporting arrangement shall be such that the bus duct load is not transmitted onto the terminations.

The insert plate required to be embedded in concrete will be provided by contractor and further anchor bolts, plates, members required to support the bus duct shall be included by the Bidder as part of the structural materials. Alternatively anchor bolts can be used in which case the bolts shall be shipped in advance for grouting in civil foundation.

Documents to be submitted for Approval

GA drawings, structural and foundation drawings, bus duct route layout, termination (for transformer connection) details etc.

FOR DESIGN, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF GRID-TIED SOLAR PHOTOVOLTAIC POWER PLANT

1. Scope of Work

The work under this item shall include the complete design, detailed engineering, manufacture, supply, transportation, unloading, storage, handling, installation, erection, testing, commissioning, trial run, performance demonstration, statutory approval, and handing over of the specified capacity of Grid-Tied Solar Photovoltaic Power Plant complete in all respects. The contractor shall provide the entire system on a turnkey basis, including

all materials, consumables, tools, tackles, accessories, civil works, electrical works, structural works, and other components necessary for the proper and satisfactory functioning of the plant.

The scope shall not be limited only to supply of solar panels and inverter, but shall also include the complete module mounting structure, AC and DC cabling, junction boxes, ACDB, DCDB, protection system, earthing system, lightning protection system, monitoring system, communication system, net metering support, synchronization with utility grid, and all associated balance of system components. The contractor shall also carry out all liaisoning works with the concerned authorities such as DISCOM, State Nodal Agency, CEIG, and other statutory departments wherever required.

The contractor shall be fully responsible for providing a complete and operational system capable of generating power safely, efficiently, and reliably under the prevailing site and climatic conditions. Any item, component, fitting, accessory, device, or work not specifically mentioned but required for safe, durable, and efficient operation of the system shall be deemed to be included within the scope of work without any extra cost.

2. General Design Philosophy

The solar power plant shall be designed as a high-efficiency, grid-interactive system intended for long-term, reliable, and maintenance-friendly operation. The entire design shall be based on proven engineering practices and shall ensure optimum generation, minimum losses, structural stability, electrical safety, and compliance with applicable standards and statutory requirements.

The plant shall be designed in such a way that the arrangement of modules, inverters, mounting structures, cable routing, earthing system, and switchgear ensures easy access for inspection, maintenance, cleaning, and future replacement if required. Proper care shall be taken in design to avoid shading losses, thermal losses, excessive cable losses, mismatch losses, and structural instability due to wind or dead load.

The contractor shall prepare detailed design drawings, single line diagrams, string layouts, equipment datasheets, cable schedules, structural drawings, protection philosophy, earthing layout, and performance calculations, and submit the same for approval before commencement of execution.

3. Solar Photovoltaic Modules

3.1 General Requirements

The solar photovoltaic modules to be supplied under this work shall be ALMM approved and shall be of reputed make, suitable for long-term outdoor operation under Indian climatic conditions. The modules shall be designed to withstand high solar radiation, high ambient temperature, humidity, dust, rainfall, and wind load conditions without deterioration in performance beyond the permissible limit.

The modules shall be selected considering system voltage, inverter compatibility, power generation requirement, degradation characteristics, and mechanical strength. Only new and unused modules shall be supplied. No repaired, reconditioned, or refurbished modules shall be accepted.

3.2 Module Construction

The solar modules shall be manufactured using high-quality photovoltaic cells encapsulated within durable protective materials to ensure long design life and resistance against environmental degradation. The frame of the module shall be of anodized aluminium alloy and shall have sufficient mechanical strength to resist handling stress, mounting stress, wind pressure, and thermal expansion effects.

The front glass shall be high-transmission, low-iron tempered glass with anti-reflective coating. This is important because ordinary glass reduces the amount of solar radiation entering the module, whereas low-iron tempered glass with AR coating improves light transmittance and thereby enhances module efficiency. The tempered nature of the glass improves impact resistance and durability during transportation, installation, and operation.

The module frame shall be corrosion resistant and designed for proper drainage of water so that moisture accumulation does not affect performance. The back sheet or rear protective material shall be weather resistant and UV resistant.

3.3 Junction Box and Connectors

Each module shall be provided with a weatherproof and dustproof junction box having minimum IP67 protection. The junction box shall be robustly constructed and shall be suitable for long-term exposure to outdoor environmental conditions. It shall be equipped with bypass diodes to protect the module against hot-spot formation during partial shading or cell mismatch conditions.

The module connectors shall be MC4 compatible or equivalent approved type, ensuring secure, low-resistance, and weatherproof electrical connection. The connectors shall permit safe and easy field installation without risk of loose connection, arcing, or moisture ingress.

3.4 Electrical Characteristics

The module shall have a power tolerance of 0 to +5 watts. Positive tolerance is important because it ensures that the actual delivered module power will not be less than the rated power and may be slightly higher, thereby increasing the confidence in installed capacity and energy generation.

The module efficiency shall generally be in the range of 18% to 21%, indicating the capability of the module to convert a significant portion of incident solar radiation into electrical energy. Higher efficiency modules reduce the required installation area and improve energy generation density.

The temperature coefficient of power shall be equal to or better than -0.45% per degree Celsius. This parameter is very important in hot climatic conditions because module output decreases as temperature increases. A lower negative temperature coefficient indicates better performance under high operating temperature conditions.

The module shall have a minimum fill factor of 75%. Fill factor is an indicator of module quality and electrical performance, and a higher fill factor generally reflects lower internal losses and better energy conversion characteristics.

The nominal operating temperature shall be around 45°C, which shall be considered while evaluating field performance under actual operating conditions.

3.5 Quality Assurance and Testing of Modules

The modules shall have undergone 100% electroluminescence testing at the manufacturing works. Electroluminescence testing is essential for identifying hidden defects such as cell cracks, microcracks, soldering defects, dead cells, and internal discontinuities which may not be visible externally but can adversely affect long-term performance.

The manufacturer shall provide all standard test certificates and type test reports from accredited laboratories. The modules shall comply with relevant IEC/MNRE requirements wherever applicable. The contractor shall submit factory quality assurance documents, inspection reports, and test certificates for review prior to dispatch.

3.6 Warranty Requirements

The solar modules shall carry a minimum product warranty of 10 years against manufacturing defects, material defects, workmanship defects, and failure under normal operating conditions. In addition, the modules shall carry a linear power output warranty of 25 years, ensuring that the power output degradation remains within acceptable guaranteed limits over the life of the module.

This requirement is essential because the solar module is the primary energy-generating component of the plant, and its long-term reliability directly governs the financial and technical success of the project.

4. Solar Inverter

4.1 General

The inverter shall be of grid-tied type, designed specifically for converting DC power generated from solar modules into synchronized AC power suitable for injection into the electrical grid. The inverter shall be of reputed make and shall be suitable for continuous outdoor/indoor duty as per actual installation conditions.

The inverter shall incorporate advanced MPPT technology to continuously track and extract maximum power from the connected PV array under varying irradiation and temperature conditions.

4.2 Functional Role of Inverter

The inverter is one of the most critical elements of the solar power plant because it is responsible not only for DC to AC conversion but also for ensuring synchronization with the utility grid, monitoring system health, maintaining power quality, and protecting the system against abnormal conditions. Therefore, only proven and reliable inverter technology shall be accepted.

4.3 Technical Characteristics

The inverter shall have MPPT operating range between 80 volts and 1000 volts, making it suitable for a wide range of string voltage configurations. This flexibility is important for optimizing string design and ensuring stable operation under different irradiation conditions.

The maximum efficiency of the inverter shall be between 97.5% and 98.9%, which indicates that conversion losses are minimal. High inverter efficiency is necessary to maximize delivered energy and reduce thermal losses.

The output frequency shall be 50/60 Hz and shall be synchronized automatically with the grid supply. The output power factor shall be approximately unity, which ensures efficient utilization of electrical power and minimal reactive power burden on the grid.

The output THDi shall be less than 3%. Low harmonic distortion is very important for maintaining the quality of power injected into the grid and protecting sensitive electrical systems from harmonic-related issues.

The inverter shall be suitable for operation at altitude up to 4000 meters and ambient temperature range of -25°C to +60°C, indicating a robust design suitable for wide environmental variations.

4.4 Inverter Protection Features

The inverter shall have integrated anti-islanding protection. This protection ensures that the inverter automatically disconnects from the grid when the utility power supply fails. This is a critical safety feature to protect utility maintenance personnel and prevent unsafe energization of disconnected grid sections.

The inverter shall also incorporate reverse polarity protection to prevent damage due to incorrect connection of DC inputs. Insulation resistance detection shall be provided to monitor insulation health and detect possible ground faults or leakage paths.

Residual current monitoring shall be integrated to improve electrical safety and detect leakage current conditions. Output overcurrent protection, short circuit protection, and overvoltage protection shall also be built into the inverter to ensure safe operation during fault conditions.

4.5 Enclosure and User Interface

The inverter enclosure shall be minimum IP65 rated to ensure adequate protection against dust and water ingress. This is especially important in outdoor and semi-outdoor installation environments where dust, rain, and humidity may adversely affect equipment life.

The inverter shall be equipped with user interface in the form of LCD display and app-based monitoring. The display shall indicate important operating parameters such as DC voltage, DC current, AC output voltage, output current, power, daily energy generation, cumulative generation, fault indications, and system status.

4.6 Data Logging and Communication

The inverter shall be provided with data logger and communication facility such as GPRS or Wi-Fi for remote monitoring. Remote monitoring is important for continuous performance observation, fault diagnosis, maintenance planning, and generation reporting. The communication system shall permit access to generation data, alarm logs, event history, and equipment performance parameters.

5. Module Mounting Structure

5.1 General

The module mounting structure shall be designed to support the solar modules safely and firmly over the entire design life of the project. The structure shall be suitable for rooftop installation and shall be designed to withstand dead load, live load, wind load, thermal stresses, and vibration effects.

The mounting arrangement shall ensure proper inclination, orientation, and inter-row spacing of modules in order to maximize solar energy capture and reduce shading losses.

5.2 Material of Construction

The mounting structure shall be fabricated from seamless box pipe sections and/or 'C' channel sections of suitable size, made from hot-dip galvanized steel. The steel shall be of sufficient thickness and strength to resist bending, buckling, warping, and corrosion during long-term service.

Hot-dip galvanization is necessary because solar power plants remain exposed to the atmosphere throughout their service life, and untreated steel structures are susceptible to corrosion, especially in humid or polluted environments. Proper galvanization significantly improves the life of the structure.

5.3 Structural Design Requirements

The structure shall be designed considering the local wind speed, building height, roof conditions, dead load of modules, load from cabling, accessories, sprinkler system if any, and maintenance loads. The design shall prevent uplift, sliding, overturning, or excessive deflection under service conditions.

Particular care shall be taken to ensure that the roof is not damaged due to mounting operations and that the imposed load remains within permissible structural limits. In case of wall-mounted or foundation-mounted arrangement, the contractor shall provide suitable anchoring, base plates, and fixing arrangements.

5.4 Fasteners and Fixing Components

All nuts, bolts, washers, clamps, and fastening accessories used for the installation of structure shall be of SS 304 grade. This is necessary because inferior fasteners corrode rapidly and may compromise the long-term safety and rigidity of the mounting system.

The contractor shall provide J-bolts, anchor fasteners, chemical anchors if required, module clamps, rail clamps, and all other fastening components necessary for the complete installation.

5.5 Foundation and Base Plate Arrangement

Suitable arrangement for base plates and foundations shall be provided wherever required. The design of foundation or anchoring arrangement shall be based on site conditions and structural safety requirements. The cost of civil work, grouting, anchor placement, base plate fixing, and alignment shall be included in the item.

6. Balance of System

6.1 General

Balance of System includes all components other than solar modules and inverters that are necessary to make the solar plant complete, safe, operable, and grid compatible. The contractor shall provide all such components in suitable rating, size, and configuration.

6.2 ACDB and DCDB

The system shall be provided with suitable DC Distribution Board and AC Distribution Board complete with appropriate protective devices. DCDB shall generally include DC isolators, string protection, surge protection devices, fuses or breakers as required, and proper termination arrangement. ACDB shall include incoming and outgoing breakers, surge protection, metering provisions, and isolation arrangement.

The boards shall be fabricated from suitable enclosure material and shall be designed for safe operation, proper cable entry, adequate ventilation where needed, and protection against environmental exposure.

6.3 Cabling and Interconnection

All DC and AC interconnecting cables shall be of suitable type and rating, capable of carrying the design current safely without excessive voltage drop or overheating. DC cables shall be UV resistant, weatherproof, and suitable for solar application. AC cables shall be suitable for power distribution duty.

Cable routing shall be neat, organized, and mechanically protected. Proper glands, lugs, ferrules, cable trays, conduits, clamps, saddles, markers, and identification tags shall be provided. The cable losses shall be minimized by proper sizing and route optimization.

6.4 Earthing System

A complete earthing system shall be provided for the solar plant. Separate and adequate earthing shall be arranged for module structure, inverter body, ACDB, DCDB, lightning arrester system, and other metallic components as required. The earthing system shall be designed to ensure safety of personnel and protection of equipment.

All earthing conductors, electrodes, strips, pits, and accessories shall be provided as per applicable standards and best engineering practice. The earthing resistance shall be measured and recorded during commissioning.

6.5 Lightning Protection System

The solar power plant shall be protected against lightning by providing a suitable lightning arrester system complete with air terminals, down conductors, and earth termination arrangement. The system shall be designed such that the risk of direct lightning strike and surge propagation into the equipment is minimized.

7. Civil Works

The contractor shall carry out all civil works necessary for proper installation of the solar system. This shall include foundations, pedestal work, grouting, mounting base preparation, wall supports if required, trenching for cabling if required, restoration work, sealing of roof penetrations, and other related works.

All civil works shall be executed in a neat and workmanlike manner without damaging the existing structure. Where rooftop mounting is involved, waterproofing integrity of the terrace or roof shall be maintained. If any damage is caused during installation, the same shall be rectified by the contractor at his own cost.

8. Installation Requirements

All materials shall be installed strictly in accordance with approved drawings, manufacturer recommendations, and relevant standards. The contractor shall employ trained and experienced personnel for handling, lifting, mounting, wiring, and commissioning activities.

Solar modules shall be mounted in proper alignment and shall be tightened uniformly to prevent mechanical stress. Electrical connections shall be done carefully with proper crimping, polarity verification, insulation integrity, and torque control. Cables shall not be left hanging loosely, and all terminations shall be neat, secure, and identified.

9. Testing and Commissioning

9.1 Pre-Commissioning Tests

Before commissioning, the contractor shall carry out all required pre-commissioning tests such as continuity test, insulation resistance test, polarity test, earthing resistance measurement, functional check of inverter, verification of communication system, checking of module strings, and verification of protections.

9.2 Commissioning Tests

The contractor shall commission the plant only after successful completion of installation checks and pre-commissioning tests. During commissioning, synchronization with grid, inverter operation, generation performance, monitoring system operation, and protective tripping functions shall be demonstrated in the presence of the Engineer-in-Charge or authorized representative.

9.3 Performance Demonstration

The contractor shall demonstrate that the plant operates satisfactorily and produces energy under actual conditions. Any abnormality, mismatch, underperformance, or fault observed during trial operation shall be rectified promptly at no extra cost.

10. Statutory Approval and Liaisoning

The contractor shall be responsible for all liaisoning work with concerned government and statutory agencies such as the State Nodal Agency, DISCOM, and CEIG. This shall include preparation and submission of documents, application forms, drawings, test reports, equipment details, net metering documentation, approval follow-up, and coordination up to final permission and energization.

No separate payment shall be made for this activity, and the same shall be deemed included in the quoted item rate.

11. Documentation

The contractor shall submit complete documentation including equipment datasheets, type test reports, warranty certificates, operation manuals, maintenance manuals, approved drawings, as-built drawings, cable schedules, earthing layout, inverter settings, protection details, and commissioning reports.

These documents are essential for future operation, maintenance, and record purposes and shall form part of the final handing-over package.

12. Warranty, Defect Liability and Maintenance Responsibility

The contractor shall remain fully responsible during the warranty and defect liability period for any defect arising due to inferior material, poor workmanship, improper design, inadequate protection, or faulty installation. Any failed component, damaged part, or underperforming equipment shall be repaired or replaced by the contractor at his own cost.

The contractor shall ensure that the plant continues to perform reliably and safely during the warranty period and shall attend faults within reasonable time.

13. Energy Generation Requirement

The solar plant shall be designed and installed to achieve average generation in the range of 4 to 5 units per kW per day on annual average basis, subject to actual site irradiation and operational conditions. The contractor shall optimize design and component selection to achieve the best feasible performance.

Energy generation shall be considered one of the key indicators of system quality, and poor design leading to avoidable losses shall not be accepted.

14. Measurement and Payment

The work shall be measured on the basis of installed and commissioned capacity in kilowatt. Payment shall be released only after satisfactory supply, installation, testing, commissioning, submission of required documents, and approval by the Engineer-in-Charge. The quoted rate shall be deemed to include all materials, labor, transport, taxes, duties, installation accessories, testing instruments, consumables, approvals, liaisoning, and all incidental charges required for completion of the work.

15. Final Technical Requirement

The entire Grid-Tied Solar Power Plant shall be delivered as a complete, integrated, and technically sound system with long service life, high safety, and efficient energy generation. The contractor shall ensure that the system is robust, maintainable, compliant with all requirements, and suitable for reliable performance under actual site conditions.

Any omission in the specification that is necessary for completeness, safety, durability, statutory compliance, or efficient performance shall be construed as included in the contractor's scope without any extra financial implication.

❖ LV PANELS: PCC/PMCC/MCC/APFC/LVDB/OTHER SWITCH BOARDS

Panel shall conform to Indian Electricity Act and rules CEA Notification/Guidelines, CPWD guidelines 2019 as amended up to date and shall be as a minimum.

The LV switchboard panels shall be floor mounting, free standing, compartmentalized, extensible, Modular type suitable for indoor installation. The panel shall be totally enclosed and dust, damp & vermin proof. Enclosure shall have IP 52 or better degree of protection for indoor unit and IP 55 or better degree of protection for outdoor unit as a minimum. Outdoor unit shall be double door and additionally provided with canopy or weather shed for protection.

Panel construction shall be complying to Form 3b type as per IS/IEC 61439 (i.e. separation of bus bars, all functional units and of terminals and external conductors etc. shall be as per Form 3b type as per IS/IEC 61439). Only metallic sheet shall be used for compartment separations/partitions. Hylam/PVC sheets shall not be allowed.

LV panels/switch boards sheet steel shall be CRCA minimum 2 mm for load bearing members, mounting plate, partition, doors/covers, canopy. Gland plate shall be CRCA sheet minimum 3 mm thick. All the doors and others openings shall be provided with neoprene rubber gaskets or of durable material gaskets.

All hardware shall be corrosion resistant. Star washers shall be used for effective continuity.

Suitable lifting arrangement with L angle welded at top for PMCC/MCC/APFC etc. shall be provided on each panel or on each shipping section for ease of lifting of switchboard.

A base channel of 100 mm x 50 mm x 5 mm thick shall be provided at the bottom of the panel on all four sides of each shipping section.

Overall height of panel shall not exceed 2300 mm (For VFD/Soft starter panel height up to maximum 2500 mm can be accepted) including minimum 100 mm ISMC base frame. However, in case of panel mounted on floor without cable trench shall be mounted at least 500 mm above the floor level on structure steel or suitable support base / stand to provide adequate bending radius for in and out cables (elevated stand to be covered suitably from all sides). **Operational height of starters and control switch gear shall not exceed 1800/1900 mm above FFL (irrespective of overall height of panel) for ease of operation.**

Shipping section length shall be maximum 2500 mm. Each shipping section shall have full side sheets of 2 mm thick on both the sides. Vertical partition of incomer/bus coupler/outgoing feeders etc. shall be of full depth of the panel. Detachable gland plate shall be provided at the top on both the ends of the shipping sections for connecting/joining of bus bars.

PCC/PMCC panel shall have 2 numbers outgoing MCCB/ACB power feeders, one number on each side of BUS to feed power to downstream MCC panel or shall be as per tender SLD/BOQ.

All MCC feeders will have two incomers (one incomer as stand by) with electrical and mechanical interlocking between the two such that only one incomer is ON at a time or shall be as per tender SLD/BOQ.

Electrical interlocking mechanism shall operate in both Manual and Auto Operational mode without fail. Panel builder must ensure that proper fail safe interlocking in both modes is provided. It is absolute responsibility of panel builder/integrator to design the panel and ensure proper & satisfactory operation & performance of the offered panels and for satisfactory operation of plant / pumping station. The SLD where furnished along with tender shall be considered as an indicative SLD for adhering to minimum requirements as specified there in and panel vendor shall be responsible for design and arrangement of incomer or any outgoing feeders and other additional requirements for satisfactory and reliable operation of panel and for meeting the stated objective of electrical system in tender / BOQ / Tender drawings.

Minimum dimension of incomer, bus coupler, starter, MCCB cubical compartment shall be as per the Table. Height of main horizontal bus bar chamber shall be minimum 300mm up to 630A rating and 350 mm or higher for 800 A and above. Vertical bus bar shall be minimum 300mm or higher as per kA level and temperature rise required. Minimum width of cable alley shall be 350mm or higher as per number of cables.

Control MCB shall be provided for control wiring circuit. Panel shall be of fuse less design.

All type of meters shall be digital type. Voltmeter shall be provided for all incomer feeders. Ammeter / MFM shall be provided as under:

- Incomer Feeders: 3Nos. CTs with ammeter with selector switch shall be provided
- Incomer Feeders of PCC/PMCC: Digital multi function meters shall be provided in addition to Ammeter and Voltmeter
- Outgoing Power Feeders less than 100A: 3Nos. CTs with ammeter with selector switch shall be provided
- Outgoing Power Feeders rated 100A and above: Digital multi function meters shall be provided
- Motor Starters rated 7.5 kW to less than 15 kW: CT on Y phase with digital ammeter shall be provided
- Motor starters rated 15 kW and above and less than 30 kW: 3Nos. CTs with ammeter with selector switch shall be provided
- Motor starters rated 30 kW and above: Digital multi function meters shall be provided
- For motor starters and outgoing power feeders equipped with MFMs, separate ammeters, anvoltmeters, ASS and VSS are required.

RS 485 of all meters/MFMs shall be looped together inside the panel and brought out in the cable alley.

LV panel shall be of fixed type, single/double front. LV panel shall be single tier for incomers and bus coupler feeders rated 500A and above. Panels with VFD and soft starter feeders rated 22 kW and above shall be in single tier only while the same shall be in single tier or two tier for less than 22 kW VFD/soft starter feeders.

Outgoing ACB feeder of 1000 A and above ratings shall be in single tier only.

Vacant space on incomer and bus coupler panel shall not be used for mounting the starter, switch gear modules, MCB feeder. Fixed capacitor/reactor may be housed below bus coupler with steel sheet separation/barrier.

VFD starter panel shall be stand alone panel in case of VFD for motors rating $\geq 75\text{kW}$. This provision does not apply in case of VFD panel bundled along with / housed within equipment housing or enclosure for equipment like turbo blowers, etc.

All auxiliary devices for control, metering, protection, indication and measurement such as push buttons, control and selector switches, indicating lamps, ammeters, voltmeters, kWh meters and protective relays shall be mounted on the front side of respective compartment, for easy operation without opening the door. Metering cubicle shall be separate/independent of ACB/MCCB incomer feeders.

Circuit breakers of required capability/suitability to interrupt applicable capacitive current shall be specifically verified/supported by manufacturers' recommendations.

The switch board components, bus bars etc. shall be designed to withstand the maximum designed short circuit level for minimum 1 second.

MCCB shall be TPN/4P, microprocessor based release/thermal magnetic release as specified elsewhere. All MCCBs shall be suitable for $I_{cs} = 100\% I_{cu}$. The rated service short circuit breaking capacity (I_{cs}) of MCCBs shall be more than or equal to the specified fault level. MCCB shall be supplied with extended rotary handle, terminal spreader, auxiliary C/O + trip contact as applicable.

Rating of MCCB/MPCB, contactors, relay etc. of motor feeders as recommended by equipment manufacturers' and shall comply with Type 2 Coordination as per IS: 60947.

Panel shall have main horizontal and riser bus bars, air insulated with coloured heat shrinkable PVC sleeves, housed in a separate compartment, segregated from all other compartments, with sheet steel barriers, sufficient louvers with wire mesh for air circulation.

The LV panels shall be provided with a continuous earth bus having sufficient cross section to carry the specified fault current for specified duration without exceeding the safe temperature throughout its entire length.

All control wiring except CT secondary wiring shall be carried out with minimum 1.0 mm^2 FRLS PVC copper flexible wires (Grey). CT secondary wiring shall be carried out with 2.5 mm^2 FRLS PVC copper flexible wires (Color coded).

Adequately rated anti condensation heater with porcelain connectors shall be provided in each breaker panel and in cable alley to maintain inside temperature 5°C above outside ambient temperature. It shall be supplied from 240V AC auxiliary bus for space heater. The space heater shall be provided with a thermostat having variable setting of $30\text{-}70^\circ\text{C}$ and manually operated switch fuse and link for phase and neutral respectively.

All starters shall be provided with Auto-Off-Manual and Local-Remote selector switches (where start PB provided at panel end) to monitor and operate MCC or LCS, ICP/PLC.

All ACBs, MFM, VFD, Soft Starters where provided shall have inbuilt RS 485 port to communicate with PLC/SCADA for monitoring and control. RS 485 terminal shall be wired upto external TB with shielded wire.

240V AC control supply shall be fed from 415/230V AC constant voltage/control voltage transformer (with $\pm 2.5\%$ and $\pm 5.0\%$ tapplings on both primary and secondary sides) one number on each bus of minimum 1.5 kVA rating (for less than 630 Amps connected load), and higher kVA rating depending on total connected working load. Suitable control logic through contactors shall be provided such that control supply is available to all feeders based on incomer 1 and incomer 2 status. Only one control transformer shall be ON at a time. **Separate control**

transformer 415/230V of suitable VA rating shall be provided for incomers. DP MCB of suitable rating shall be provided on both incoming as well as outgoing side of control transformer. All CTs, PTs and constant voltage/control transformer shall be cast resin type with terminals. CT shorting link type control terminal shall be provided. Only Ring type lugs shall be used for CT termination.

2 Nos. auxiliary contactors to be considered for PLC interface.

All capacitors generally shall be at 440V or 525V if provided with detuned reactor or as specified in BOQ. Capacitors shall be heavy duty type with discharge resistors and with dielectric losses $\leq 0.2\text{w/kVAR}$.

Adequate number of spare outgoing breaker/power feeders shall be provided in all panels/switchboards. At least Two number of power feeder with highest rated outgoing breaker shall be provided as spare in PCC/PMCC and at least two numbers of 4 pole 63A rating (or higher rating or higher nos. as per Bidder's design requirement) shall be provided as spare power feeders in all panels/switchboards (PCC/PMCC/MCCs) as applicable (For PCC/PMCC the 2 numbers spare feeders shall be provided on each side of bus as a minimum). For PDB/LDB, minimum 2 numbers outgoing feeders of highest rating (for each phase) shall be provided as spare.

Following communication RS 485 Modbus, DI, AI and DO, AO to be considered for various type of feeder for PLC/SCADA interface.

	INCOMER (ACB/ MCCB)	SOFT/VFD/SD STARTER (MPR)	MOV
Communication	Inbuilt Modbus RS 485 for control and monitoring metering, energy and protection parameters (Applicable only for ACB)	Modbus RS 485 monitoring and control (SS and VFD) & MPR Only monitoring & Trip. In VFD: PF, energy saving also to be monitored.	-
Digital Input (DI)	Breaker ON/OFF	Motor Run	Valve Open
	Breaker Trip	Motor Trip	Valve Close
	Auto / Manual (For ACB)	Auto / Manual	Local/Remote
		Local / Remote	Trip/Fault
Digital Output (DO)	Breaker ON/OFF (latched type)	Start/Stop (latched type)	Valve Open
			Valve Close
Analog Input (AI)		Speed Feedback (Only for VFD)	Valve Position Feedback
Analog Output (AO)		Speed Reference (Only for VFD)	Valve Position Reference (Only for VFD)

In addition to above MFM and Temperature scanner with RS 485 Communication MODBUS shall be taken for interfacing with PLC/SCADA for monitoring and for controlling further as required.

Bus Bar

Bus bars shall be of high conductivity, electrolytic Aluminium (E91E) suitable for carrying the rated and short time current without overheating supported on insulators made of non hygroscopic, non flammable material to ensure free thermal expansion with tracking index equal to or more than that defined in IS.

Aluminium bus bars shall be sized for maximum 0.8 A/mm^2 current density only.

Whenever incoming supply is through bus duct, incoming bus bar of incomer shall be extended till the top end of panel and phase positioning/orientation of bus bars shall be suitable for transformer LV terminal arrangement to avoid additional phase cross over chamber.

Bus bars for risers shall be rated to carry minimum 80% or higher of the rated current of all feeders connected to the risers as per the design of the system/loading.

The current rating of neutral shall be minimum half that of phase bus bars. For LDB neutral rating shall be equal to that of phase bus bar.

Both horizontal and vertical TP and N, bus bars, bus joints and supports shall be capable of withstanding dynamic and thermal stresses of the specified short circuit currents for 1 second.

Only high tensile steel bolts, nuts and washers duly zinc passivated or cadmium shall be used for all bus bars joints and supports.

The hot spot temperature of bus bars including joints at design temperature shall not exceed 85 °C for normal operating conditions.

All bus bars shall be insulated with heat shrunk PVC sleeves of 1100V grade.

The bus bars shall be arranged such that minimum clearance between the bus bar for 50kA fault current shall be maintained as below.

- Between phases : 27mm minimum
- Between Phase and Neutral : 25mm minimum
- Between phase and Earth : 25mm minimum

To fulfill the requirement of 65kA for 1 second, necessary clearance as per relevant IS shall be maintained.

Auxiliary Supply Bus Bars

Auxiliary bus bar of **Tinned Copper EC grade** of suitable size shall run throughout the length of main busbar/vertical bus bar alley and supply shall be tapped to individual feeder directly from the bus and shall not be looped between the feeders. Control MCB shall be provided for individual feeder. Exact size/capacity of bus bar shall depend on various controls, metering and auxiliary power distribution requirement. Auxiliary bus shall be provided for following applications:

- Panel space heater supply and motor space heater supply,
- Control supply for breaker tripping, closing and indication circuits,
- Control supply for breaker spring charging motors, motor starter control and indication circuits and
- AC potential supply for MFM, meters, starter and voltage operated relays etc.

Power and Control Wiring and Terminal Blocks

All wiring shall be done with FRLS PVC copper flexible wires with IS marks. The insulation grade for these wires shall be 660V grade. The control wiring shall be enclosed in plastic channels/Race way and neatly bunched together.

Control circuit wiring shall be FRLS PVC copper flexible wire of minimum 1.0 mm² size and CT circuit wiring shall be minimum 2.5 mm² size. CT wiring shall be R Y B colour coded and terminals shall be CT shorting link type only. Power wiring inside the starter module/MCCB/MCB shall be rated for full current rating of feeder MCCB/MCB.

All feeder modules shall be provided with neutral link. Suitable size and rating terminal blocks shall be provided for all outgoing feeders in the cable alley for connecting power and control cables. Cable shall never be connected directly to MCCB/MCB terminals.

Flexible wire shall be used only up to and including 100 A MCB/MCCB. For above 100 A MCCBs bus bar shall be used. Minimum size of FRLS Copper wire shall be up to and including 16A: 2.5 mm²; 20A: 4 mm²; 32A: 6 mm²; 40A: 10 mm²; 50A: 16 mm²; 63A: 25 mm². and 100A: 35 mm².

Each wire shall be identified at both ends by PVC ferrules. Inter panel wiring shall be done through rubber grommets. A minimum of 2 numbers or 20%, whichever is higher, spare terminals shall be provided on each terminal block.

Marking on the terminal strips shall correspond to wire numbers on the wiring diagrams. All spare contacts and terminal of panel mounted equipment and devices shall be wired to terminal blocks.

Earthing

The minimum earth bus size shall be minimum **65mm x10mm (hot dip galvanised strip) or 40mm x 10mm (Aluminium) or** higher to suit the fault level/kA requirement.

All doors and movable parts shall be earthed using minimum 1.5 mm² FRLS Copper flexible wires (Green colour) to the fixed frame of the switch board. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All non-current carrying metallic parts of the mounted equipment shall be earthed. Minimum 4 numbers, 10 mm dia. hole shall be provided on the earth bus for termination of earth strip/wire.

Name Plate

Name plates shall be provided as per standards.

LV panel shall be with details like name of Client (on first row/top row), Project name (second row), name of Contractor (third row) and Panel builder/manufacturer (in fourth row) all with equal of descending order letters size on top of front side of panel.

LV panel shall be with name plate (on front side of door of incomer) having minimum details like (1) Power supply voltage, (2) Control supply voltage, (3) Frequency, (4) Panel fault level, (5) Panel protection class and (6) Panel manufacturing IS standards considered etc. details.

Painting

The LV panel shall be treated with seven tank/nine tank process with degreasing, water rinsing, De-rusting, water rinsing, phosphating, water rinsing, passivation.

After seven tank process the panel shall be powder coated with Siemens grey RAL 7035 / 7032 or such other suitable shade with cliqnet approval for inside and outside of LV panel.

Mounting plate shall be painted / powder coated with white or suitable shade.

Thickness of paint shall be between 80 to 100 Microns.

Switchgear Modules

Air Circuit Breakers

Circuit breakers shall be air break, electrical draw out type for feeders 630A and above. All ACB shall be with microprocessor based release with overload, short circuit and inbuilt earth fault protection. Only for APFC incomer thermal magnetic type can be accepted.

The ACB shall be minimum 50kA (1 Second) or higher as per fault rating, $I_{CS} = 100\%I_{CU} = I_{cw}$. All ACBs shall comply and tested as per IS: 13947/IEC 60947-1 and IEC 60947-2 standards.

ACB for all incoming, Bus coupler should be Four Pole Type. PCC outgoing feeders shall be Four Pole/Three Pole + Solid Neutral (TPN) Type.

ACB for incoming and bus coupler shall be identical and interchangeable.

ACB models shall be: **Schneider: Master pact NW, Siemens:3WT^{PLUS}/ 3WA, LK-E&A (Formerly L&T E&A): Omega U-Power, ABB: E-Max2; or Equivalent** model from Approved Vendor list. Data sheet with parameter comparison shall be submitted for approval. However, in case of change in models / introduction of new model by vendor in due course, the latest model equivalent or better than specified model shall be offered / considered.

ACB shall be with **inbuilt Communication Module** RS 485 for MODBUS for communication with SCADA/PLC for both control and monitoring.

Electrical and mechanical interlocking shall be provided between ACB incomers and bus coupler with required key locks, under voltage coil etc. as per the system requirement. Only ACB auxiliary built-in contact shall be used for interlocking i.e. auxiliary contactor/plug-in relay shall not be used.

ACB Trip Release LSIG (Micro Processor based) should have minimum as following:

- Overload with time delay

- S/C with time delay and instantaneous trip setting
- Earth fault with time delay
- Under/over voltage for incomer
- LSIG fault record display (Only For Incomer and Bus coupler)
- Metering and Energy display (Only For Incomer and Bus coupler)
- Ammeter display (For Outgoing feeders)

ACB shall be fitted with following:

- Auxiliary built-in contacts having not less than 4 NO + 4NC contacts
- Built in resin cast current transformer
- Shunt and under voltage tripping device
- The ACB shall be suitable for locking the breaker in various positions. Interlocks shall be provided to: Prevent the breaker from being isolated unless it is in the 'OFF' Position; Prevent the breaker from being racked in to the service position unless it is in the 'OFF' position; Prevent the breaker from being accidentally pulled completely 'OFF' the guide rail.
- Safety shutters of an insulation material shall be provided to prevent access to all live contacts, when the breaker is in the inspection position or completely withdrawn.

Moulded Case Circuit Breakers (MCCB)

All MCCBs shall be comply and tested as per IS: 2516/IEC 60947-1 and IEC 60947-2 standards.

Incomer MCCBs shall be 4 P, 50kA or higher (and $I_{cs} = 100\% I_{cu}$) with micro-processor based release with in built O/C, S/C and E/F protection.

Outgoing MCCB TPN for power feeders up to and including 200A shall be with thermal magnetic release with adjustable O/L and Adjustable/Fixed S/C protection. Outgoing MCCBs from 250 A and above shall be with microprocessor based release with in built Adjustable O/C, Adjustable S/C and Adjustable E/F protection.

All MCCBs shall be 50 kA or higher, $I_{cs} = 100\% I_{cu}$ and with extended rotary handle and terminal spreader. Auxiliary change over contact 1 No + 1 NC and trip contact shall be provided as per the requirement.

MCCB of Soft Starter/VFD feeder shall be TPN with microprocessor release with overload/short circuit and inbuilt earth fault release.

MCCB as part of DOL/Start Delta motor starter module shall be current limiting type, TPN, (rating and protection type as indicated above) and type tested for Type 2 Coordination as per IS: 13947 / IS/IEC: 60947.

MCCB models shall be: **Schneider: NSX/CVS** or **Siemens: 3VA/3VJ** or **LK-E&A (Formerly L&T E&A): D Sine** or **ABB: T-Max**; or **Equivalent model** from approved vendor list. However, in case of change in models / introduction of new model by vendor in due course, the latest model equivalent or better than specified model shall be offered / considered.

Electrical interlocking shall be provided between MCCB incomers and bus coupler with required under voltage coil, auxiliary contactors as per the system requirement.

On & trip indication of MCCB shall be provided for starter feeders having MCCB breaker.

Switches/Fuses

The switches or fuse switches shall be load break, heavy duty/motor duty, air break type provided with quick make/break manual operating mechanism. The operating handle shall be mounted on the door of the compartment having the switch. Fuses shall be non-deteriorating HRC cartridge link type.

Rating of heavy duty switches or motor duty starter modules shall meet the requirement of AC23 duty as per IS: 13947.

Contactors

The contactors shall be air break type, equipped with three main contacts and minimum (2 NO + 2 NC) auxiliary contacts. All contactors shall be 3 Pole, AC3 duty except for lighting feeder where in the contactor shall be 4 P

and AC1 duty. External by pass contactor used for soft starter shall be AC1 or AC3 as recommended by soft starter manufacturer.

Unless otherwise specified, the coil of the contactor shall be suitable for operation on 240V, 1 Phase AC supply and shall work satisfactorily between 65 to 110% of the rated value.

Contactor used for capacitor feeder shall be capacitor duty contactor with inbuilt leading contact with wiper function for limiting/damping the capacitor inrush current with NO NC Auxiliary contact.

Bimetal Relay

All bimetal overload relays shall be with in-built single phasing prevention and with Manual/Auto reset type (selectable) with at least 1 NO and 1 NC contact with reset type push buttons in the front, mounted on door such that it shall be possible to reset the O/L relay without opening the compartment door.

Motor Protection Relay (MPR)

Motor Protection Relay (MPR) shall be provided for starters rated 30kW and above. MPR is not required for VFD/Soft starter motor feeders.

Motor protection relay (MPR) shall be numerical type with over load, short circuit, earth fault, under current, unbalance, phase loss/reversal, stall, locked rotor, no load running.

Single phasing prevention with adjustable under/over voltage protection shall be provided separately if the same is not inbuilt feature in MPR.

MPR shall be Numerical with adjustable parameter with inbuilt MODBUS over RS 485 interface (for item rate tender will be as specified in SOQ/Tender drawings). MPR shall be DIN rail mountable base module and LCD display module shall be panel door mountable. ZCT/CBCT shall be provided for earth fault / leakage protection (range 0.1A to 2A). It shall have programmable 2 DI and 2 DO.

MPR shall display 3 phase current, unbalance 9% as minimum and earth current monitoring. MPR shall store fault records/Start- Stop records/motor run hours/maximum starting current etc.

For motors 30kW and above external CT (3 nos) 5A, Resin cast of suitable VA shall be used.

Data sheet with parameters comparison shall be submitted for approval. However, in case of change in models / introduction of new model by vendor in due course, the latest model equivalent or better than specified model shall be offered / considered.

Motor Starter

DOL starter to be considered for rating less than 7.5kW rating. Star-delta starter is to be considered from 7.5kW rating and upto less than 75kW rating. Soft starter to be considered for 75kW and above ratings.

VFD shall be provided for any rating if specifically asked for/as per the requirement/application. Soft starter shall be provided for lower ratings also if specifically asked for/as per the requirement.

MCCB rating upto 800A as incomer for Soft starter and VFD starter is acceptable.

MPCB with overload protection, short circuit protection and single phasing/phase loss protection, AC3 duty contactor for DOL feeders and Start Delta feeders up to and including 15kW.

All MPCB shall be with rotary switch.

MCCB (with adjustable overload, adjustable short circuit, earth fault) microprocessor release or thermal magnetic release (with adjustable overload, adjustable/fixed short circuit) as per MCCB rating, AC3 duty contactor, numerical motor protection relay as applicable, A/M switch, L/R switch, indicating lamps, push button etc. shall be provided.

Provision for door mounting PMU shall be provided in the starter cubicle of submersible pump motor. Wiring shall be done up to terminal connector for PMU input from field. Alternately PMU mounted within enclosure can be permitted to be installed outside the panel within LT room or outdoor near the pump as per contractor's design.

Minimum 8 channel or higher, temperature scanner shall be provided in starter feeder for 90kW and above rated motor feeders wherever motor is supplied with RTD and BTD.

Temperature scanner/Thermister and PMU (as applicable) shall be interlocked with starter feeder with control/tripping circuit of starter feeder. Temperature scanner shall be door mounted. Soft starter/VFD shall be with input terminal for RTD (PT 100) and Thermistor for motor temperature (winding and bearing) monitoring/protection.

Temperature Scanner

Temperature scanner of required channels with minimum 2 spare channels shall be provided to detect high winding, and bearing temperature in order to generate tripping signals. The input signals to temperature scanner shall be derived from the motor. Industrial type PT 100 resistance temperature detectors shall be provided in the motor windings and bearings.

1	Service and type	Motor winding and bearing temperature measurements – microprocessor based
2	Range	0 to 200 °C
3	Alarm Contacts	Adjustable 4 Nos. (high temperature and very high temperature) for motor winding and bearing
4	Type of Relay contacts	One Single Pole Double Throw per set point (Relay)
5	Input Signal	From RTDs for each Motor winding and bearing winding
6	No. of channels	6 Nos. for Winding + 2 nos. Bearing + 2 Spare
7	Accuracy	± 1 °C
8	Communication	RS 485 for Instrumentation panel interface if specified to be provided in SOQ/elsewhere in the tender.

Instrument Transformers (CTs/PTs)

Current transformer and potential transformer shall generally conform to IS: 2705, IS/IEC: 60044-122 and any special requirement with reference to numerical relay shall be taken care of by contractor. All CTs shall be resin cast type and secondary 5 A. APFC feedback CTs, MFM CTs, MPR CTs shall be of Class 0.5 and 10 VA. CTs (80A and above) of digital ammeter, APFC panel metering shall be Cl. 1 and 5 VA. CTs less than 80A shall be Cl 1.0 and 2.5 VA.

The current transformers in breaker feeders shall be capable of withstanding the applicable peak momentary short circuit and the symmetrical short circuit current for 1 second.

Indicating/Measuring Instruments

The meters shall be digital type and generally of square pattern type of 96mm x 96mm suitable for flush mounting. Instrument shall generally conform to IS: 1248 and shall have accuracy class of 1.0 or better. Digital meters shall have 3½ digit LCD display as a minimum.

All auxiliary equipment such as shunt transducers, CTs, PTs etc. as required shall be included in the supply of panel/switch board.

The current coil of ammeters and potential coils of voltmeters shall continuously withstand 120% of rated current and voltage, respectively, without the loss of accuracy.

Digital ammeter and voltmeter shall be with in-built or separate selector switches.

Voltmeter for three phase shall be provided with three line display.

Multi function meter shall be with 3 line display, accuracy class: 0.5 suitable for measuring and displaying the following parameters: A, V, F, PF, kW, kWH, kVA, KVAR, KVARh, Md (Md for PCC/PMCC incomer feeder only), Harmonic and with inbuilt RS 485 communication port. (**Schneider**: EM 6400NG; **LK-E&A (Formerly L&T E&A)** : MFM 4420 (for Incomer) & MFM 4410 (for Starter&Outgoing); **Secure**: Elite 444 (for Incomer) & Elite 443 (for Starter & Outgoing); equivalent model of other approved make). Data sheet with parameter

comparison shall be submitted for approval. However, in case of change in models / introduction of new model by vendor in due course, the latest model equivalent or better than specified model shall be offered / considered.

Push Buttons

Push buttons shall have rated operational current of not less than 4A (AC 11).

Push buttons for START, OPEN, CLOSE, LEFT, RIGHT, FORWARD, REVERSE etc. shall be flush type with spring aided self reset contacts.

Push buttons for STOP/EMERGENCY STOP shall be mushroom headed type with stay put contacts and shall be coloured red. The operation of the button shall be press to lock and twist to release.

The stop PB for each outgoing feeder/starter at MCC and for field LCS shall be EMERGENCY STOP push button.

Push buttons shall be in compliance with IEC 60947-5-5.

Illuminated PB is also acceptable.

Colour of push buttons shall be as follows:

Stop/Open/Emergency	:	Red
Start/Close	:	Green
Reset/Test	:	Yellow/White

Indicating Lamps

Indicating lamps shall be LED type and colour shade for the indicating lamps shall be as below:

ON indicating lamp	:	Red
OFF indicating lamp	:	Green
TRIP indicating lamp	:	Amber
PHASE indicating lamp	:	Red, Yellow and Blue
TRIP circuit healthy lamp	:	Milky

Fixed Compensation

Fixed capacitor banks for transformer compensation (for no load as well as leakage reactance) shall be provided. MCCB 50kA or higher as per specifications along with ammeter, CT 3 nos, capacitor duty contactors, ON delay timer, heavy duty multiple capacitor units (in smaller kVAr ratings viz 10,5,2,1) totaling to 5% value of transformer rating. Capacitor shall not be mounted below incomer feeder. Capacitor, if provided below bus coupler, capacitor housing/compartment shall be fully separated with steel sheet. Proper ventilation shall be provided.

7% detuned reactor with thermostat, 440V shall be provided in series with 525V capacitor or as per SOQ, if working VFD load is more than 50% of total load or if specified in SOQ. kVAr rating of capacitor shall be suitable for reactor rating.

For Capacitor banks of ratings > 50 kVAr for transformer fixed compensation, separate enclosure shall be provided. Fixed capacitor banks meant for transformer compensation for ratings > 50 kVAr shall not be permitted to house in main LV PMCC/PCC panels. Only 4P MCCB power feeder shall be provided in PCC/PMCC panel for the same.

Danger Notice Plates

The danger notice plate shall be affixed in permanent manner on operating side of the panels. The danger notice plate shall indicate danger notice both in Hindi and English and local language with a sign of skull and bones as per IS: 2551.

Cubicle/Feeder Size Criteria For LV Panels

ACB cubicle shall be min. 1800mm height and minimum compartment size as under:

ACB Rating	Width of Compartment (I/C or O/G) (mm)	Width of Compartment (Bus Coupler) (mm)	Depth (mm)	Remark
630 A – 1250 A 4P	800	900	1000	Cable entry
1600 A 4P	900	1000	1000	Cable entry

2000 A - 2500 A 4P	900	1000	1200	Bus duct entry
3200 A – 4000 A 4P	1100	1200	1300	Bus duct entry

NOTE: Dimension mentioned above is minimum. Height of ACB feeder shall be 1800 mm excluding main Bus bar chamber. Above 1000A ACB outgoing feeders shall be in single tier. Up to and including 1000A ACB outgoing breaker feeder shall be in single/double tier.

MCCB cubicle minimum compartment size shall be as under:

MCCB Rating	Minimum Compartment Width (mm)	Minimum Compartment Height (mm)	Depth (mm)	Remark
Up to 100A	350	250	250	Copper flexible shall be used
125A – 200A	400	350(3P)/400(4P)	300	Bus bar/strip
Above 200A to 400A	500	450	400	Bus bar/strip
Above 400A to 550A	600	500	500	Bus bar/strip
Above 550A	600	600	500	Bus bar/strip

NOTE:

1. Dimension mentioned above is Minimum. Depth of panel as per required depending on cable size/ site condition and for ease of maintenance.
2. The minimum height provided is for horizontal mounting of MCCB. However, in case vendor provides vertical mounting of MCCB, then vendor shall provide higher height of compartment then specified above and in this case the cubicle height shall be equal to specified width of compartment as a minimum or higher as required.

VFD and SOFT Starter cubicle shall be minimum 1800mm height and minimum cubicle compartment size as under:

Motor Rating	Minimum Width of Compartment (For VFD and for Soft Starter with External Bypass Contactor)	Minimum Width of Compartment (For Soft Starter with Built in Bypass Contactor)	Depth of Compartment
Less than 75 kW	700	700	800
75 kW to ≤ 132 kW	800	750	900
Above $132 \leq 250$ kW	900	800	900
Above 250 kW	1000	900	1000

NOTE: Dimension mentioned above is minimum. S/S and VFD feeder for 22 kW and above shall be in single tier only.

TECHNICAL DATA SHEET FOR LOW/MEDIUM VOLTAGE PANEL BOARD

Sr. No.	PARTICULAR	DETAILS
1.0	SITE CONDITIONS	
1.1	Type/Make	Indoor/As per Tender BOQ
1.2	Mounting	Floor/Stand mounted as per BOQ/Site Conditions
1.3	Design Ambient Temperature	50°C
1.4	Atmosphere	Corrosive, Humid and Dusty
2.0	CONSTRUCTION	
2.1	Housing	2.0 mm thick CRCA sheet for Body, Partition, Cover/Door
2.2	Protection Class	IP 52 (Indoor)
2.4	Base Channel	100mm x 50mm x 5mm Channel

2.5	Shipping Section Length	2500mm (Maximum)
2.6	Side Sheets for Shipping Section	Full side sheet on both side of shipping section
3.0	OPERATING CONDITIONS	
3.1	Voltage	415V \pm 10%
3.2	Number of Phase	3
3.3	System	3 Phase, 4 Wire
3.4	Frequency	50 \pm 5% Hz
3.5	Fault Current	50 kA as per SLD
3.6	Neutral Grounding	Solid
4.0	CONTROL SYSTEM	
4.1	Voltage	
	For Indication	240V AC
	For Metering	240V AC
	For Protection	240V AC
4.2	Control Supply Through Control Transformer/ Constant Voltage Transformer	240V AC for PMCC
4.3	Wiring	Control Wiring: 1.0 mm ² FRLS PVC Cu Flexible Wire (Grey); CT Wiring: 2.5 mm ² FRLS, Color Coded: Door Earthing: 1.5 mm ² FRLS (Green)
5.0	BUS BAR	
5.1	Phase Bus Bar Material	EC Grade Aluminium
5.2	Neutral Bus Bar Material	Same as Phase Bus Bar
5.3	Earth Bus Bar Material	65 x 10 mm (Hot Dip Galvanised Strip) or 40mm x 10mm (EC grade Al)
5.4	Current Density	1 sq. mm = 0.8 A. Size of bus bar based on design temperature, kA level and current density
5.5	Hard Ware	High Tensile Steel Bolts, Nuts and Washers duly Zinc/Cd Passivated shall be used for all bus bar joints and supports
6.0	PLC Based System	As per SLD/SOQ
7.0	ACB	
7.1	Type, Rating, Number of Poles	EDO, 50kA Rating and Pole as per SLD
7.2	Protection	LSIG with Display and Fault Record Display Control and Monitoring from Remote Location
7.3	Display of Metering	Basic (A,V,F) and Energy for I/C and Only Current Display of Outgoing
7.4	Communication port	Inbuilt RS 485 (on MODBUS/Ethernet)

7.5	Model	Schneider: Master pact NW, Siemens: Siemens:3WT^{PLUS}/ 3WA, LK-E&A (Formerly L&T E&A): Omega U-Power, ABB: E-Max2; or Equivalent model from Approved Vendor List
8.0	MCCB (Ics= 100% Icu)	
8.1	Incomer and Bus Coupler MCCB	Microprocessor based Release with Adjustable O/L, Adjustable S/C, Inbuilt Adjustable E/F, 50kA, 4 Pole
8.2	Outgoing MCCB	
8.2.1	For Rating Above 200 A	Microprocessor based Release with Adjustable O/L, Adjustable S/C, Inbuilt Adjustable E/F, 50kA, 3/4 Pole as Specified in SLD
8.2.2	For Rating Up to and including 200 A	Thermal Magnetic based Release with Adjustable O/L, Adjustable/Fixed S/C, 50kA, 3/4 Pole
8.2.3	For SS/VFD Starter Feeder MCCB	Microprocessor based Release with Adjustable O/L, Adjustable S/C, Inbuilt Adjustable E/F, 50kA, 4 Pole
8.2.4	Accessories	Extended Rotary Handle, Terminal Spreader, Auxiliary Change Over Contact + Trip Contact to be provided
9.0	Electronic Motor Protection Relay	
9.1	Type	Electronic MPR with LCD display (3 Phase Current), Record Storage, DI/DO Interface etc. as per Detailed Specifications
9.2	Protection/Interface	Confirm the Following
		1) Over Current 2) Short Circuit 3) Earth Fault 4) Current Unbalance 5) Phase Loss/Reversal 6) Under Current (Dry Run) 7) Stall (Bearing Broken) 8) Locked Rotor 9) Ground/Earth Fault/Leakage (ZCT) 10) Single Phasing with Under voltage and Over Voltage 11) Over temperature (with PTC Thermister) 12) 3 Programmable DI and 2 Programmable DO 13) Fault Record, Start/Stop, Run Hrs. Maximum Starting Current Record
10.0	PAINTING	
10.1	7 Tank Processed Sheet	Required
10.2	Colour and Shade and Thickness: Panel Exterior and Interior	RAL 7035 80 Micron – 100 micron
10.3	Mounting Plate	Glossy White
11.0	Current Transformer	
11.1	Type	Resin Cast
11.2	Class of Accuracy	Cl 0.5 for MFM, APFC Load Sensing, Summation, MPR Cl: 1 for Ammeter

11.3	Burden (VA)	As per Specifications
12.0	Hardware	For Bus Bar Joints High Tensile With Zinc Passivation/Cd Plated
13.0	Space Heater	230V AC with Thermostat
14.0	Pocket for Drawings at Door	Yes
15.0	Instrumentation Compartment	Separate Compartment for Energy Meter, Hour Meter, Level Controller etc. with Necessary Internal Wiring
16.0	Panel Internal Lighting	250mm Long LED Panel Light 3/4W or Higher with Auto NO Contact/Switch with Panel Door and control MCB for VFD/SS/Starter Feeder/Incomer/Cable Alley

Note: Other specifications not mentioned in datasheet shall be considered as per tender specifications/SLD.

❖ **AUTOMATIC POWER FACTOR CONTROL PANEL (APFC PANEL)**

APFC panel shall be floor mounting, free standing, compartmentalized, extensible, modular type suitable for indoor installation.

The panel shall be IP 52 for metering and switchgear module and shall be IP 42 for reactor/capacitor section. Full partition shall be provided between switchgear components and capacitor section. Each feeder module shall be fully compartmentalised. Capacitor/reactor shall be mounted in separate vertical section/cubicle adjacent to switchgear cubicle instead of mounting at the rear end/backside of switchgear module as per availability of space.

The control equipment including capacitors shall be mounted in panel made of 2mm CRCA sheet. Panel shall be fully compartmentalised, extensible and with main bus bars in horizontal bus bar alley.

Capacitor feeder rating shall not exceed 100 kVAr rating.

Ammeter, ammeter selector switch and CT shall be provided in 50 kVAr and above rated feeders to measure capacitor current.

APFC panel control logic shall be such that when DG is ON, APFC panel shall be OFF and shall become automatically ON when the Grid power/utility power is restored.

The fixed capacitor bank will be provided on each incomer, as applicable, on upstream side of incomer breaker. Adequate arrangement of interlocking between APFC panel and transformer fixed compensation power capacitor bank for no load power factor improvement must be made in such a way that during load condition i.e. when associated incomer breaker is ON and downstream load is working (load / current is being sensed above certain threshold), the fixed compensation capacitor bank shall be switched off. Similarly, when incomer breaker is OFF or the downstream load are OFF (load / current is zero / below certain threshold), the fixed capacitor banks shall be ON i.e. in functional/working mode. The objective of this interlocking arrangement is to compensate for p.f. during no load condition and it shall also be ensured that power factor does not go into leading side when pumping system is not running / plant under no load condition. For this purpose the fixed capacitor bank shall be adjusted / fine tuned at site to decide the required kVAR to be kept ON out of total and same will be reviewed and set from time to time periodically.

APFC panel shall be operated on AUTO and MANUAL mode. Individual capacitor feeder shall be possible to be operated on AUTO/MANUAL mode even when A/M switch in incomer feeder is on AUTO Mode.

All capacitors shall be heavy duty MPP/Heavy duty Gas filled with discharge resistor and as per the technical data sheet provided here in. However in case of only smaller capacity ie < 5 kVAr, APP type capacitors are also acceptable.

Heavy duty exhaust fan 6"/8" (shall be continuous duty, metal housing with metal impeller) with canopy shall be provided at the top. Louvers with wire mesh (up to maximum 1mm opening) shall be provided at the bottom end of capacitor section. Minimum 1 number of fan shall be provided per meter length of panel or part thereof or more numbers as required.

Minimum distance between two capacitors and from all sides of panel enclosure (including terminal) shall be 25mm.

Earthing terminal of capacitor shall be connected to earth bus bar.

Automatic Control Panel and Fixed Capacitor Panel (for Transformer Compensation) shall comprise following.

MCCB for protection of each capacitor bank (MCCB should be suitable for capacitor switching and kA rating shall be as per main panel kA rating). For smaller ratings of capacitors ie <10 kVAr only D curve MCBs of appropriate ampere ratings are acceptable.

Incomer MCCB shall be TPN, microprocessor based/thermal magnetic (adjustable O/L and Adjustable S/C) as per LV panel specifications.

APFC relay shall be microprocessor based with inbuilt RS 485 for sensing and correcting the power factor of the system with required number of steps to achieve the specified power factor. Minimum steps of power factor relay shall be 10 or as per SOQ. Minimum operating current/sensing current shall be 10 mA/10% of load. Minimum 2 numbers additional spare relay contact shall be available for future use.

Two numbers vacant feeders with mounting plate and cutouts shall be provided for future use.

A/M switch with Auto/Manual indicating lamps shall be provided in addition to R Y B indicating lamps.

Each outgoing capacitor feeder shall be provided with suitably rated MCCB, capacitor duty contactor with inrush damping resistor, A/M switch, 'ON' and 'OFF' push with ON, TRIP, AUTO indication lamp, ON delay timer (only for Manual mode of individual feeder), 440V capacitor unit with discharge resistor.

Control circuit of individual feeder shall have control MCB for protection and indicating lamp shall be only through auxiliary contact.

All outgoing MCCB feeders shall be 50kA, $I_{cs} = 100\% I_{cu}$, with trip indication/fault signal contact, with extended rotary operating handle, any other components required for satisfactory and safe operation shall be provided.

Capacitor shall be compact in size and hermetically sealed. In built fuses and surge suppressors shall be provided for protection of each capacitor element.

Capacitor banks shall comprise identical delta connected three phase units. Capacitor banks shall be non-flammable, non-toxic, non-PCB, dry technology, inert gas (N₂)/PU resin impregnated, MPP heavy duty type/Gas filled.

Only one wire shall be connected to each contactor terminal i.e. whenever more than one capacitor is controlled from contactor suitable size bus bar strip shall be provided and power shall be tapped. Else separate contactors shall be used for each capacitor unit.

If load is VFD driven and working VFD driven load is more than 50% of total load, or if required or specified in SOQ, APFC panel shall be with detuned reactors. 7% detuned reactor, 440V, Al. wound with thermostat shall be provided in series with capacitor unit. Capacitor voltage shall be 525V or as specified in SOQ and kVAr rating suitable for reactor kVAr rating. Filter rating (Reactor + Capacitor) shall be rating of APFC panel.

Except for the specific requirements of APFC panel specified here in, rest all specifications shall be as per LV panel/switchboard specifications specified herein.

Capacitor rating generally shall be at 525V if provided with detuned reactor or as specified in SOQ and APFC Panel shall conform to IS: 16636 (2017).

Three Phase Filter Reactor

Anti resonance three phase filter reactor, Aluminium wound, 440V detuned reactors (5.67% or 7%) as required are to be used in series with shunt capacitors to prevent harmonic resonance and harmonic overloading of capacitors, transformers, whenever power electronic equipment (Drives, UPS etc.) producing nonlinear currents are used. Detuned systems shall be such that the self resonant frequency is below the lowest line harmonic.

Features of Reactors

- High linearity, low losses and noise level
- High over loading capability
- Inbuilt temperature micro switch

Micro switch potential free contact shall be used in control circuit of respective capacitor feeder to trip the contactor in case of high temperature.

Reactor shall be kept in independent cubicle and adequate ventilation shall be provided.

Power Factor Correction Thyristor Switch Module

Thyristor switching instead of contactor switching shall be used when load variation is rapid. Semi conductor fuses shall be used for protection of Thyristor switches in addition to MCC, BHRC fuses shall not be used. Discharge reactors shall be used for fast discharge for fast reconnection of capacitor.

Technical Features

- Suitable for real time power factor correction
- Switching time less than 5 milli seconds
- PIV: 2200
- Permanent self controlling of voltage parameter, capacitor current, temperature of the thyristor switch
- Suitable for manual operation also
- Automatic switch off in case of over current and over temperature
- Display of: Operation, Faults, Activation.

APFC Controller with RS 485

Microprocessor based intelligent control, menu driven, single/3 CT sensing, 5A CT selectable with RS 485 communication port and features as below.

- Display: LCD illumination, large and multi functional characters.
- Parameters: Voltage, monitoring of individual capacitor currents, Real time PF, Power kW, kVA, kVAR, Temperature, Energy KWh, KVAh, KVARh
- Steps: 4, 6, 8, 12,16 as required
- Mounting: Panel mounting (size: 144mm x 144mm)
- Current input: 1 A or 5 A selectable
- Operating temperature: 0 to 60 °C
- Supply voltage: 230V AC
- Target PF: 0.8 inductive - 0.8 capacitive.
- Minimum operating current: 10 / 50 mA
- Sensing: Single/3 CT, 3 CT sensing for unbalanced load.
- Dual target power factor setting: for utility and DG mode operation.
- Facility of including “Fixed capacitor bank” for purpose of transformer compensation. This can be set such that the controller doesn’t ‘see’ this capacitor.
- Potential free contacts/alarm output: Insufficient compensation, over compensation, under current, over current, over temperature, harmonics exceeded.
- Suitable for Thyristor switching if Thyristors are used instead of contactor.

Minimum rating of MCCB, Cable/flexible wire size for capacitor feeder shall be as below.

Cable Size Selection Chart (Minimum)

Sr. No.	Capacitor Rating (KVAr)	MCCB Rating (Amps)	FRLS Copper Cable/Wire size (mm ²)
1	Up to and ≤ 5	16 (MCB Acceptable)	2.5
2	10	32	4
3	12.5	32	6
4	15	63	6
5	20	63	10
6	25	63	16
7	30	100	25
8	40	125	35 mm ² /Bus bar from bus to MCCB
9	50/60	160	50 mm ² /Bus bar from bus to MCCB
10	75	200	70 mm ² /Bus bar from bus to MCCB

CAPACITOR DATA SHEET

Sr. No.	PARAMETER	Unit	
	Capacitor Type		Heavy duty MPP/Heavy duty Gas Filled
1	Conformance to Standards		IS: 13340/IEC 60831
2	Rated Voltage	V	440/525 as required/Applicable
3	Inrush Current	A	Up to 200 Ir
4	Maximum Permissible Current/Over Current	A (Imax)	1.5 Ir
5	Maximum permissible Voltage/Over Voltage	V (Vmax)	1.1 Vr
6	Temperature Class	⁰ C	60
7	Losses (per phase)	W/kVA	Dielectric: less than 0.2 Total : less than 0.5
8	Capacitance Tolerance		-5% / + 10%
9	Dielectric		Poly Propylene
10	Impregnation		Non-PCB PU Resin/Inert Gas Nitrogen
11	Number of Switching Operation		5000 as per IEC 60832
11	Useful Life	Hours	125000 Minimum
12	Maximum THD in Voltage		3%
13	Maximum THD in Current		15%

Note: Rest all construction features and other requirements shall be as per specifications of LV Panel.

Test and Test Reports

All tests shall be conducted in accordance with the latest edition of IS: 2834 and as applicable for controls. Type test certificates for similar capacitor units shall be furnished for review and acceptance.

Drawings to be submitted for the approval of the Client/PMC/TPI

- GAD with elevation, side view, sectional view and foundation details.
- Complete schematic and wiring diagrams.
- Detailed BOM and GTP.
- Manufacturers' technical data sheet of capacitors and APFC relay.

❖ ACTIVE HARMONIC FILTER (AHF) PANEL

Active Harmonic Filter (AHF) to mitigate system harmonics

The Active Harmonic Filter (AHF) is intended to remove harmonic distortion in a 3-phase, 4-wire, 415V +10% & -15% AC, 50Hz +/-5% electrical system resulting in reduced current harmonic distortion and hence reduced voltage harmonic distortion as per IEEE-519.

These specifications describe requirements for Industrial grade (Commercial Modular Type not acceptable) floor mountable made from 2.0mm CRCA sheet, Gland Plate 3.0mm, minimum IP-20 for Indoor installation, extensible panel.

Principle of operation

AHF should mitigate harmonics as limit prescribe as per IEEE:519 standard (Minimum from 3rd to 49th order harmonics distortion) at the point of supply line connection and eliminate it by generating the counter harmonics. The AHF Panel shall also correct power factor and load balancing.

The active harmonic filters shall meet the following basic requirements:

- Active filter shall be able to connect in both open loop and closed loop configuration.
- AHF shall have inbuilt current limiting logic to avoid over-loading and tripping.
- AHF shall be in single enclosure and commercial modular PCB mounted design not acceptable
- Momentary peak harmonic current loading shall be 2.5 times the rated compensation current for 10 ms.
- AHF Panel shall be with over load capacity 120% for 60 sec.
- IGBTs shall be of 7th generation or latest in power circuit.

Sr.No.	AHF Technical Specifications	Requirement of Parameters
1	AHF Panel / Module Rating	As per SOQ / Tender specification / Design
2	Design Temperature & Ambient working Temperature	50°C / 40°C Shall be capable to work at 50°C with suitable de-rating. Manufacturer shall provide basis for the same.
3	AHF Panel Main Incomer	MP (LSIG) MCCB / ACB, Rating as per SOQ / Financial bid-Tender
4	Module Protection (For Each Module)	MP MCCB with Semiconductor Fuse for each power module for IGBT protection and for incoming protection & isolations.
5	HMI Colour display screen panel	7 Inch, Touch Screen Tin Film Transistor (TFT) LCD colour display screen panel with Real time clock and should display Load side, supply side and filter parameters as such like Voltage, Current, Frequency, PF, THD, Voltage and Current Harmonic spectrum, Temperature, Active Power, Reactive Power, Apparent Power and suitable for remote monitoring and diagnosis etc.
6	AHF Panel remote monitoring and diagnosis at PLC/SCADA	Suitable Communication Port/MODBUS RS485 for interfacing with PLC/SCADA for monitoring and for controlling as required.

5	Separate Display Meter	Separate Harmonic spectrum & Waveforms display Meter shall be required
6	HarmonicAttenuationRatio	Minimum 95% or betteratratedcurrent
7	HarmonicOrderFiltrationCapability	upto51 st orders / as per IEEE:519standard
8	Power loss of AHF rating	shall be < 3.0 % of AHF rating
9	OverloadCapacity	120%overloadfor1minutes
10	Display	GraphicalLCDwithRealTimeClock.
11	NetworkConnectivity	RS-485withModbus-RTUprotocol
12	ProtectiveFunctions	Minimum Over Current, Phase Loss, Adjustable Over Current,Timed Over Current, DC Bus Over Voltage, DC BusUnder Voltage, Over Temperature, Ground Fault,Charging Fault, CTDetectionFault etc.
13	ReferenceStandardsCompliance	IEEE519 latest
14	Panel Bus Bar Material / Current density (Aluminum)	EC Grade Aluminum / 1 sq. mm = 0.8 A Maximum. Size of Bus Bar based on at 50°C Design Temperature
15	Panel Bus Bar Material / Current density (Copper)	Tinned Copper / 1 sq. mm = 1.4 A Maximum. Size of Bus Bar based on at 50°C Design Temperature
16	Earth Bus Bar Material	40mm x 10mm (EC Grade Al)
17	Control Wiring	FRLS PVC Copper Flexible 1.5 sq. mm for Control wiring 2.5 sq. mm for CT wiring
18	Exhaust Fan Make / MOC	Cooltron / Rexnord / High Cool Make of Metallic housing with metal Impeller / blade / vanes
19	Exhaust Fan at Top & for each Module	Minimum 8" size & Minimum one no. for each module of 6" size
20	Painting & Colour	As per Manufacturing Standard

❖ **SOFT STARTER (FORMING PART OF LV PANEL) OR STAND ALONE PANEL**

Scope

This specification covers the requirement for design, manufacture, installation, testing and commissioning of step-less reduced voltage/solid state torque controlled soft starter for motors in MCC panel to provide linear ramp starting and stopping of AC induction motors.

Constructional and Performance Features (Microprocessor Soft Starter)

The PCB power structure shall consist of six SCR's mounted on a heat sink for ratings up to suitable rating of motor. PCB shall be self tuning to accept control power input as per design.

Soft starter shall have current transformer/sensor in all the three phases for current monitoring.

All phases should be controlled during start/stop.

Soft starter shall consist of built-in RS 485 MODBUS RTU for monitoring and control through PLC/ SCADA.

Soft starter should be built for continuous operation without need of by pass for any reason.

Soft starter shall have features which allows the soft starter to operate with only 2 controlled phases in case of short circuit of 1 set of thyristor avoiding unplanned stop and possibility to keep running motor until the softstarter is repaired.

Control terminals shall be easily accessible and located on the front bottom of the device.

Sizing/Selection Criteria for Soft Starters

Soft starter de-rating factor for selection of soft starter shall be based on design ambient temperature (50°C), altitude (up to 1000 m above MSL as standard or higher as per site requirement) etc. declared by OEM as % de-rating in their published catalogue available in the PUBLIC DOMAIN only. Rating/model selection based on design software/certificate issued by OEM will not be acceptable/considered for selection.

Further the soft starter shall meet following conditions to be confirmed by soft starter manufacturer/ OEM.

Start Current (cold start)	:	400% of I_n (rated current of motor) for 20 seconds (Class 20 Tripping Class)
Starting Frequency	:	Up to 10 number of starts per hour

Following shall be considered while sizing the soft starter and its enclosure.

Soft starter shall be de-rated as per manufacturers' recommendation for 50°C operating conditions based on site/operating condition and such de-rated current of soft starter shall be minimum 110% of full load current of motor as per IS: 12615 (latest edition) or as per SOQ.

Soft starter shall be rated for DOL starting and shall have **In-built/External Bypass** contactor of AC1 or AC3 rating as recommended by soft starter OEM.

Soft starter shall be provided with breaker (MCCB/ACB) along with fast acting semi conductor fuse protection, with fuse base and with series contactor of required rating as recommended by OEM.

Soft starter signal to be interlocked with PLC and in manual mode timer based interlock to be provided to ensure that signal to turn on soft starter is fed only if contactor close signal is received to switch off supply to contactor through PLC when soft starter is not ON.

Contractor/Vendor shall furnish the heat dissipation load data and shall provide the cooling arrangement accordingly to ensure that the temperature rise within enclosure does not exceed 5°C over the maximum ambient temperature of 50°C .

Minimum two cooling fans shall be provided or higher number as required. Cooling fan shall be continuous duty, metal housing with metal impeller, minimum 6" size (minimum 8" for 160kW and above). The enclosure cooling fans and temperature sensing device (RTD/Thermistors) with tripping arrangement shall be provided and shall also be interlocked with soft starter operation i.e. in case of cooling fan failure or excess temperature (55°C or as set), the soft starter shall be tripped/shall not turn ON.

Vents for air suction into panel shall be provided with louvers with filter (front washable and replaceable). However for 160kW rating and above vents shall be Louvers with wire mesh (up to maximum 1mm opening) and in this case enclosure shall be generally with IP 42 protection class.

Soft starter shall be provided with conformal coating according to IEC 60721-3-3 to withstand harsh environment.

Auxiliary contact of incoming breaker and contactor shall be used in series to provide "Soft Starter Ready" interlock signal for PLC/remote operation

Detachable display/key pad with digital parameter adjustment, preferred with cable suitable for door mounting. The control key pad and display shall have the option for remote mounting. For safety reasons the controller should have green lights for running and red for start/stop.

Enclosure/panel shall be generally as per IP 52 protection.

Control Module Design Features

User Adjustments

The acceleration start ramp and stop ramp timers shall have minimum individual adjustments from 1 to 60 seconds.

The initial torque setting shall be adjustable from 0 to 200% of motor torque.

The end torque setting shall be adjustable from 50 to 200% of motor torque.

Current limit starting shall be adjustable from 150% to 500% of the motor's full load current.

Pump Control (Standard Feature)

The standard feature pump control shall be implemented to provide closed loop control of motor to match the specific torque requirements of centrifugal pumps for both starting and stopping.

Pump stop shall be initiated without the need for a dedicated pump stop input. A coast-to-rest stop shall still be possible with stop input.

Controller's Features and Modes

- a) **Starting modes** required for controller includes linear torque control for Start, Pump Control Current Limit Start (Voltage Ramp Start, Voltage Ramp with Current Limit Start, Full Voltage DPL Start, Soft Start with Selectable Torque Boost etc.), Bypass Control and Bypass Contactor mode with all the protection parameter working.
- b) **Stopping modes** required for controller includes linear torque control for Stop, Pump Control (DOL/Coast to stop), Bypass Control, DC/Dynamic brake for fast stop of motor with high moment of inertia etc.

Protection and Diagnostics

Protections of Controller shall meet applicable standards.

Protective Features

Motor Thermal Overload—selectable for starting class 10A, 15A, 25A under load protection (to avoid dry run), Soft Start thermal overload, PTC input, Phase imbalance, Phase reversal, Over voltage, Under voltage, Locked Rotor, Excessive Starts per hour for application, Phase loss input/output etc.

Electronic thermal memory shall be provided for enhanced motor protection.

All Protections should be available in bypass mode also.

When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

Soft starter shall preferably be with input terminal for RTD (PT 100) and Thermistor for Motor Temperature (winding and Bearing) monitoring/control/protection.

Fault Indications

Controller shall indicate latest fault indications/occurrence for: Line failure, Phase imbalance, Over temperature: motor, Over temperature: Soft Starter, Shorted Thyristor, Open Thyristor, Locked Rotor, Motor output loss, Overload and Under load – Shaft Torque, Over voltage, Under voltage, Excessive Starts and Phase reversal etc.

Viewing Functions

Motor Current, Three Phase Voltage, Shaft Power in kW/HP (selectable), Motor thermal capacity, Motor Energy consumption (kWh), Power factor, Run time in hours etc.

Soft starter model shall be: Schneider: ATS-480; ABB: PSTX; Danfoss: MCD600, Siemens 3RW or equivalent model of Rockwell or additional vendor from approved vendor list. However, in case of change in

models / introduction of new model by vendor in due course, the latest model equivalent or better than specified model shall be offered / considered.

Notes:

1. For soft starter standalone panel, rest all construction features and other requirements shall be as per the specifications of LV panel.
2. The soft starter features specified are in general and any manufacturer specific deviations in certain features can be reviewed and accepted based on merit/application requirement.

❖ VARIABLE SPEED (VFD) AC DRIVE SYSTEM AND VFD STAND ALONE PANEL

General Requirement/Specifications

Variable frequency drive (VFD) system shall consist of all components required to meet the performance, protection, safety and testing and certification criteria of this specification. These components may include harmonic filter/ power factor correction unit, input transformer, VFD converter/DC-link/inverter and output filter and necessary components, pre assembled and wired as required.

Any modifications to a standard product required to meet the specification shall be performed by VFD manufacturer only.

The VFD shall meet the following specific requirements as a minimum.

The fabrication, painting and other such construction requirements of VFD cabinet/panel/enclosure shall meet the requirements as per the specifications for LV panels.

The incoming breaker of VFD feeder shall have micro processor based S/C, O/L and E/F protection (minimum 50kA SC current rating) as minimum along with door interlock facility.

VFD shall be de rated as per manufacturers' recommendation for 50 °C operating conditions and altitude based on specified site/operating conditions and such de rated current of VFD shall be minimum 110% of full load current of motor as per IS: 12615 (2018)/as per SOQ.

VFD shall be provided with TPN ACB/MCCB and as recommended by VFD manufacturer as per their published chart along with fast acting semi conductor fuse protection, with fuse base and with series contactor. AC3 category (VFD signal to be interlocked with PLC and in manual mode timer based interlock to be provided to ensure that signal to turn on VFD is fed only if contactor close signal is received) to switch off supply to contactor through PLC when soft starter is not ON.

Contractor/Vendor shall furnish the heat dissipation load data and shall provide the cooling arrangement accordingly to ensure that the temperature rise within enclosure does not exceed 5 °C over the maximum ambient temperature of 50 °C.

Minimum two cooling fans shall be provided or higher number as required. Cooling fan shall be continuous duty, metal housing with metal impeller, minimum 6" size (minimum 8" for 160kW and above). The enclosure cooling fans and temperature sensing device (RTD/Thermistors) with tripping arrangement shall be provided and shall also be interlocked with VFD operation i.e. in case of cooling fan failure or excess temperature (55 °C or as set), the VFD shall be tripped/shall not turn on.

Vents for air suction in to panel shall be provided with louvers with filter (front washable and replaceable). However for 160kW rating and above vents shall be Louvers with wire mesh (up to maximum 1mm opening) and in this case enclosure shall be generally with IP 42 protection class.

VFD shall be provided with **conformal coating, to protection level 3C2 for water supply and sewerage (pumping station/treatment plant) projects and protection level 3C3 for industrial effluent projects** or such harsh environment and according to IEC 60721-3-3.

VFD shall be with programmable keypad with graphical display mounted on door (Remote Mounting) and inbuilt RS 485 serial port for remote communication.

Auxiliary contact of incoming breaker and contactor shall be used in series to provide "VFD Ready" interlock signal for PLC/remote operation.

Input filters, transformer, power conversion, output filters and auxiliary equipment enclosure shall be NEMA 12 design. Air cooled units/enclosure shall be NEMA 12 ventilated, generally IP 52 or better degree of protection, with gasketed doors.

Voltage and Current Harmonics at the supply side of the drive system at PCC (point of common coupling) shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations of the IEEE 519 2014 or latest edition.

VFD manufacturer to provide the harmonic calculations and suggest the required harmonic corrections based on plant SLD at each VFD input and at PCC (Point of Common Coupling) as per the suggested harmonic mitigation plan/solution. Bidder shall provide complete plant SLD with all additional data as required to VFD manufacturer for this purpose.

Performance

VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal 10-100% speed range. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without motor connected to the VFD output.

VFD shall be capable of producing standard/variable torque for centrifugal pumps and centrifugal blowers and shall produce full rated torque (constant torque) at any speed in the operating range for applications like Positive Displacement type Twin/Tri Lobe air blowers, Screw Pumps etc.

VFD shall be digitally controlled, using Pulse Width Modulation (PWM) with flux vector control open loop and closed loop. It shall have IGBTs in the inverter section throughout the power range.

VFD shall be provided with required EMC filter complying to EN 61800-3 depending on the maximum length of the cable from VFD to motor.

VFD shall be capable of being re-set and operating normally after clearing ground fault.

Harmonics Distortion and Power Factor

The total harmonics distortion of the voltage and current at inverter output shall be as per IEC 61800 and/or IEEE 519-2014/latest edition.

VFD shall include an input filter/reactor/choke to protect itself against damage due to normal transients and surges on incoming power line and reduce harmonic distortion on the AC power line.

VFD system including power factor correction system and/or harmonic filter shall never have a leading power factor under utility or generator operation.

The system design shall not have any inherent output harmonic resonance in the operating speed range.

Motor Compatibility

VFD system shall provide an output waveform that will allow utilization of any standard motors, without any need for any special insulation or de rating.

VFDs utilizing output transformers are not acceptable.

VFD output shall produce no electrically induced pulsating torques to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations.

VFD shall inherently protect motor from high voltage Delta V/Delta T stress, independent of cable length of motor.

VFD system shall be designed to produce no standing waves or over-voltage conditions based on a cable length. If cable length from VFD to motor exceeds 50meter or is more than recommended maximum permissible length, then output filter shall be provided. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system or external but as per specification certified by VFD manufacturer.

VFD manufacturer to also recommend the maximum permissible length of cable without an output filter.

VFD system shall be capable of producing full rated torque in the event of a power loss of 5cycles or less and continuous operations with a 30% voltage sag on the input power line.

Serviceability/Maintainability

VFD system should be designed for front access only.

VFD system shall be provided with the capability for remote diagnostics via modem communication /inbuilt communication port RS 485 with PLC/SCADA system at main control room.

VFD shall be suitable for monitor and control from PLC/SCADA.

Protections and Annunciations

Power Component Protection:

VFD system shall include distribution class surge arrestors to protect input transformer and VFD against voltage surges. These shall be integral with the drive panel cabinet.

Protective Features and Circuits (Main Protections): Over current, short circuit between phase, short circuit between phase and ground, impendent short circuit, input phase loss, output phase loss, motor overload, over voltage, under voltage, over speed, solid state thermal protection, IGBT over temperature, heat sink over temperature, phase reversal etc. and other internal faults.

Upon power-up VFD shall automatically test for valid operation of memory, option module, loss of analogue reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre charge circuit.

VFD shall have a selectable ride through function that will allow the logic to maintain control for minimum of one second without faulting.

The deceleration mode of VFD shall be programmable for normal and fault conditions. The stop modes shall include freewheel stop, fast stop, DC injection braking and as fast as possible.

Upon loss of the analogue process follower reference signal, VFD shall sense the fault and/or operate at a user defined speed or last speed.

VFD should be able to protect the motor when PTC probes are connected.

VFD shall have interlocking with forced cooling fan operation, where ever forced cooling is provided for the drive motor. VFD shall start only when forced cooling fan is running and VFD shall stop before forced cooling fan stopped/tripped.

VFD should be able to limit the motor terminal voltage to twice the DC bus voltage.

Following minimum controls shall be provided in VFD control panel.

- START
- STOP
- Fault Reset
- Auto and Manual Selection

- Manual Set Points.

The following minimum indications shall be displayed in VFD control panel.

- Ready to Start
- Running
- Motor Running On By-Pass
- Alarms
- Tripped
- Input Voltage and Frequency
- Input Power
- Output Voltage and Frequency
- Output Power and Output Current
- Control Supply ON
- Cooling Failure

Abnormal conditions shall initiate alarm and shut down drive based on the nature of the fault.

VFD shall display all faults in plain text and help screens shall be available to guide the user in the troubleshooting. Codes are not acceptable.

VFD shall be with programmable input terminal/probe for RTD (PT 100) for motor temperature (winding and Bearing) monitoring/control/protection.

Data Displays/Programming Terminal

A door mounted LCD display shall be furnished, capable of displaying the VFD operational status and drive parameters.

The Programming terminal of VFD shall be accessible for programming and control even if the main door is closed.

As minimum the following door mounted digital indications shall be available for viewing through 2/4 line or similar suitable in English language display: Speed Demand in %, Output Current in Amps., Output Frequency in Hz, Input Voltage, Output Voltage, Total 3 Phase kW Output, Kilowatt Hour Meter (Digital Energy Meter) and Elapsed Time Running Meter etc.

Use of shuttle button shall carry out the navigation in the menu and the parameter setting.

Parameter setting shall be easily accessible and user friendly with actual text messages and actual setting range.

The programming terminal shall offer the possibility of memorizing and downloading 4 configurations of VFD to save time during the commissioning and to avoid mistakes.

Preferably 4 programmable function keys shall be available for short cuts, application functions

VFD shall have self diagnostic properties to display faults and warnings as they occur. VFD shall be able to store at least 8 last faults into the fault memory including the value of 11 parameters of monitoring for each fault. The fault memory shall be accessible by the programming terminal.

Design Criteria and Operating Conditions

Rated Input Voltage	:	3 Phase, 380 V to 480 V, +10% / -15%
Rated Input Frequency	:	48 to 63 Hz
Fundamental Power Factor	:	0.97 or better at nominal load
Efficiency	:	≥ 98 % at nominal load
Output Voltage	:	0 - U _N , three phase
Output Frequency Range	:	0 to 500Hz or suitable as per manufacturers' standards
Degree of Protection	:	IP-20/21 as a minimum (stand alone without panel)

	:	enclosure)
	:	VFD Enclosure/Panel generally with IP 52 protection.
Operating Ambient Temp.	:	Maximum 50 °C with continuous current output.
Maximum Operating Altitude	:	1000 m without de-rating
Maximum Relative Humidity	:	95 % without condensation
Mounting	:	Within Enclosure/Panel (Vertical)
Maximum Corrosion Level of the Cooling Air	:	IEC 60721-3-3, class 3C1/as per site condition.
Chemical Gases	:	Coating shall be provided to comply with IEC 60721-3-3 Class 3C3/3C2 as specified above
Solid Particles	:	IEC 60721-3-3, Class 3S2
Maximum Vibration Level	:	According to IEC 60068-2-6
Shock Level	:	According to IEC/EN 60068-2-27
Noise/Sound Level	:	Maximum 80 dB-A at a distance of 3m at any Speed/Load condition
Harmonic Distortion	:	According to IEEE 519 – 2014 or latest revision
Short Time Overload Capacity	:	110% for 1 minute for Variable Torque Application 150% for 1 minute for Constant Torque Application
Speed Regulation	:	± 5.0 % without encoder or tachometer feedback
Efficiency	:	Minimum 96% at 100% Speed and 100% Load Minimum 95% at 80% Speed and 50% Load
Power Factor	:	Minimum 0.95 True PF lagging from 30% to 100% Speed
Control Supply	:	could be internal so provided by VFD itself, or provided by an external 24V DC supply

Safety

VFD shall integrate the “Power Removal” safety function which prohibits unintended equipment operation. The motor no longer produces torque.

Power removal function shall comply with the definition of the draft product standard IEC/EN 61800-5-2 for both stop functions, Safe Torque Off (“STO”) and Safe Stop 1 (“SS1”).

This safety function shall comply with standard for safety of machinery EN 954-1, Category 3 standard for functional safety IEC/EN 61508, SIL2 capability (safety control signaling applied to processes and systems).

VFD manufacturer shall provide certified schematics and list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.

The relay contacts shall comply with EN-81 13.2.2.3.

User Interface

VFD offered with possibility to extend/expand the number of inputs/outputs of VFD in future shall be preferred.

Two Analogue Inputs:

• For Voltage	:	0 to 10V, Programmable
• For Current	:	0 to 20mA Programmable
Potentiometer I/P	:	+ 10V, 10mA maximum
Analogue Output	:	2 x Programmable Analogue Outputs (0 – 20mA) (Programmable for Speed and Current)
Logic Inputs	:	4 x Programmable Logic Inputs, isolated from the mains (One of these inputs could be used for PTC/thermistor probe) All logic inputs may be used either in sink or source
Safety Input	:	One input from above shall be dedicated to the power removal safety function. In option, digital I/P may be used with 115V control supply
Relay Outputs	:	3 x Programmable digital O/P with a changeover dry contact

Following I/Os shall be provided/wired to PLC as a minimum.

Description	Type of I/O
Drive On/Off Status	DI
Drive Trip Status	DI
Selector Switch in Auto Mode Status	DI
Drive Start Command	DO
Drive Stop Command	DO
Speed Control Command	AO
% Speed Indication	AI
% Current Indication	AI

Communications

VFD shall have inbuilt communication port to communicate with PLC/SCADA system preferably over MODBUS. Alternately Profibus DP or Ethernet TCP/IP protocol or Device Net or FIPIO or other suitable protocol offered by VFD manufacturer suitable for communication with PLC/SCADA can be accepted subject to provision of same at PLC/SCADA side.

Communication card/protocol and cable as necessitated by PLC/SCADA shall be provided. All drive status monitoring and control shall be possible from PLC/SCADA over communication cable/port.

VFD shall be able to accept/control speed or torque command which may come from different control sources as follows.

- I/O Terminals
- Communication Network
- Programmable Card
- Remote Graphic Display Terminal

Advanced monitoring and diagnostic functions shall be available through the programming terminal like monitoring of following.

- The communication scanner
- Command words sent by the different sources
- Command words taken by the AC drive
- 4 words which addresses are selectable etc.

Application Programming

VFD shall have built-in application macros available in the Simply Start menu, to allow selection of the range of pre-programmed control configurations and further, VFD shall be able to store at least two customer modified macro configuration, to suit the specific application. It shall be possible to reset the parameter settings back to the original macro settings through the key pad. Parameter readouts shall be in the text format and not coded.

Notes:

1. Rest all constructional features and other requirements shall be as per the specifications of LV panel.
2. VFD starter features specified are in general and any manufacturer specific deviations in certain features can be reviewed and accepted based on merit/application requirement.
3. VFD starters meant for application for motors/any other driven equipment of ratings < 75 kW, the VFD starters can be housed in common enclosure of LV PCC/PMCC panels. The specifications and all other criteria as narrated in details above shall be applicable. However the cubicles for housing VFDs shall be liberally sized to take care of heat dissipation and ensure required degree of protection class. Further such

VFD housing cubicles shall be properly and totally segregated from other switchgears/instrument compartments of complete LV panel.

4. The VFD starters meant for application for motors/any other driven equipment of ratings ≥ 75 kW, the VFD starters shall have to be provided mandatorily as stand alone panels.

❖ INDUCTION MOTOR (LOW VOLTAGE)

Scope

This specification covers the design, manufacture, inspection, testing at works, supply, delivery to site, installation, testing at a site and commissioning of TEFC, squirrel cage, solid shaft induction motors with all accessories for driving various pumps/equipment working on three phase LV AC supply required for the complete operation of the plant as per the scope of this work.

All motors shall be as per these specifications unless for any other more stringent requirements mentioned elsewhere.

Codes and Standards

The design, material, construction, manufacture, inspection, testing and performance of induction motors shall comply with all currently applicable status, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also confirm to the IS: 12615 (2018)/IEC 60034 amended up to date.

General Design and Constructional Requirements

Motors shall be continuous maximum rated as per IS: 12615 (2018) and IS: 4722 (latest edition) and preferably be designed for low starting current and smooth acceleration except for cases where the driven equipment characteristic demand otherwise. Motors shall be of 4/6/8 pole design as required and provided with terminal box large enough to accommodate armoured PVC/XLPE insulated Aluminium conductor cable of required/specified size/ratings. Motors shall be of energy efficiency class IE3 as per IS: 12615 (2018) except submersible motors which shall be IE2 as per IS.

All motors shall be foot/flange mounted or as per pump/driven equipment coupling requirements and squirrel cage induction type and shall be capable of developing at least minimum 10% more power than demanded by the Pump/Submersible Pump or driven equipment over its duty point of operation.

The minimum power rating for motors to drive pump/submersible pump/driven equipment should be selected as per table below based on CPHEEO manual to meet the power demanded over its duty point of operation.

Required BKW of Pump/Submersible Pump/Driven Equipment	Minimum multiplying factor to arrive at motor rating
Below 7.5 kW	1.3
7.5 kW and above but below 15 kW	1.2
15 kW and above but below 75 kW	1.15
75 kW and above	1.10

Operating Conditions

1) Frequency and Voltage Variation

All LV motors shall be TEFC squirrel cage motor and the motor shall be suitable for the following.

Design Temperature	:	50 °C
Supply Voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage Variation	:	$\pm 10\%$
Frequency Variation	:	$\pm 5\%$

Combined Variation of Voltage and Frequency : $\pm 10\%$

2) Starting

- a) Unless otherwise specified, motors shall be designed for direct-on-line starting.
- b) Motors shall be designed for re-acceleration under full load after momentary loss of voltage with the residual voltage being 100% and is in phase opposition to the applied voltage.
- c) Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. The starting time of motor shall be less than the hot thermal withstand time to permit application of conventional bimetal relays or thermal release against locked rotor and overload conditions.
- d) The motors shall be suitable for starting under specified load conditions with 75% of rated voltage at the motor terminals.

3) Direction of Rotation

Motors shall be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. When a motor is provided with bi-directional fans, a double headed arrow should be provided.

Normally clockwise rotation is desired as observed from driving (coupling) end. Ample space shall be provided in terminal box for interchanging any two external leads for obtaining reverse phase sequence.

Performance

Motors shall be rated for continuous duty S1 unless otherwise specified. For hoist/crane it shall be S4 duty.

All performance characteristics shall be as per IS: 12615 (2018) or latest revision and the torque and other specific requirement shall be selected by the concerned equipment vendor to suit the application.

Construction Details

Motor Casing and Type of Enclosure

Motors for use in safe area shall be of industrial type meeting the specified ambient conditions, starting and operating requirements. Motors for use in hazardous areas shall have type of protection Ex-d or other as per area classification and to meet requirement of applicable Indian Standards.

The motor enclosure including terminal boxes and bearing housing shall have IP 55 degree of protection.

Motor casing shall be provided with a suitable drain for removal of condensed moisture for motors operating in safe area.

All vertical motors shall be provided with suitable canopies covering the motors fully.

Motors designed to handle external thrust from the driven equipment shall be supplied with a thrust bearing at the NDE.

Motors shall have standard frame sizes for various output ratings as per relevant IS.

Motors installed in outdoor areas shall be provided with FRP type canopies/covers of 2mm thick.

All external surfaces of the motor and its canopy shall be given coat of epoxy based paint shade 632 as per IS.

Insulation and bracing

Unless otherwise specified, motors shall be provided with class F insulation with the permissible temperature rise above the specified ambient temperature shall be limited to that of class class B. **VFD operated motor shall be with Class H insulation ONLY with temperature rise limited to Class F.**

The winding shall be tropicalized. The windings shall preferably be vacuum impregnated. Alternately the windings shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmosphere.

Windings shall be adequately braced to prevent any relative movement during operation.

Overhung of winding shall be double coated with epoxy gel.

However, motors operating with Variable Frequency Drive shall have winding and other features as follows.

- Winding shall be double insulated, vacuum impregnated.
- Winding shall have class H insulation with temperature rise limited to Class F.
- Motors shall have adequate and suitable cooling arrangement and frame size shall be suitably selected for effective heat dissipation unless otherwise specified in SOQ.
- Motors shall be suitable to continuously operate within 30% to 100% speed range variation.

Phase Connections and Terminal Box

The windings shall be connected in Delta. The ends of the windings shall be brought out into a terminal box. All motors shall be with six terminals and suitable links to connect them in star or in delta. Motors rated up to and including 2.2kW which may be accepted with three terminals. The terminal box shall be located on the RHS as viewed from driving (coupling) end (for motors above 3.7kW). The terminal box shall be rotatable in steps of 90 degree to allow cable entry from any direction. Adequately sized earth terminal shall be provided in the motor terminal box. Terminal box shall be provided at the side of the motor.

Bearing and Lubrication

Motors shall have grease lubricated ball or roller bearings with minimum L 10 rating life of 5 years (40,000 hours) at rated operating condition.

Bearings shall be capable of grease injection from outside without removal of covers with motors in running condition.

Necessary seal to prevent entry of dust/moisture and loss of grease shall be provided. Grease nipples shall be provided with appropriately located relief devices which ensure passage of grease through the bearings.

VFD operated motor shall be considered with insulated bearings for motor rating 90kW and above (not applicable for package product like turbo blower etc.).

Cooling System

All motors shall be self-ventilated, fan cooled. VFD operated motors shall be VFD duty and shall be fully compliant to VFD drive conditions.

Rotor

The motor shall be squirrel cage type, dynamically balanced to provide a low vibration level and long service life of the bearings.

Shaft Extension

Motors shall be provided with a single shaft extension with key-way and full key. Motor shaft shall be sized to withstand 10 times the rated design torque.

Lifting Hook

All motors weighing more than 30kg shall be provided with lifting hook of adequate capacity.

Earth Terminals

Two earth terminals of adequate size, located preferably on diametrically opposite sides shall be provided for each motor. Necessary nuts and spring washers shall be provided for earth connection.

Accessories

- Anti condensation heaters of 240V, single phase, shall be provided for motors rated 30kW and above. Heaters shall remain ON when the motor is not in service and as such shall not cause damage to the windings. Heaters shall be metal encased with a low surface temperature.

- RTD/BTD: 2 number per phase RTD and 2 numbers BTD for bearings both drive and non driven ends shall be provided for motors rated 90kW and above, suitably terminated in auxiliary terminal box. Separate terminal box shall be considered for space heater and RTD/BTD.
- Name plates shall be provided on each motor as per IEC/IS.
- Noise level and motor vibrations shall be within the limits as laid down in IS.
- **Special application motor for higher pump RPM than motor:** For special applications like high pressure RO pumps etc. where in the pump RPM selected are more than motor RPM, such motors shall be driven by VFD only to achieve higher motor RPM as per pump RPM and the de-rated motor torque at such higher RPM shall be more than pump torque requirement with minimum 10% safety margin or higher as recommended by pump manufacturer/vendor. The motor for such application shall be de-rated and offered with required higher frame size/rating as recommended by motor manufacturer/vendor and shall be suitable for VFD duty requirements specified.

Notes:

The motor and make of motor as per manufacturers' standards shall be acceptable for following

- The TEFC squirrel cage induction type drive (motor) for imported equipment coming as part of equipment from foreign country. However same shall be generally meeting IE3 efficiency class requirements.
- DC motors (e.g. Turbo Blowers etc.)
- Motor for special applications viz. Braking applications like mechanical screens, EOT Crane Hoist/Electric Hoist, Electric Actuators, SBR Decanter etc.

Motor Testing

Testing of motors shall comply with the requirements of IS: 4029/IS: 15999.

Motor shall be subjected to all routine tests as per IS: 12615 (2018)/IS: 15999 applicable standard with latest amendments, shall be carried on the motors in OEM factory, in witness of Client/PMC/TPI agency.

All type tests certificates shall be furnished during factory test. Generated values of efficiency and power factors at full load, ½ load and ¾ load shall be furnished by the Bidder.

Testing and inspection plan, methodology and applicability for various ratings of motors is specified in details in the Inspection & Testing Chapter provided in this specifications.

Drawings

The contractor shall submit the following documents of motors obtained from motor manufacturer /vendor for review and approval.

- GAD and Preliminary outline dimensional drawings showing details of motor, terminal box etc.
- Typical cross sectional drawing showing constructional details with complete bill of materials and relevant standards.
- QAP, Performance Curves, Marking and labeling plate details.
- Data Sheets/Guaranteed Technical Parameters.

❖ CABLES

All power and control cables for use on low/medium/high voltage shall be heavy duty type, multi strand Aluminum/Copper conductor, PVC/XLPE insulated, extruded inner sheathed, armoured and overall PVC sheathed as described below.

The medium voltage power and control cables have following minimum overall cross sectional areas.

- | | | | |
|----|-----------------|---|--|
| a. | Power Cables | : | 6 sq mm and above (Aluminium)/Up to 4.0 sq mm (Copper) |
| b. | Control Cables | : | Up to 2.5 sq mm (Copper) |
| c. | Lighting Cables | : | Up to 2.5 sq mm (Copper)/6 sq mm and above Aluminium |

Cables shall be sized based on maximum continuous load current and permissible voltage drop. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other etc. as per applicable standards have be taken into account.

Below ground cables in paved areas shall be in concrete lined trenches with pre-cast concrete covers having proper slope and suitable drainage arrangement to avoid water collection. In unpaved areas cables shall be in lined trenches or directly buried in the ground.

In hazardous areas and transformer bays, trenches shall be completely filled up with sand.

Concrete lined cable trenches shall be sealed against ingress of liquids or gases wherever the trenches are in hazardous area or enter into control room or substation area.

Cable trenches shall be sized depending upon the number and voltage grade of cables to be lined. Where underground cables cross roadways, pipe sleepers at grade etc., they shall be protected by being drawn through PVC sleeves/ducts or suitable RCC Pipes/DWC to provide permanent crossing. Pipes laid shall be sealed at both ends for mechanical protection.

High voltage, medium voltage power, control and signal cables shall be separated from one another/each other by adequate spacing or running through independent pipes, trenches or cable trays as applicable. Cable trays, racks and trenches shall be sized to allow for laying 20% cables in future. Cable installation shall provide minimum cable bending radii as recommended by cable manufacturers’.

Cable route markers shall be installed at every 30meter interval all along the routes of directly buried cable trench and also at locations where the direction of cable trench changes.

All power and control cables shall be of continuous length without intermediate joints. Where joints are unavoidable, these shall be provided with the permission of Engineer-in-charge. All cables shall carry tag numbers for easy identification. In case of control cables all cores shall be identified at both sides by their terminal numbers using PVC ferrules as per interconnection diagrams.

Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every meter. The embossing/engraving shall be legible and indelible.

Control cables having 6 cores and above shall be identified with prominent and indelible Arabic numerals on the outer surface of the insulation. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50mm between two consecutive numbers. Colour coding for cables up to 5 cores shall be as per IS.

A HV XLPE CABLES

Scope

The scope shall cover supplying, laying, testing and commissioning of 3 core cables of circular stranded Aluminium conductors, XLPE extruded dielectric, copper tape screened, armoured, extruded semi conducting compound inner-sheathed and PVC overall sheathed conforming to IS: 7098 Part 2 with latest amendments.

The cables shall be armoured with galvanized steel strip/wire armour.

Cables shall be capable of operating at sustained conductor temperature of 90 °C and suitable for maximum conductor short circuits temperature of 250 °C.

Operating Conditions

Electric system

- System Voltage : 11kV
- Frequency : 50Hz

Environment

- Ground Temperature : 35 °C
- Ambient Air Temperature : 50 °C
- Atmospheric Conditions : Humid and Dusty

Construction

11kV grade stranded compact circular Aluminium conductor, conductor screen with extruded semi conducting compound, cross linked polyethylene (XLPE) insulated, insulation screening with extruded semi conducting compound in combination with copper tape, GI flat/round wire armoured, PVC outer sheathed HV cable as per IS: 7098 Part 2 with latest amendment.

Cable Marking

Embossing on outer sheath shall be as follows.

The PVC outer sheath shall be legibly embossed/printed with the legend "ELECTRIC CABLE 11000 VOLT", cable size, IS number, identification of manufacturer and year of manufacture, sequential length marking etc. shall be supplied in non returnable drums as per IS: 10418 standard. Cable identification details as above shall be written on drums also as per IS.

Testing

Manufacturer shall carry out routine tests and acceptance tests in accordance with the relevant IS/IEC standards. Routine/acceptance tests reports shall be furnished before dispatch of cables/supply of cables at site. The copies of Type test results shall be submitted along with each drum length.

B LV Power and Control Cables

The scope shall cover supply, laying, testing and commissioning of low and medium voltage XLPE cables.

All cables shall carry tag numbers for easy identification. In case of control cables all cores shall be identified at both sides by their terminal numbers using PVC ferrules as per interconnection diagrams.

XLPE Insulated Power/Control Cables (Medium Voltage)

1.1kV grade stranded Aluminium/Copper conductor, XLPE insulated, extruded inner sheath, GI strip/ wire armoured (Aluminium armoured for single core cable) LV XLPE cable as per IS: 7098 Part 1 with latest amendment.

RTD/BTD/Signal Cables

Contractor/Vendor is responsible for sizing of all cables considering factors like maximum distance between panel/control room and the units/motors.

Specifications for cables for RTD/BTD/Analog signals shall be as follows.

Cables shall be of 660V/1100V grade, single/multi-pair/triad/core cables as per requirement. Triad/multi core signal cables shall be annealed, tinned, high conductivity 0.5/1.0/1.5 sq mm stranded Copper conductor, polyester tapped PVC insulated number of cores twisted into pair, laid up collectively, individual pair/triad shielded and overall shielded with aluminum mylar tape, armoured with galvanized steel wire/strip, overall sheathed with PVC conforming to IS: 1554 and IEC 189 Part II.

Splicing and Termination

Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and circular junction boxes. They shall be made only with approved polycarbonate type connectors. No joints shall be allowed within the conduit pipes, cable entry pipes or ducts for cable laying and wire pulling.

Testing

Cables shall be tested in accordance with IS: 7098.

Finished Cable Tests at Manufacturers' Works

The finished cables shall be tested at manufacturers' works. Following routine tests for each and every length of cable and copy of test results shall be furnished for each length of cable along with supply. If specified, the cables shall be tested in presence of Client/PMC/TPI.

1. Voltage Test

Each core of cable shall be tested at room temperature at 3kV AC RMS for duration of 5 minutes.

2. Conductor Resistance Test

The DC resistance of each conductor shall be measured at room temperature and the results shall be corrected to 20 °C to check the compliance with the values specified in IS: 8130 (1976).

Testing and inspection plan, methodology and applicability for various types, sizes and ampere ratings of cables is specified in details in the Inspection & Testing Chapter provided in this specifications.

Cable Test before and after laying of cables at site.

1. Insulation resistance test between phases, phase to neutral and phase to earth.
2. Continuity test of all the phases, neutral and earth continuity conductor.
3. Sheathing continuity test.
4. Earth resistance test of all the phases and neutral.

Sealing and Drumming

Cable shall be supplied in non returnable drums as per IS: 10418 standard. Cable identification details like voltage, size, name etc. shall be written on drums also as per IS.

C Cable Accessories

All accessories like cable glands, lugs and terminal markings etc. shall be used conforming to relevant standards/as specified.

The end termination for HV cables shall be heat shrinkable type.

For 1100V grade cables, Ni-Plated Brass Double Compression type glands weather protection of IP 65 as minimum.

Crimping type lugs of Copper/Aluminium (as applicable) of required sizes shall be used.

D Cable Laying

HV power, MV power and control cables shall be separated from one another/each other by adequate spacing or by running through independent pipes, trenches or cable trays. Cable laying and termination shall be such that chances of cable getting damaged are eliminated.

LV cable shall be laid in cable tunnel or tray racks or buried underground with appropriate protection. Black shall indicate the neutral, while red, yellow and blue for three different phases. All LV cables when laid on the cable racks shall be properly dressed and clamped as required without criss crossing and unnecessary overlapping. Cables shall be properly dressed and clamped.

Laying of HV and LV underground cables

Minimum depth of cable trench shall be 750mm for LV cables and 900mm for HV cables from finished ground level (FFL/FGL). Before placing of cables in the excavated trench, bottom shall be cleared from all rocks, stones and sharp objects. The cables shall be protected by filling bottom of the trench with a layer of sand. This sand layer shall be leveled prior to laying of cables over it. Such laid cables shall be covered with 150mm of sand on

top of the largest diameter cable and sand shall be lightly compacted. A flat protective cover of 75mm thick second class red bricks shall then be laid properly in alignment followed by backfilling of the remaining portion of trench with soil, duly rammed and leveled.

While routing, necessary barriers and spacing shall be maintained for cables of different voltages in case they are laid side by side (in adjacency).

Telephone/Telecommunication cables shall cross the power cables only at about right angles and these two shall not run in close proximity.

LV cables shall be bent in radius not less than 12 times their individual overall diameters, while HV cable shall have bends not less than 15 times their individual overall diameters.

Cable routing between cable trench and equipment/motors shall preferably be taken through GI/DWC pipe sleeves of adequate size. Pipe sleeves shall be laid at angle of maximum 45 degree to the trench wall. Bending radii of pipes shall not be less than 8 times their individual overall diameters.

It shall be ensured that both ends of the pipe sleeves are sealed with approved WP sealing compound after cabling. In places where it is not possible, cables shall be laid on smaller branch trays.

All cable shall be identified close to their termination point by cable tag numbers as per cable schedule. Cable tags shall be punched on aluminium straps (2mm thick, 20mm wide of sufficient length) securely fastened to the cable and wrapped around it.

Routes of these cables shall be arrived at on the basis of relevant drawings and with due consultation with the Engineer-in-charge.

E Drawings and Schedules

Size of cables shall be given in single line power diagrams. Cable schedule shall be prepared on the basis of relevant drawings. All cables and wires shall be adequately sized to carry continuously the normal currents expected on the relative circuits. All trenches for electrical cables shall be separate from water or sewage pipe line trenches.

F Splicing and Termination

Straight through joints shall be avoided. In case, these are absolutely necessary they shall be made at convenient locations suitably protected as approved and sanctioned by the Engineer-in-charge but in no case within the conduit pipes or ducts.

Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and circular junction boxes. They shall be made only with approved porcelain connectors.

❖ CABLE ACCESSORIES AND MISCELLANEOUS ITEMS

This defines specifications and requirements mainly for miscellaneous items and accessories, which are generally supplied by the erection contractor/agency.

All materials, accessories and consumables to be supplied by the contractor shall be selected from the list of specified makes and shall conform to the specifications given here under.

The accessories shall be manufactured in accordance with prevailing latest IS specifications wherever they exist or with the BS or NEC specifications, if no such IS standards are available. In the absence of any specification, the materials shall be as approved by the Client/PMC/TPI.

All similar materials and removable parts shall be uniform and interchangeable with one another. Makes of bought out items selected by the contractor must be from the approved vendor list of tender.

Cable Trays

These shall be channel type, fabricated from structural steel, hot dip galvanised complete with all accessories such as bends, tees and reducers.

MS/Aluminium flat clamps with GI/Chrome plated bolts, nuts/screws to be used for clamping cables.

Sizes of these trays shall be as specified in bill of quantities/drawings approved by Client/PMC/TPI.

Size 150mm and above shall be ladder type and below 150 mm shall be perforated type. Collar size of the ladder type cable tray shall be 100 mm and 50 mm for perforated type.

Alternatively **FRP cable trays** manufactured as per applicable/relevant standards of required thicknesss and sizes are also acceptable with prior approval by the Client/PMC/TPI

Cable Glands

Cable glands shall be heavy duty double compression type of Ni-Plated brass. These shall be suitable for armoured/unarmoured cables, which are being used.

Cable Connectors

Cable connectors, lugs/sockets, shall be of Copper/Aluminium alloy, suitably tinned, solder less, crimping type.

These shall be suitable for the cable being connected and type of function (such as power, control or connection to instruments etc.).

Cable Indicators

All cables shall be identified by cable tag of 2mm thick, 15mm wide of enough length of Aluminium straps securely fastened to the cable. PVC identification number, ferrules shall be used for each wire.

Conduits for Cables

For laying of cables under floor, medium duty GI/UPVC/DWC/RCC pipes shall be used.

Pipe shall be laid at on angle of maximum 45 degree to trench wall. Both ends of pipe shall be sealed with approved water proof sealing compound after cabling work.

Size of pipe shall depend upon the overall outer diameter of cable to be drawn through pipe.

To determine the size of pipe, minimum 40% area of selected pipe shall be free after drawing of cable.

❖ LOCAL PUSH BUTTON STATIONS

Each motor shall be provided with a local control station in the vicinity (area) of the motor.

Construction Features

Push button and related control switches shall be as per IS: 6875.

The local push button station/local control station (LCS) shall have Polycarbonate/FRP/die cast Aluminium enclosure or as specified in BOQ of IP 65 with gland plate with knock out holes suitable for outdoor application.

All control stations shall be suitable for 10A continuous current rating 240V AC as well as 110 V/220 V DC control supply.

All push buttons shall be fitted with 2 NO + 2 NC rated to carry and break 6A at 415V (10A at 240V AC).

The open/close/start push buttons shall be of the momentary contact push to actuate type and shall be green in colour.

The stop push buttons shall be stay put type with mushroom knob and lockable in pressed position and shall be red in colour.

All ammeters shall be of moving iron type having an accuracy class of 1.0 and suitable for 1A CT secondary. The size of ammeter shall be 72mm x 72mm or minimum 65mm dia. The ammeter front glass shall be toughened/transparent Acrylic.

20% spare or minimum 2 number spare terminals shall be considered.

Type of Push Button Stations

Type of LCS	Application	Features Required
Type A	Motor without VFD	Start and Stop PB
Type B	Motor with VFD	Start, Stop, Speed Increment and Speed Decrement. Ammeter if specified in BOQ/Scope of work for motor rated above 30kW
Type C	Motor above 30kW	Start, Stop PB, Ammeter if specified in BOQ/Scope of work
Type D	MOV	Open, Close and Stop PB
Type E	Reversible Motor	Forward, Reverse and Stop PB

❖ JUNCTION BOX

Construction Features

Junction box shall be with sheet steel enclosure of minimum 2mm thick (14 SWG) and shall be with canopy of 2mm for outdoor application. The enclosures shall be painted with two coats of epoxy paint with final colour shade (both internal and external) of Siemens grey shade RAL 7035 with minimum paint thickness 100 micron.

Separate junction box shall be provided for power and control cable termination.

The boxes shall have Aluminium bus bars supported on insulators suitable for termination of power cables and terminal connectors of required size for termination of control cables.

The bus bar connections shall be suitable for terminations of submersible pump motor flat cable/PVC/XLPE Copper cables and armoured cable from PMCC/MCC as per requirement.

Double compression gland and Aluminium/Copper lugs shall be used for termination.

Minimum 20% or minimum 2 number (whichever is higher) of spare terminals shall be supplied in junction boxes for each size of terminals.

JB shall be wall/stand mounting with zinc passivated bolts and nuts and earth terminals as per IS and name plate as required.

Junction box shall be mounted on required steel structure.

❖ INTERNAL AND EXTERNAL ILLUMINATION SYSTEM

General

The illumination system shall consist of lighting poles, lighting distribution boards, lighting panels/power panels complete with FSU/ELCB/MCB, fixtures, cables, junction boxes, terminal blocks, cable glands, 3 pin 5 A/15 A convenience socket outlets, conduits and accessories and supporting and anchoring materials, lighting fixtures with LED lamps/tubes, sodim vapour lamps, wires etc. All materials, fittings and appliances use in electrical installation shall conform to the relevant IS specifications, required area classification and environmental conditions and shall be anticorrosive painted/FRP enclosures.

The wiring for lighting circuits shall be done by wires run in PVC conduits for indoor areas. For outdoor lighting, wiring shall be done by armoured cables. **Mains circuit pipe & wiring of all building shall be run separately.**

Illumination Level

The following minimum levels of illumination (average lux level) shall be provided in the respective areas.

Sr. No.	Area/Building	Illumination Level
1	Pump House/Centrifuge or Press Area/Sheds/Blower Room	150 Lux
2	Control Room/Laboratory	300 Lux
3	Office	200 Lux
4	Switchgear/MCC Rooms	200 Lux
5	Sub Station (Switchyard)	50 Lux
6	Toilet Block/Wash Room etc.	100 Lux
7	Roads/Walkways	10 Lux
8	Yard/Outdoor Area	10 Lux
9	General Process/Outdoor Equipment Area	100 Lux

The lighting fixtures offered shall comply with the following requirements.

- a) Luminaries shall have high efficiency Lumen Output/Watts.
- b) Enclosures shall preferably be FRP/Cast Aluminium with corrosion resistance paints.
- c) All indoor and outdoor lighting fixtures shall be power saving long life LED type only.

All lighting fixtures shall be supplied complete with control gear and lamps. Special fixtures, wherever required to meet operational requirements, aesthetics etc. shall also be provided by the Bidder. Make of lighting fixture shall be embossed on each lighting fixture.

Lighting wiring for indoor applications between LDB to SB shall be done by FRLS PVC insulated, 3/4Core x 4/2.5 sq mm, 660/1100V grade, Copper conductor flexible wire (phase, neutral and earth).

Lighting wiring for indoor applications between SB to lighting fixtures shall be done by FRLS PVC insulated, 3/4Core x 1.5/2.5 sq mm, 660/1100V grade, Copper conductor flexible wire (phase, neutral and earth).

Wiring in the all plant buildings / structures shall run through concealed conduit only. Surface conduit are strictly not permitted.

All lighting cables for outdoor application shall be armoured type only.

Conduit wiring shall be done in 25mm dia. minimum 16 gauge black enameled steel structure conduit or PVC concealed conduit with 1100V grade PVC insulated copper wire of minimum size 1.5/2.5 sqmm for fixtures/5A receptacles and 4sq mm for power sockets. Not more than 7 wires shall be accommodated in each conduit. All lighting fittings/convenience outlets shall be earthed through the third wire/separate core in conduit/cable.

All lighting fixtures shall be supplied complete with control gear and lamps. Special fixtures, wherever required to meet operational requirements, aesthetics etc. shall also be provided by the Bidder. Make of lighting fixture shall be embossed on each lighting fixture.

On walkway, platforms and other outdoor areas, lighting fixtures shall be nearer to landing of stairs or ladders, gauges, flow meters, panel boards or other equipment requiring good illumination.

In outdoor equipment area at ground level, lighting fixtures shall be mounted preferably 4 meter above floor level. Where this is impractical, the minimum height of any lighting fixture shall not be less than 2.5meter. Socket outlets in process plant areas shall be approximately 1200mm above floor level and 300mm above floor level in office area.

Lighting/power panels shall be mounted such that the top of the panel ie 1800mm above finished grade. Control gears of lighting fixtures with separate control gear shall be mounted at suitable height from ground/platform for easy access/maintenance.

All lighting circuits and convenience receptacles shall be fed from lighting/power panels. Main/Lighting Distribution Board (MDB/LDB) shall be dust and vermin proof and shall be provided with SFUs (HRC)/MCCB as incomer and outgoing feeders where fault level is more than 9kA.

Main and Branch Distribution Boards

Each main DB should be provided with 4 pole isolator as incomer and DP ELCB+MCB as outgoing circuit in each phase and all sub DBs should be with Isolator + ELCB as in comer and MCB as outgoing to control and for protection of lighting circuits.

All DBs should be double door type. Hinged door to cover the operations knobs shall be provided. MCBs shall not be loaded beyond 80% of rated capacity. Minimum of 20% MCB in each panel shall be kept as spare. Power and lighting panel shall be of 16 gauge sheet steel construction and shall be suitable for surface or flush mounting.

All outdoor lighting shall be automatically controlled by means of synchronous timers with manual override control. Normally about 8-10 fixtures shall be wired in each circuit. Lighting feeders requiring automatic control shall be provided with contactors of suitable rating.

Sufficient number of three pin type 5A/15A receptacles as per IS: 1293 shall be provided. Flush mounting type receptacle shall be used where concealed wiring has been adopted and surface type shall be used for other areas. For exhaust fans and wall mounted air cirucaltors, socket and switch enclosure shall be separate whereas for rest receptacle and controlling on/off switch shall be mounted in the same enclosure.

In building such as sub station, DG shed, workshop, maintenance shop etc. industrial type metal clad socket outlets and plugs shall be provided. The sockets shall be supplied complete with plugs.

Adequate number of ceiling fans of 1200mm sweep (with double ball bearing and regulator) shall be provided in offices and rooms allocated to operating and maintenance personnel etc. In places where ceiling fans are provided, lighting fixtures shall be suspended below fan level with the help of conduits/chains to avoid shadows on the floor.

Minimum 2 number or sufficient exhaust fans as required during detailed engineering/ recommended by equipment manufacturer shall be provided at battery room, laboratory room, sub station/switchgear-MCC room, DG room, all pump houses, filter house etc.

The exhaust fans shall be provided with louvers/net to prevent insects. For pump house below ground level, suitable GI ducts for exhaust shall be provided as decided during detailed engineering and instructed by Engineer-in-charge.

Lux levels shall be maintained at various locations as indicated above and shall be backed up by calculations from manufacturer.

Switch Box

Switch Box shall be made of metal on all sides, except on the front.

In the case of cast boxes, wall thickness shall be at least 3mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, up to a size of 20cm x 30cm and above this MS boxes

having minimum sheet thickness of 1.6mm shall be used. Switch boxes shall be galvanized after fabrication. Except where otherwise stated 3mm thick phenolic laminated sheets like summica shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern. All fittings shall be flush pattern. It shall be provided with adequate number of knock outs on all sides for ease of wiring either with conduits or without conduits.

Modular type switch boxes are also acceptable.

Wiring/Conduit System

Surface Conduit Wiring System

PVC conduit pipes of approved minimum 1.6mm wall thickness shall be used. The minimum PVC conduit diameter shall not be less than 25mm. Maximum number of wires permissible in a conduit shall be seven/nine for wire size of 2.5sq mm/1.5sq mm respectively.

In long distance straight run of conduit, inspection type junction box at reasonable intervals shall be provided.

Fixing of Conduit

Conduit pipes shall be fixed by heavy duty GI pressure saddle with screws in an approved manner at an interval of not more than one metre but on either side of the couplers bends, or similar fittings, saddles shall be fixed at a distance of 30cm from the centre of such fittings. The saddle should not be less than 20 gauge for conduits.

Where conduit pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or girder lips as required by the Engineer-in-charge. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girders clips and clamps shall not be less than as stated below.

Recessed Conduit Wiring System

Recessed PVC conduit wiring system shall comply with all the requirements of surface conduit wiring system specified in clauses above and in addition to the requirements specified in the following clauses.

The chase in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, fixed work, special care shall be taken to fix the conduit and accessories in position along within the building work, to avoid damage to the finished wall etc.

All outlets such as switches, wall sockets etc. shall be flush type.

The outlet box shall be same as above and shall be mounted flush with the wall. The metal box shall be efficiently earthed with conduit by an approved means of each attachment.

To facilitate drawings of wire in the conduit. GI mesh wire of 10 SWG shall be provided while laying of recessed conduit.

Lighting Poles

Steel Octagonal Type

Steel octagonal pole with base plate made from CR sheet steel. The pole should be made as per IS and shall be coated with hot dip galvanizing as per IS: 2629/4759 with required base plate and suitable to sustain local wind speed.

Lighting poles shall be of octagonal poles made from sheet steel conforming to BSEN 10025. Internal and external surface of octagonal pole shall be hot dip galvanized to minimum 65 micron DFT. Octagonal poles shall be provided with base plate and provision for fixing foundation bolts. Base plate shall be as per IS: 2062. All poles are tapered octagonal and shall be in single section.

The street light poles shall have minimum 7meter height, Top dia. – 70mm, Bottom dia. – 135mm and 3mm thickness sheet with bracket for mounting the light fittings and all required accessories. Base plate of minimum dimension 225mm x 225mm x 16mm.

The Flood light poles shall have minimum 9meter height, Top dia. – 70mm, Bottom dia. – 155mm and 3mm thickness sheet with bracket for mounting the light fittings and all required accessories. Base plate of minimum dimension 260mm x 260mm x 16mm.

All poles shall be supplied along with pipe cap, single/double arm of 1m/0.5m height and over hung 1m/1.5m long GI pipe having dia. to suit the socket of 250/150/70W etc. 240V, HPSV/LED/MH/HPMV lighting fixture as applicable and with following.

1. PVC junction boxes on pole with 8 way connector and 1 no. 4A SP MCB.
2. Street light pole shall be as per approved drawings.
3. Internal pole wiring with 3 core 1.5/2.5sq mm flexible stranded copper conductor, FRLS insulated wire from junction box to up to Street light/Flood light/fixture as required.

Balancing of Circuits

The balancing of circuits in three phase installations shall be arranged before hand to the satisfaction of Engineer in charge.

Drawings

All wiring diagrams shall indicate clearly in plan, the main switch board, the distribution fuse board, the run of various mains and sub mains and the position of all points with their classification.

Rating of Lamp, Fans, Socket Outlet Points, Exhaust Fans, Pedastal Fans

Lamps installed in pump house and other means shall be LED Type only.

Pedastal Fans, Table fans and ceiling fans shall be rated at 60 watts. Exhaust fans shall be rated according to their capacity.

Industrail Pedastal Fans must be provide for Every Panel cooling.

5A socket outlet points and 15A socket outlet points shall be rated at 100watts and 1000watts respectively, unless the actual values of load are known or specified.

Capacity of Circuits

Lights and fans may be wired on a common circuits, such circuit shall not have more than a total of ten points of light, fan and socket outlet or a load or 800watts whichever is less.

Power circuits on buildings shall be designed with a maximum of two outlets per circuit, based on the loading.

Where, not specified the load shall be taken as 1kW per outlet. Wherever the load to be fed is more than 1kW it shall be controlled by an isolator switch or miniature circuit breaker.

Indoor and Outdoor Light Fixtures/Lightings (LED LIGHTING)

LED fixtures shall be generally having following.

- | | | |
|-------------------------------------|---|---|
| • LED luminous Efficacy lumens/watt | : | 100% minimum |
| • Efficiency of Electronics System | : | 80% - 85% minimum |
| • LED Lamp/Light Efficiency | : | 85% - 90% minimum |
| • Total Harmonic Distortion | : | For Outdoor Fittings: $\leq 20\%$
For Indoor Fittings: $\leq 20\%$ |

- Power Factor : ≥ 0.85
- Colour Rendering Index (CRI) : ≥ 70
- Colour Temperature/Apparent : $\geq 5700\text{K}$ (Cool day light)
- Radiation : No Ultra-Violet (UV) or Infra-Red (IR) No RF to interfere with radio equipment
- LED Life : Long Life, generally 50,000 Hrs.
- RoHS compliant, Eco Friendly green technology, Mercury free.
- Outdoor LED fixtures must be fully enclosed with minimum IP Rating of IP 66/65 (Weatherproof). LED optical system must be gasketed (enclosed) to minimize light dirt depreciation.
- Electrical safety for outdoor LED Lights shall be of class I.
- Luminaries must be clearly marked with manufacturer name, model number, electrical rating and agency approval (If applicable - CSA, UL etc.).

Industrial Luminaire

Indoor LED wall mounting Industrial Luminaire shall be LED type minimum 10W to 48W.

Each fitting shall be required LM 79 and LM 80 Certificates.

Tube light shall be 20W or higher wattage with integral/non integral driver, surge 4kV, IP 20, 4 feet with LEDs of wattage 0.2W to 0.5W assembled on single MCPCB with housing used as a heat sink shall be made of thick sheet steel conforming to IS: 513/CRCA polyester powder coated and high UV and corrosion resistance with diffuser and/or Polycarbonate optics with company mark/name.

120 to 300V, Power Factor more than 0.9, THD < 20%

CCT 4000 K to 6500K, Uniformity Ratio > 0.7,

Luminaire Efficacy > 85 lumens/watt ,

LED Driver Efficiency > 85 %

Fixtures shall be with earthing arrangement facility suitable for ceiling or pendant mounting suitable for 19mm conduit with stove enameled reflector gray outside and white inside which can be installed without aid of any tools, complete in all respects and ready for use.

Emergency Light

Emergency light unit working on 230V AC supply shall be self containing LED type of minimum with 20W & 600mm long type 'SWITCH ON MAIN FAILURE. It shall be electronic automatic type which incorporates a unit trickle charge circuit, which shall prevent over charging or battery The battery shall be maintenance free. The unit shall provide 4 hours illumination following power failure. The units shall generally conform to IS: 9583.

Gate Lights

The gate lights shall be post top lantern LED type, weather proof and shall be suitable for use with one number 40W LED and aesthetics appearance shall be as approved by Client/PMC/TPI.

Min. 4nos. Post Top Lantern LED fitting comprises of Copper dust finish die cast aluminum spigot and spun aluminum canopy fixed with opal polycarbonate, pipe arrangement for vertical mounting, open construction driver and accessories wired upto terminal block.

The post top lantern shall be suitable for use with one number 40W LED.

GI pipes of suitable dia. shall be provided at gate concrete pillar as conduit for wiring and fixing post top lantern luminaire.

Outdoor Yard/Road Lighting

Outdoor Luminaire

The luminaire shall be LED type with minimum 40W to 240W LED complete with all accessories and each street light/flood light industrial luminaire shall be IP 65 and Surge 4kV and shall be required LM 79 and LM 80 certificates.

External LED flood light fixture shall be of min.100W.

LED outdoor street light/flood light/well glass industrial luminaire shall be with high power white LEDs wattage of 1 watt and above assembled on single MCPCB, efficiency more than 130 lm/w and corrosion free high pressure die cast aluminum housing with smooth finish powder coated and heat sink extruded aluminium with diffuser and Polycarbonate optics/lenses with company mark/name engraved or embossed.

120 to 300V,
Power Factor more than 0.95,
THD < 20%,
CCT 5000 K to 5700 K,
Uniformity Ratio > 0.45,
Luminaire Efficacy > 85 lumens/watt,
LED Driver Efficiency > 85 %.

The required parameters of LED fixtures have been enumerated above.

❖ EARTHING SYSTEM

Earthing system design and installation shall generally be as per IS: 3043. All metallic non current carrying parts of electrical apparatus, current and potential transformer secondaries, columns, vessels, towers, stacks, storage tanks etc. shall be earthed at least by two distinct separate earth conductors from the earth plate connected to main earthing loop.

The main grid conductor shall be hot dip galvanized MS flat. The amount of galvanizing shall be minimum 610 gm per sqm. The main earth loop shall be laid at a depth of 500mm below grade level.

Earthing conductor shall be laid around the battery limit of the plant. Horizontal conductors shall be laid in both longitudinal and transverse direction to facilitate earthing of various equipment in most economical and reliable manner.

Cable trays in process areas shall be earthed with the help of risers emerging from main earthing conductors laid below/adjacent to structures carrying cable trays. Trays shall be earthed at an interval of approximately 30meter and in any case shall be connected to the earthing grid at minimum two points.

Joints and tappings in the main loop shall be made in such a way that reliable and good electrical connections are permanently ensured. All joints below grade shall be welded and suitably protected by giving two coats of bitumen and covered with hessian tape.

Adequate number of minimum 65mm dia. or higher size as per IS: 3043, 3meter long GI pipe earth electrodes with earth pit shall be provided. All earth electrodes shall preferably be driven to a sufficient depth to reach permanently moist soil.

Multiple earth connection shall be taken from suitably located earth plates connected to earth loop. All hardware used for earthing installation shall be hot dip galvanized or zinc passivated. Spring washers shall be used for all earthing connections of equipment. Unless otherwise specified, earthing connections to individual equipment shall be done in accordance with standard equipment earthing schedule.

Lightening protection shall be provided for equipment, structures and buildings as per IS/IEC 62305. Self conducting structures may not be provided with aerial rod and down conductors but shall be connected to the earthing grid at minimum two points of the base. An independent earthing network shall be provided for lightening protection and this shall be bonded with the main earthing network minimum at two points at the buried electrodes.

The resistance value of an earthing system to the general mass of earth for the electrical system and equipment shall be as follows.

- a) For the electrical system and equipment a value that ensure the operation of the protective device in the electrical circuit but not in excess of 5ohms. However, for generating stations and sub stations this value shall not be more than 1ohm.
- b) For lightening protection, the value of 5ohms as earth resistance shall be desirable, but in no case it shall be more than 10ohms.

Connection

The earth system connection shall generally cover the following.

- Equipment earthing for personnel safety
- System neutral earthing
- Static and lightning protection
- System neutral
- Current and potential transformer secondary neutral
- Metallic non current carrying parts of all electrical apparatus such as transformers, switchboards, bus ducts, motors, neutral earthing resistors, capacitors, UPS, battery charger panels, welding receptacles, power sockets, lighting/power panels, control stations, lighting fixtures etc.
- Steel structures/columns etc.
- Cable trays and racks, lighting mast and poles
- Storage tanks, vessels, and all other process equipment
- Fence and Gate for electrical apparatus (e.g. transformer, yard etc.)
- Cable shields and armour
- Shield wire

All main earthing shall be used for earthing of equipment to protect against static electricity.

All LV, medium and high voltage (HV) equipment (above 250V) shall be earthed by two separate and distinct connections with earth.

Plant instrument system clean earthing, UPS system clean/safety earth shall be separate from the electrical earthing system.

All earthing connections for equipment earthing shall preferably from the earth plate mounted above ground wherever provided. Equipment foundation bolts shall not be used for earthing.

Earth connections shall be made through compression type cable lugs/by welded lugs.

All hardware used for earthing installation shall be hot dip galvanized or zinc passivated. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.

Lighting fixtures and receptacles shall be earthed through the extra core provided in the lighting circuit/cable for this purpose.

The reinforcements of sub station building and sub-station floor shall be connected to main earth grid.

The earth electrodes shall be situated at a distance not less than 3meter from the building fencing structure and equipment foundations. The surrounding the electrodes, soil shall be treated up with salt, coke and charcoal. The distance between two electrodes shall not be less than twice the depth of electrode.

Minimum requirement of earth pits as per IE rules are as under.

- Two numbers independent for two/four pole structure.
- Two numbers independent for HT & RMU body.
- Two numbers independent for transformer body.
- Two numbers independent for transformer neutral.
- Two numbers independent for DG body.
- Two numbers independent for DG neutral.
- Two number for lightning arrestors.
- Two numbers for LV panel at sub station and at pump house.

The main earth electrodes after being driven into the ground shall be protected at the top by constructing concrete or block masonry chamber or pre-cast chambers of size 300mm x 300mm x height 300mm with CI cover. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall preferably not exceed 1ohm. The remaining space in the bore hole shall be filled with bentonite. The bentonite will hold the earth rod in position. The neutral conductor shall be insulated throughout and shall not be connected at any point to the consumers earthing system.

It shall not be allowed to use the armour of the incoming feeders cable to the sub-distribution board as the only earthing system.

Sheathed lugs of ample capacities and size shall be used for all underground conductors for sizes above 3 mm² whenever they are to be fitted on equipment of flat copper conductor.

The lugs shall be fitted on equipment body to be grounded or flat copper only after the portion on which it is to be fixed is scrubbed, cleaned or paint or any oily substance on a subsequently tinned.

No strands shall be allowed to be cut in case of stranded ground round conductors. GI embedded conduits shall be made electrically continuous by means of good continuity fixing and also rounding copper wires and approved copper clamps.

Earthing of Lighting Poles

All external poles are to be looped together with continuous 8 SWG GI earth wire clamped a dollies provided on every fuse box of poles and looped onwards to the other pole. Every fifth pole shall be connected to earth through an earth electrode.

Recommended Size of Earthing Conductors

Below mentioned are the recommended minimum sizes of earth conductors. However, Earthing strips/conductors, if required of higher size as per Ground Fault Calculations, should be laid as per SOQ or as per site requirement.

Type of Equipment	Earth Conductor (See Note)
Motors upto 3.7kW	8 SWG solid GI wire
Motors from 5.5kW to 30kW and welding receptacles	10mm dia GI wire rope
Motors above 37kW	16mm dia GI wire rope OR 40mm x 5mm GI strip
Building columns, fencing	40mm x 5mm GI strip
Storage Tanks (Vertical/Horizontal)/Vessels	40mm x 5mm GI strip
Small equipment and instrument	8 SWG GI solid wire
Lighting, Power and Instrument Panels	10mm dia GI wire rope
Main Earth Bus/LV and HV Switchgear Interconnections	75mm x 8mm GI strip
Power Transformer/HV Sub stations	50mm x 6mm Cu for Neutral 75mm x 8mm GI strip for rest
Push Button Stations (LCS)	8 SWG GI solid wire
Street Light Poles	8 SWG GI solid wire
Lighting Transformer	16mm dia. GI rope

Pipe Rack	40mm x 5mm GI strip
Bonding of pipe	25sq mm insulated flexible Cu cable

Notes:

- 1) Earth connection to individual equipment from nearest earth plate/grid may also be done alternately using aluminium/copper conductor PVC insulated core of size not less than half the cross section of the respective power cable to equipment (motor, panel etc.). Connections shall be made using crimp type lugs.
- 2) Number of runs of Cu/GI earthing strips shall be as per ground fault calculations.
- 3) The size of strip mentioned may be changed as per availability meeting the minimum area requirement of specified size of strip/conductor.

Maintenance Free Safe (Chemical Type) Earthing System

Chemical type earthing electrode shall be used for equipment body earthing. It shall be made with steel core and a copper exterior to provide increased conductivity and corrosion resistance. The electrodes shall be minimum 3meter length, 17mm diameter with 99.9% pure electrolyte copper coating of minimum 250 microns and ANSI/UL 467 approved. Adherence of copper to steel rod is achieved through a pioneered bright acid copper plating process using 14 stations using proper current densities, temperature and brightener additives to achieve copper plating with finer grain structure and a smoother, harder and more uniform surface. It shall have minimum tensile strength of 80,000 PSI and straightness tolerance 0.01" per linear foot and shall meet the requirement of ANSI/UL 467, CSA and ANSI/ NEMA. UL logo and control number where applicable shall be stamped on each rod for easy inspection after installation. The rod shall be tested according to IEC 62561-2 and comply to the requirements of IEC 60364-5-54. The rods also should withstand short circuit currents. All fasteners used should confirm to the requirements of the above standards.

Back filling compound used shall have resistivity less than 20ohm-cm in its set form. Earth resistance shall be remained same over a wide temperature variation of -60 °C to + 60 °C. It shall be suitable to absorb and retain moisture for long time and shall reduce soil resistivity, Dissipate fault current very fast, Eliminate needs of salt and chemical around electrode and maintain compatibility of soil and rod contact. Earth enhancing compound (Soil conductivity improver) used should be tested according to IEC 62561 – 7 from an NABL accredited laboratory. Exothermic welding material used shall be tested as per IEEE 837

Construction Procedure of Chemical Type Earth Pit

A hole of 100 to 125mm dia. shall be augured/dug to a depth of about more than 3meters or as per instruction of Engineer-in-charge.

Earth electrode of minimum 3meter length shall be placed into this hole.

It will be penetrated into the soil by gently driving on the top of the rod. Here natural soil is assumed to be available at the bottom of the electrode so that min 150mm of the electrode shall be inserted in the natural soil.

Earth Enhancing material (minimum 20kg) shall be filled in to the augured/dug hole in slurry form and allowed to set. After the material gets set, the diameter of the composite structure (earth electrode + Earth Enhancing material) shall be of minimum 100mm dia. covering entire length of the hole.

Remaining portion of the hole is filled with backfill soil which is taken out during auguring/ digging.

Construction of masonry earth chamber and cast iron cover with earth resistance result with date or as per instruction of Engineer-in-charge.

For interconnection to the main earthing grid, 40mm X 5mm thick copper clamp shall be provided.

A) PIPE-IN-PIPE Technology Safe earthing

Two pipes of coaxial diameters joined together for enhancing the service life and performance of the overall earthing system.

The cavity in between the electrodes shall be filled with crystalline conductive compounds for current dissipation and anti corrosive properties.

The electrode cross section shall be circular for the uniform distribution of fault current all around from electrode to earth.

Inner pipe of length 3meter shall be hot dip galvanized/zinc coated with minimum galvanizing thickness 80 - 100 micron or Copper plated (minimum 250mm) as per Drawing/SOQ. Minimum size of pipe as per Drawing/SOQ. Outer pipe of length 3meter shall be hot dip galvanized/zinc coated (minimum 150 micron) or Copper plated (minimum 250mm) as per Drawing/SOQ. Minimum Size of pipe as per Drawing/SOQ. A hole of 200mm - 225mm dia. shall be augured/dug to depth of about more than 3meters or as per instruction of Engineer-in-charge.

Earth enhancing compound of minimum 50kg shall be filled. **Earth enhancing compound shall be filled till top of Earthing Pipe electrode.**

B) Plate Type Earthing Stations

The earthing station shall be as per drawing/IS: 3043. The equipment neutral earthing shall be with Copper plate earthing station.

The plate electrode shall be 600mm x 600mm x 3.15mm Copper plate for neutral earthing.

The earthing conductors shall be of Copper strip in plate type earthing.

GI pipe with funnel of good quality shall be used for watering the earthing electrodes/stations.

The brick masonry or pre case CC chamber with cover/chequered plate shall be provided for housing the above referred funnel and pipe.

Earthing Unit Measurement

Earthing station/pit complete with excavation, electrode, watering pipe, soil treatment, masonry chamber with cast iron cover etc. as per tender specifications/drawings shall be treated as one unit.

Different sizes of strips/wires per unit length covering/including cost of interconnection the earthing station to earthing grid, and to respective equipment with fixing accessories like earthing clamps, saddle, labour etc. shall be traded as unit length.

The earth system connection shall generally cover the following.

1. Equipment earthing for personnel safety
2. Transformer, DG and System neutral earthing
3. Static and lightning protection
4. Current and potential transformer secondary neutral
5. Metallic non current carrying parts of all electrical apparatus such as transformers, switchboards, bus ducts, motors, neutral earthing resistors, capacitors, UPS, battery charger panels, welding receptacles, power sockets, lighting/power panels, control stations, lighting fixtures ceiling fan and exhaust fan, street light, flood light pole circuit/cable.
6. Fence and Gate for electrical apparatus (e.g. transformer, yard etc.)
7. Cable shields armour and shield wire.

The scope of work shall also cover supply, laying, installation, connecting, testing and commissioning of following.

- Plate (600mm x 600mm x 3.15mm Copper plate) type/Pipe type (Chemical type) earthing station with Copper bonded earth electrode/Copper plate of size as per tender/IS.
- Earthing Copper strips from Plate earthing station and hot dipped GI strip for pipe earth to equipotential bar/earth grid.
- Earthing GI/Copper strips/wires from earth grid/equipotential bar to power panels, DBs, motors, indoor/outdoor lighting systems etc.
- Bonding of non current carrying parts and metallic parts of the electrical installation.
- Quantity of pits mentioned are minimum or higher as per soil resistivity. Measurement of soil resistivity to be carried out by contractor at no extra cost.

- All the earthing material and installation and construction of earth pit, chamber etc. shall be as per IS: 3043 and tender.
- Galvanising thickness shall be 86 micron and 610 g/m² as a minimum.

❖ SAFETY EQUIPMENT

The contractor shall provide safety equipment and accessories for HV panels, DG panels, LV control panels etc. as per statutory requirement.

Generally following shall be provided as a minimum (forming part of scope of this work).

- Supply and spreading synthetic rubber mat, 1meter wide, 2mm thick, conforming to IS: 15652 Class A for 1.1kV LV voltage in front of LV PMCC/MCC/LVDB/APFC etc.
- Supply and spreading 1meter wide 2.5mm thick synthetic insulating mat as per IS: 15652 Class B suitable for operation of 11kV equipment in front of all HV panels for their entire length. The insulating mat should have ISI mark on every one meter.
- Pairs of electrically tested 22kV rubber gloves. These are to be kept in a suitable wooden box.(Min 3Nos. or higher as required)
- A shock treatment instruction chart in English and local language duly framed as detailed in IS: 1355.Details of the nearest medical facility available with phone number shall also be kept. Font and size of chart should be readable / big size and as per instruction of Engg-in-charge of client. (Min 8Nos. or higher as required)
- First aid box containing first aid kit for treatment of electrical burns in the main switch room or as directed by engg-in-charge of client. (Min. 5Nos. or higher as required)
- ABC powder type 'Ceasefire' portable type Fire Extinguishers as per IS: 13849 of minimum 6.5 Kg capacity with necessary clamps for erection on wall and for individual substation, HV and LV panel/control rooms, Dg set, transformer yard, Scada Room as required and as per fire safety guidelines and norms and as per instruction of Engg-in-charge of client. (Min.20Nos. or higher as required)
- Danger/Caution notices / Exit Sign / Restricted Area / Shock treatment chart etc. in English shall be fixed permanently on the equipment, LV, HV panel room, switch yard etc to comply the requirement of IE rules.
- Safety posters for vigilance against electrical accidents as detailed in IS: 1255.
- Fire buckets with MS angle stand and with 4 number round bottom fire buckets marked fire shall be provided in the Switchyard, HV panel room, LV panel room, DGset, transformer yard. Stand shall be with canopy. Stand shall be grouted in RCC. (Min.7Nos. or higher as required)
- 3meter and 6meter long folding Aluminium ladders for safe maintenance of lighting system etc.
- 1no. 7.5meter cleared height, 300LBS capacity, Extra Heavy Duty Industrial, 25 feet Platform height, Mobile Telescopic Platform ladder with wheel, made with Duty Rating of Type-IA as per applicable Safety codes of the American National Standard Institute (ANSI) for Street light Pole, bracket fixtures maintenance works.
- SLD and earthing layout of suitable size duly framed/laminated shall be fixed on the wall near the entrance.
- Any other as per statutory norms / requirement shall also be provided.

❖ DIESEL GENERATOR SET WITH AMF PANEL

Supply, installation, testing and commissioning of Diesel Generating set of KVA rating as per SOQ / specifications at 0.8 PF, 1500 RPM (4 Pole), 415 V \pm 2.5%/1% and 50 \pm 1% Hz or more, 3 phase, 4 wire complete with control panel, controller, cabling etc. as applicable and necessary controls and safety devices in panel confirming to relevant IS specifications. The set must be of continuous operational duty with speed regulation of \pm 1% or better.

DG set rating shall be as per CPCB IV Standard rating as per Present prevailing and applicable norms and shall comply with latest emission norms of CPCB-IV latest amendments emission smoke limit & noise limit norms of Ministry of Environment and Forest (MOEF) by Government of India (GOI)

OR

DG set rating shall be as per CPCB II as per Present prevailing and applicable norms.

DG set rating shall be for prime continuous rating power (PRP) in accordance with ISO8528 / ISO3046 / IS:4722 / IS:13364 (Part-1 & 2) / BS5514 / BS5000 (Part 99) / IEC34.

DG set shall meet present prevailing and applicable all statutory safety codes / norms & pollution control regulation requirement norms. It must fulfil all norms, provisions and conditions set by concerned and relevant Statutory Authorities.

DG Set foundation shall be as per OEM recommendation.

Generating Set

The DG set shall be Prime Duty, comprising diesel engine of adequate capacity directly coupled to an alternator mounted on a common rigid steel base frame.

The rated capacity shall be as per SOQ/tender specifications.

DG set is required to function at places situated at an altitude up to 1000 M, ambient (Engine cooling system temperature up to 50⁰C) temperature and relative humidity up to 95%. In case if the site is located at more than 1000m altitude or for engine desing ambient temperature of more than 50⁰C, DG set shall be offered to provide required output after suitable de-rating.

DG set should be able to start by push button starting and/or auto start.

The controller of DG panel shall be with RS 485 port (Modbus protocol) for remote data monitoring and logging.

COP (confirmation of product) of Nodal/Statutory authority shall be provided by manufacturer for noise and emission levels.

It shall be with suitable accoustic enclosure to meet MoEF/CPCB norms. Enclosure shall be made of CRCA sheet and high quality noise absorbent and fire retardant grade acoustic insulation material to IS:8183.

A. Engine

Diesel engine shall have constant speed, water cooled, suitable for generating set application 1500 RPM, powered by multi cylinder, cold starting, heavy duty type rated in accordance with ISO 3046/IS with latest amendments

Engine cooling system shall be designed and tested to 50⁰C ambient temperature.

Diesel Engine below 140kVA rating shall have mechanical governing system and 140kVA and above rating shall be with Electronic governing system.

The engine should have automatic belt tensioning arrangement for battery charging alternator system.

The engine should have facility for the indication of oil level in oil sump during running of the engine.

The engine water circular pump should be directly driven by engine gear system. V belt driven system will not be adopted/accepted.

The engine shall be rated for continuous duty at site ambient conditions with an inherent overload capacity of 10% for 01 hour in any 12 hours.

The engine should have equipped with the following accessories.

- Fly wheel to suit flexible coupling with guard
- Dry type air cleaner
- Corrosion inhibitor liquid
- Fan blower type with guard
- Radiator with guard
- Water pump, centrifugal type, engine mounted
- Fuel pump PT type, Fuel filter

- Governor – Electronic type to meet test requirements as per ISO 8528
- Fuel injection equipment
- Exhaust silencer Residential / Hospital Grade type. Height of exhaust pipe above DG room height shall be as per pollution control regulation and suitably supported. The exhaust pipe to be wrapped with asbestos rope till the end point.
- Electric starting equipment comprising starting motor with soft start engagement feature on 12/24 V DC supply
- Lube oil cooler, Lube oil pump, Lube oil filter
- Turbo charger if applicable as per manufacturer design / standard
- Solid state potentiometer for increase or decrease of speed which can be wired with remote operation (For DG with synchronizing only, not applicable for solo application).
- Any other as required

B. Power Control Unit

Micro processor based power control unit for monitoring, metering, protection and control system with LED backlit LCD display. DG set shall have Modbus interface.

Engine Metering	Alternator Metering	Engine Protection	Alternator Protection	Operator Interface	Data logging
Speed of Engine in RPM	3 Phase voltage (phase to phase and phase to neutral)	Low lube oil pressure	Over/under Voltage	Manual stop/start	Engine hours
Lube oil pressure	3 Phase current	High/Low coolant temperature	Over current, short circuit	Remote start/stop	Engine starts
Coolant temperature	Frequency	Over/under DC voltage	Over/under frequency	---	Up to 10 recent fault records
Battery Voltage	kVA	Fail to Crank/ start	Loss of AC sensing		
Running hours		Weak Battery	Field overload	---	
---	---	Over-speed		---	
		Sensor failure			

C. Alternator

Alternator shall be rated for 40 °C design ambient temperature, altitude up to 1000 M, relative humidity 95%. It shall be based on **80% loading** (unless otherwise is specified in elsewhere in tender specifications or rating is specified in SOQ) and 0.8 PF. Short time overloading of alternator shall be as per OEM standard. Alternator shall be brushless, self-excited, digital automatic voltage regulator, class H insulation, double bearing AC generator in accordance with IS: 4722 with latest amendments with screen protected drip proof enclosure and damper winding on pole faces.

Insulation class of alternator shall be of H class. Space heater shall be provided for 250kVA and above rated alternator. 2 numbers per phase thermistors with temperature scanner shall be provided for 500kVA and above rated alternator. Terminal box shall be suitable to terminate number of cables for respective rating, necessary terminal extension box shall be considered as per requirement.

D. Battery

Set of starting batteries consisting of required nos. of 12/24 V and of required AH capacity VRLA SMF (Valve regulated lead acid, sealed maintenance free) batteries connected in series with first charge of electrolyte with leads, lugs and terminals etc. duly installed on MS frame near the Engine.

Battery Charger

DG set shall be with offline battery charger and suitable to charge the battery when DG is on.

Battery Charger shall be consisting of

- Transformer and rectifier with surge protection network
- DC Voltmeter

- DC Ammeter

Selector switch for Trickle, off and boost and current adjustment

E. Base Frame

The Engine and Alternator should be assembled on a sturdy fabricated, adequately machined base frame, made out of high quality MS channels. The base frame should be provided with lifting facilities and drilled foundation holes suitable for installation in concrete foundation with anti-vibration mounting. DG set is to be supplied with anti-vibration mountings pad suitable for the DG set load.

F. Fuel Tank

Day fuel tank of adequate liters capacity with inlet and outlet pipe connections, filling cap, drain plug, level indicator and floor mounting pedestal along with hand operated fuel transfer pump and suitable hose.

The fuel tank shall be inbuilt part of the DG set. The fuel tank shall be suitable for minimum 4 hours of operation of DG set on full load subject to maximum 990 liters capacity.

G. Control Panel

The specifications for LV panel are described in full details in relevant LT Panel section. DG panel make shall be as per tender / approved by DG set manufacturer. DG set panel shall be designed and constructed as per tender specification and provisions specified elsewhere in the tender. The accessories shall be provided as shown in section of specifications for LV panels. Construction parameters, accessories etc. shall be as per LV panel specifications.

Apart from standard accessories, DG control panel shall have following minimum additional accessories.

- a) TNC/Breaker control switch (for ACB incomer)
- b) Digital Voltmeter and voltmeter selector switch (0-500V)
- c) Digital ammeter and ammeter selector switch
- d) Current transformers Resin cast for metering and protection. C1 0.5, 10 VA.
- e) Digital type Multi-function Meter shall be with 3 line display, LCD, Accuracy Class: 0.5 Suitable for measuring and displaying the following parameters: A,V,F,PF,KW,KWH, KVA, KVAR, KVARh, Md, Harmonic & with inbuilt RS 485 communication port. (Schneider- EM 6400NG; L&T –MFM 4420; Secure – Elite 445; equivalent model of other approved make). Data sheet with parameter comparison shall be submitted for approval.
- f) Power factor meter.
- g) Frequency meter
- h) Auto/Manual, Local/ Remote selector switch.
- i) Emergency stop Push button.
- j) LED Indicating lamps

Besides standard accessories following are to be provided as per governing standards and actual requirement.

- k) Battery Charger consisting of following.
 - Transformer and rectifier with surge protection network
 - DC Voltmeter
 - DC Ammeter
 - Selector switch for Trickle, off and boost and current adjustment
- l) Electronic AMF/AMF Cum Synchronizing Logic relay (Nb2 or Equivalent) to cover the following functions as a minimum.
 - Mains supply failure monitor
 - Supply failure timer
 - Restoration timer
 - 3 impulse Automatic engine Start/Stop attempts
 - Failure to start indication
 - Off/Manual/Auto/Test Selectors
 - Power On/Off Switch

- Synchronizing relay with load sharing arrangement with arrangement to change over MASTER (for AMF cum Synchronizing Panel)

Sr. No.	Condition	Indication	Alarm	Trip Annunciation
	Phase Indicating lamps ON, OFF, TRIP			
1	Mains on	Yes		---
2	Generator on	Yes		---
3	Load on Mains	Yes		---
4	Load on generator	Yes		---
5	Auto/Manual	Yes		
6	Common Fault		Yes	
7	Over and Under Voltage		Yes	
8	Battery Charger Fault		Yes	
9	Low Fuel Oil Level		Yes	
10	Over Load		Yes	
11	Low Lub Oil Pressure	Yes		Yes
12	High Water Temperature	Yes		Yes
13	High Lub Oil Temperature			Yes
14	Set fails to start (with alarm)	Yes	Yes	Yes

Special Notes:

Up to 70kVA rating the engine can be air cooled type and above 70 kVA rating engine shall be water cooled type.

The diesel engine generator set shall be with acoustic enclosure.

The diesel engine can be naturally aspirated, turbocharged type or turbocharged with after cooler arrangement type as per respective manufacturers' standards.

H. Acceptance Test

Following tests shall be carried out for DG set and control panel by the vendor to the entire satisfaction of the purchaser at manufacturers' works.

a) Phase I Test

- Insulation resistance test
- Continuity test
- High voltage test on power wiring of control panel
- Visual examination to ensure that the DG set, accessories, control panel etc. are provided for the finish and general appearance of the work as per specifications/tender
- Dimensions and alignment
- A no load test for a period of five minutes to see that the engine, alternator and other accessories are functioning normal

b) Phase II Test

- On successful completion of the phase I tests full load test will be carried out for 30 minutes continuously by loading artificially.
- The overall efficiency of the DG set at $\frac{1}{4}$ load, $\frac{1}{2}$ load and full load shall be worked out.
- All necessary arrangements for testing under artificial load conditions such as cables, electrodes, load and consumable like diesel, lubricating oil etc. shall be provided by the OEM/vendor.

c) Documents Requirements

- Alternator manufacturers' routine test certificate/prime power rating documents.

- Engine manufacturer's routine test certificate/MoEF certified power (BHP) documents.
- Calibration/test certificates with setting manuals of manufacturers' of ACB/MCCB, meters, all instruments and relays shall be presented for review during inspection and shall be part of dispatch documents.
- Transient response test for sudden application and rejection of loads of 25%, 50%, 75% and 100% of rated capacity.
- Wave form test (type test results are acceptable).
- Vibration and Noise level test shall be provided after installation at site.

I. Specific Requirement

The vendor should be in possession of type and routine test certificates as per IS issued by CPRI or any other testing laboratories.

Vendor shall submit the following drawings for approval before manufacturing.

- a) CPCB-IV Emission limit /Smoke limit norms of Ministry of Environment and Forest (MOEF) by Government of India (GOI) test certificate of present validity issued by statutory (ARAI etc.) authorized agencies for certification.
- b) Alternator manufacturer technical data sheet.
- c) Engine manufacturer technical data sheet.
- d) DG set manufacturer technical data sheet / Technical Particulars.
- e) General Arrangement Drawing with indicating all accessories details.
- f) Foundation Drawing
- g) Alternator Termination drg. & details for cable termination.
- h) DG set Control / AMF / Synchronising Panel: Technical data sheet / Technical Particulars, BOM, GA drawing, Power and Control Wiring Drawing

All minor civil works like opening in wall for exhaust pipe and fuel pipe etc. required for installation of DG sets is included in the scope of the contractor/vendor.

The work of installation, testing and commissioning of DG set shall be done by qualified and competent Engineer/Supervisor and all instructions shall be strictly followed for the completion of work with good workmanship as required and as per IE rules and regulations of Statutory body and other mandatory requirements.

The vendor has to supply the following items free of cost on commissioning of the DG set.

- Technical literature, control and power circuit diagram, manufacturers' manual of engine, alternator, panel etc. in number of sets as specified.
- List of essential spares.
- One set of essential maintenance tools like grease gun, tool kit with Ratchet spanner set, torque wrenches, Allen keys etc.

The routine test of engine and alternator shall be arranged at manufacturers' premises by the vendor. Prior intimation shall be given regarding the readiness of engine and alternator for conducting the routine test as per relevant IS standards.

Load testing of the entire installation or load as available (minimum 40% of DG rating preferred) at site, shall be carried out at site, on commissioning of the DG set.

Contractor/Agency shall be responsible for obtaining necessary statutory approval for installation and operation of DG set (Electrical Inspector, Central/Local Pollution Control Board etc.).

5.0 INSPECTION & TESTING

Inspection of offered equipment/items at manufacturers' works' shall be done by the Client/ PMC/TPI as specified here in as per relevant inspection and testing standards and as per approved, quality assurance plans, technical data sheets, SLD, documents and drawings.

Inspection Criteria of Various Major Equipment/Items at Manufacturers' Works:

Major electrical equipment/items as specified below, shall be tested and inspected at vendor manufacturers' works as narrated, prior to dispatch to ensure compliance with the specifications, requirements and applicable codes and standards and approved quality assurance and testing plans by the Client/PMC/TPI.

- **HV Panels/RMU**

100% quantity of HV breaker panels and RMU, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

100% quantity of **HV FCMA/HFSR/VFD starter panels**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **LV Panels**

100% quantity of LV panels for **Amperes Ratings ≥ 630 Amps**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **VFD Stand Alone and MCC Panels with VFD**

100% quantity of VFD stand alone panels and all LV panels with VFD starters irrespective of **Amperes Ratings**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **APFC Panels**

100% quantity of APFC panels for **KVAr Ratings ≥ 100 KVAr**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **Transformers**

100% quantity of transformers for **kVA Ratings ≥ 500 KVA**, routine tests and other specified and necessary tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **DG Sets**

100% quantity of DG set for **kVA Ratings ≥ 500 kVA**, routine tests, other specified and necessary tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **HV Cable**

For all types, ratings and sizes of HV cables, if the quantity of each size, type and where length of cable is **≥ 250 meters**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **LV Cables**

For all types, ratings and sizes of LV cables, if the quantity of each type and size **≤ 120 sq. mm** and where length of cable is **≥ 1000 meters**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

Similarly For all types, ratings and sizes of LV cables, if the quantity of each type and sizes **> 120 sq. mm** and where length of cable is **≥ 500 meters**, tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **HV Motors**

100% quantity of motors of each type and rating of entire lot, routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI. Type test of one motor of each type and rating out of entire lot, shall also be witnessed @ Manufacturers' works by the Client/PMC/TPI.

- **LV Motors**

Motors ≤ 45 kW: Routine tests carried out internally and type test certificate of identically rated motor **≤ 45 kW** shall be submitted for review and acceptance by the Client/PMC/TPI.

Motors > 45 kW to < 160 kW: Out of all motors rated > 45 kW to < 160 kW, **25% quantity of motors of each type and rating or one number (whichever is higher)** out of entire lot, routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI and routine tests of all other motors carried out internally and type test certificate of identically rated motor shall be submitted for review and acceptance.

Motors ≥160 kW: For motors rating ≥160 kW, **40% quantity of motors of each type and rating or one number (whichever is higher)** out of entire lot, routine tests shall be witnessed @ Manufacturers' works by the Client/PMC/TPI. **Type test of one motor of each rating** out of entire lot, shall also be witnessed @ Manufacturers' works by the Client/PMC/TPI. Routine tests of all other motors carried out internally shall be submitted for review and acceptance.

- For all major equipment/items specified above, where factory inspections are exempted as clearly specified above, all tests as per relevant and applicable standards as well as approved QAPs, data sheets, SLD, documents and drawings must be carried out by the manufacturers'/vendors/panel builders etc. and test certificates, As built drawings and BOM, MTCs etc. shall be submitted to the PMC/TPI prior to dispatch for getting dispatch clearance of the Client/PMC/TPI.
- All other items shall be cleared for dispatch based on review of material test certificates/ manufacturers' test reports' by the Client/PMC/TPI.

All expenditure pertaining to inspection including to and fro travel, local conveyance, lodging and boarding etc. shall be borne by the Contractor for minimum 2 representatives of Client/PMC/TPI Agency.

The Client or his authorized representative may visit the works during manufacture of various electrical equipment/materials to assess the progress of work as well as to ascertain that only quality raw materials are used for the same. He shall be given full assistance to carry out stage inspection. Client's representative shall be given minimum two weeks advance notice for witnessing the final testing.

Field tests as per approved procedures/procedures available with Engineer-in-charge or his authorized representative shall be performed on the electrical system/equipment before it is being put into service. All test equipment shall be arranged by the Vendor/Contractor. Test reports shall be approved by the Engineer-in-charge before acceptance of the equipment and complete plant.

6.0 ELECTRICAL INSTALLATION

This specification covers the technical requirements for equipment, materials and installation methods, testing and commissioning of electrical system.

The contractor shall possess a valid electrical contractor's license for the state in which site is located and shall ensure its validity during the duration of the contract.

The contractor shall employ adequate skilled and unskilled labour to complete all work according to programme of work. Skilled workers shall possess the minimum qualifications stipulated by statutory or competent authorities.

The contractor shall employ adequate numbers of supervisor to control the labour force and to carry out the work as per schedule. Supervisory staff shall also possess the minimum qualifications stipulated by statutory and competent authorities.

Various types of equipment shall be installed in accordance with approved drawings and/or manufacturers' instructions and good engineering practices. Particular attention shall be paid to lubrication of moving parts and bearings, alignment, tightness of all connections (mechanical and electrical) and wiring.

The transformers and DG sets shall be moved to its location and shall be correctly positioned on their bases.

All parts of the transformers, which are supplied loose, such as conservator, radiator banks, buchholz relays, dial thermometers, bushings, etc. shall be fitted onto the transformers.

Transformer oil if supplied in drums shall be filled into the transformer after duly testing/filtering, up to the correct level required. The transformer may have to be dried out and oil filtered.

The contractor shall place the switchgear correctly on the base of foundation prepared for the same. If the switchgear consists of a switchboard with number of panels bolted together, he will place all the sections of the switchboard correctly, align them and bolt the sections together to form one continuous switchboard. The switchgear shall then be secured to the foundation by means of nuts and bolts or foundation bolts grouted in the base. The contractor shall also make inter section bus/wiring connections.

In case of wall/structure mounted equipment, boards, the contractor shall fabricate and install the structural steel frame work suitable for mounting the various equipment boards. The contractor may have to prepare drawing showing the proposed general arrangement, of the structural frame which shall be subject to the approval of the Engineer-in-charge. The fabrication and installation of the framework shall be recommended only after the approval of drawings. Various items of the equipment, board shall be mounted in accordance with the approved drawings.

Motor shall generally be installed by others, along with the driven equipment. The contractor may, however, be asked to install motors in specific instances.

Cable routes and mode of installation shall generally be as shown in the construction drawings.

Identification tags indicating cable designation, shall be affixed to each cable at ends and at an interval not exceeding 15 meters or at the location where cables change direction or elevation. Signboards with necessary indication/arrow mark with necessary structure/foundation shall be also be installed, of adequate size as approved by Engineer-in-charge, for the entire cabling system buried underground.

HV XLPE/PVC armoured cables shall be terminated or jointed by means of cold setting epoxy based cast resin jointing system or heat shrinkable or push on type cold setting kit.

All cable glands should be of nickel plated brass, double compression type. All Alu/Cu cables shall be terminated through crimping type Alu/Cu lugs respectively.

All electrical equipment viz. transformers, switchgear, motor control centers, motors, control stations, switches, lighting, fittings and other electrical apparatus shall be connected to the main earth loop by means of two separate and distinct external earth conductors. The material, type and size of earth conductors will be as shown in the drawings or as specified.

Electrical installation in hazardous areas if applicable as defined in IS: 5571 shall be carried out with utmost care and special precautions shall be taken to ensure operational safety.

All personnel, especially supervisory staff, working on such installations shall be fully conversant with the applicable National Standards and Code of Practice and shall have previous experience of such work.

The contractor shall take all reasonable safety precautions during construction and testing of the works. Particular attention shall be paid to the following:

- a) To prevent any conductor or apparatus becoming accidentally or inadvertently charged.
- b) Prior to electrical installation (or part there of) being connected to the main supply, the Contractor shall ensure that uncommissioned or incomplete circuits cannot be inadvertently energized and completed circuit cannot be used without the Engineer's consent.
- c) No hot work is carried out without work-permit issued by the Engineer in FLP zones (if stipulated by process application).

The tests specified below/elsewhere as part of this tender document shall be carried out on the electrical equipment and installation before commissioning the same. The tests shall be performed by or under the direct supervision of a competent person, qualified to carry out the tests. All tests shall be carried out in the presence of the authorized representative of the Employer/Owner and/or the Engineer, unless this stipulation is waived in writing.

7.0 PAINTING

All surfaces of equipment/structural steel shall be sand blasted, degreased and pickled in acid as required to provide a smooth & clean surface, free of rust/scale/grease.

After cleaning the surface shall be given one coat of high quality red oxide or yellow chromate and baking in the oven (for equipment only).

All surfaces shall be then finished with 2 (two) coats of finished epoxy based paint of shade 631 of IS: 5 or with a paint shade of Client's choice unless otherwise specified.

8.0 DETAILS OF TESTS

I POWER and DISTRIBUTION TRANSFORMERS

- i) Check HV and LV cable terminations, ground connections, fittings and accessories, oil level and oil leaks at various joints. Check breather, thermometers and buchholz relay for proper functioning and operation. Check junction box, marshalling box etc. for correct wiring.

- ii) Oil Test

Crackle test and dielectric test as per Clause 7.11 of IS: 10028. The oil shall withstand at least 40kV with a gap of 4mm.

- iii) Insulation Resistance Test

This may be carried out on new transformer without drying out the transformer, provided the transformer has not been idle or stored for a long period. Otherwise, this test shall be carried out during drying out of transformers. Insulating resistance test shall be carried out between primary & secondary to ground as well as between primary and secondary. Windings not under test shall be grounded during the test.

A megger rated 1000V or higher shall be used for the test.

- iv) Polarity and Phasing Out Test

Check external connection of the transformer in accordance with diagram of connection and phase sequence (anti-clockwise)

II HV AND LV SWITCH GEAR/RMU/HT PANEL

- i) Check proper mechanical operation of circuit breakers including alignment of trolleys in case of draw out type circuits breakers, smooth operation of all mechanical parts, lubrication, mechanical interlocks etc.
- ii) Check contact alignment and wipe, proper sequence of closing and opening of main and arcing contacts.
- iii) Check electrical relays, instruments and controls for correct wiring.
- iv) Insulating test on bus bars – phase to phase and phase to ground. This test will be carried out with circuit breakers in service position, but contacts remaining open.
- v) Insulation test on relays & control wiring including current and potential transformers and wiring of CT and PT secondaries.
- vi) Insulation test on circuit breakers in withdrawn position – phase to phase and phase to ground with contacts closed.
- vii) Adjust correct settings of relays and/or direct acting trips - as specified.

viii) **Operation test**

Energise only control circuits and carry out closing and tripping operations (where AC supply derived from main supply is used for operation, the switch-gear bus may be energised). Check operations of electrical interlocks. Check tripping of circuit breakers by manual operations of protective relays contacts. Check operations of mechanical closing and tripping devices. Check lockout conditions for closing of circuit breakers by simulating the required conditions. Check control, indications, sequence interlocks and alarms.

- ix) Polarity and connections of instrument transformers – Check for correctness of CT and PT connections provided. Check electrical continuity of secondary with ELV tester.
- x) Check operation of instruments, meters, relays and tripping of circuit breakers by primary/ secondary injections as specified.
- xi) Check continuity of power circuits and earth continuity of all non current metallic parts with a low voltage a (6 volts or less) continuity tester.

III MOTOR CONTROL CENTRES, SWITCHGEARS/LV PANEL/APFC PANEL

- i) Check equipment, internal wiring, smooth mechanical operation, interlocks etc.
- ii) Check continuity of power circuits and earth continuity of all non current carrying metallic parts with a low voltage continuity tester.
- iii) Insulation test for power and control circuits between phases, between phases and neutral and between phase/neutral and ground.
- iv) Check operation by energizing control circuits (without energizing power circuits) for correct functioning. Simulate external controls and interlocks for the same. Note chatter or humming of contactor and rectify, in necessary.
- v) Check fuse ratings and adjust relay setting (overhead, single phasing preventers etc) in accordance with load ratings.
- vi) Polarity and connections of instrument transformers – Check for correctness of CT and PT connections provided. Check electrical continuity of secondary circuits with ELV tester.

IV MOTORS AND ROTATING EQUIPMENT

- i) Check equipment for free movement of rotor, and play, lubrication and for any other visual checks.
- ii) Insulation test of motors – between winding and ground. Use 500V megger for MV motors and 1000V megger for HV motors.
- iii) Check electrical continuity with ELV tester.
- iv) No load running of motor noting down no load current and voltages in all three phases.

V CABLES

- i) Insulation Test between each phase and neutral and between each phase/neutral and ground.
- ii) DC high voltage test on HV cables in accordance with the relevant Indian Standards and Code of Practice. This test shall be carried out on cables installed in final positions, and all joints and terminations have been made. The cables, however, may not be connected to the equipment, so that the equipment may not be subject to the test voltage.

- iii) In case of lighting wiring, insulating test shall be carried out on lighting feeders with branch circuits open. Branch circuits shall be tested separately with lamp holders, plug receptacles and lighting fittings in position, but without lamps. In case of lighting circuits will lamp ballasts and glow starters, insulation resistance may be measured between phase and ground only.
- iv) In case of directly buried cables, insulate resistance of cables shall be measured before and after the back fillings.
- v) Test all receptacles for correct phase sequence.

VI EARTHING SYSTEM

- i) Measure earth resistance of each electrode separately. If a number of earth electrodes are interconnected with one another, combined earth resistance shall also be measured. The earth resistance of each electrode and/or a group of electrodes shall not exceed the values specified.
- ii) Carry out line earth loop impedance test. The loop comprises the line conductor from the point of fault, back to the supply transformer, the path through transformer winding, the earthed neutral point of the transformer and path for that point to the point of fault through the earthing system.
- iii) Continuity test for earth continuity conductors with ELV tester.

VII DG set : All standard tests as per engineering practice are to be conducted as specified elsewhere in the technical specification of the tender.

9.0 STATUTORY APPROVALS

The Contractor shall be totally responsible for obtaining statutory approval from the electrical inspector, PGVCL or any other statutory authority for the entire installation including DG Set, Transformers carried out by him unless otherwise specified and agreed. Necessary test reports shall be submitted by him to electrical inspector. This will be an integral part of the contract and shall not be paid for separately. **The contractor shall liaison with local electric supply company for getting power supply and only necessary fees, if any, payable to supply company shall be borne by the Owner. If RMC insist Initially Agency must pay the required fees. After presenting receipt of such payment, RMC will reimburse all such fees to Agency.**

10.0 ACCEPTANCE OF INSTALLATION/ERECTION

On completion of the work the Engineer-in-charge, together with the Contractor, will carry out an inspection of the Installation. The Engineer-in-charge will issue a completed copy of the Client's Acceptance of Electrical Installation to the Contractor as confirmation that the works have been accepted, subject to any matters noted on the form being attended to.

11.0 PRICE BREAKDOWN

- 1.1 Whenever requested by the Engineer-in-charge, the contractor shall furnish detailed price breakdown for supply and installation of each of the items of electrical works including for each type/size of applicable cable/light fitting/earth pit/earth stations.
- 1.2 This breakdown prices are required for the purpose of justification for progress payment and also for working out addition and deletion, if any, in the scope of work at a later date.

12.0 VENDOR DATA REQUIREMENTS

Following minimum documents shall be submitted by contractor along with the bid as well for review and approval during detailed engineering, as indicated.

Sr. No.	Description	With Bid/ Offer	For Review/ Approval	As Built
1	Technical Details for Major Equipment		*	*
2	List of Recommended Spares		*	*
3	Data Sheets/GA drawings/BOM/SLD/Wiring and Schematic Diagrams for Power and Control Circuit/Data sheets of Relay for 11kV HV VCB Panel/Transformers/Motor/Bus Duct/DP Structure as applicable		*	*
4	GA Drawings with sectional view, door open view, top and bottom view, Rear view, Mounting plate details etc./BOM/SLD/Wiring and Schematic Diagrams for Power and Control circuit for LV Panel/Starter/APFC Panel/Bus Duct		*	*
5	Technical Data Sheet/Catalogue of ACB, MFM, Soft Starter, VFD, APFC Relay, Detuned Reactor		*	
6	GA Drawing/BOM/Technical Details for LCS/Indoor and Outdoor Light Fixtures /LDB/Switch Board/Safety Equipment		*	*
7	Data Sheet and BOM for Cable Tray		*	*
8	Cable Schedule/Data Sheet/Make and Type for HV/LV Power and Control Cables.		*	*
9	Earthing (Grounding) System Calculation and Details		*	*
10	Lightening Protection System for Buildings and Structures (If and as Applicable)			
11	RCC Foundation Details for various Electric Equipment.		*	*
12	Inspection Schedule and QAPs for Major Equipment		*	
13	Test Certificates		*	*
14	O and M Manual (If and As Applicable)		*	*

14.0 APPROVED VENDOR LIST – ELECTRICAL EQUIPMENT AND COMPONENTS

ITEM DESCRIPTION	APPROVED MAKE
MV SWITCHBOARD & MV SWITCHGEAR / HT PANEL-11 / 33kV - INDOOR / OUTDOOR TYPE (VCB/SF6)	ABB / BHEL / GE / JYOTI / L&T / SCHNEIDER / SIEMENS
RING MAIN UNIT (RMU) MV - 11 / 33kV - INDOOR / OUTDOOR TYPE (VCB/SF6)	ABB / BHEL / GE / JYOTI / L&T / SCHNEIDER / SIEMENS
PROTECTIVE RELAYS (NUMERICAL TYPE)	ABB / ALSTOM / GE / L&T / SCHNEIDER / SIEMENS
PROTECTIVE / AUXILIARY RELAYS (ELECTROMECHANICAL TYPE)	ABB / ALSTOM / EASUN REYROLLE / GE / L & T / SCHNEIDER / SIEMENS
INSTRUMENT TRANSFORMERS (CT / PT / CBCT)	AUTOMATIC ELECTRIC / AEP / ASHMOR / ECS / GILBERT AND MAXWELL / INDCOIL / JYOTI / G SONS POWER / KAPPA / PRAGATI / PRECISE / SILKAANS
SURGE SUPPRESSORS	ABB / EMERSON / ERICO / MTL / OBLUM / PEPPERL+FUCHS / PHOENIX / RAYCHEM SCHNEIDER / SIEMENS / WEID MULLER
LIGHTNING ARRESTORS	BIRLA NGK INSULATORS / DHRUVA / ELPRO / JEF / JAYSHREE / OBLUM / WS
ALARM ANNUNCIATORS (SOLID STATE TYPE WITH LED ILLUMINATION) / FACIA ANNUNCIATOR	APLAB / ALSTOM / DIGICONT / ICA / IICP / MINILEC / PROCON INST. (P) LTD / PROTON ELECTRONICS
BATTERY BACKED POWER PACK	ALAN / BHARANI / GOGATE / G'LEC
BATTERY CHARGER & DCDB	AMARA RAJA / AMCO POWER / AUTOMATIC ELECTRIC / CALDYNE AUTOMATICS / CHHABI ELECTRICALS / EXIDE / ELECTRONIC SYSTEMS / HBL POWER SYSTEMS / HIREL-HITACHI / MASS- TECH CONTROLS / UNIVERSAL INSTRUMENTS / SERVILINK
SMF / VRLA / NI-CD / LEAD ACID (PLANTE / TUBULAR) BATTERY	AUTOMATIC ELECTRIC / AMARA RAJA BATTERIES LTD / AMCO / EXIDE / FUJIYAMA / HBL POWER SYSTEMS LTD / LUMINOUS POWER / OKAYA
ELECTRONIC CIRCUIT RELAY	ALLEN BRADLEY / OEN / OMRON / PLA
CONTROL AND RELAY PANEL	ABB / ALSTOM / GE / EASUN REYROLLE / L&T / SCHNEIDER / SIEMENS
DISTRIBUTION TRANSFORMERS	ABB / BBL / BHEL / GE / KEC / SCHNEIDER / G SONS POWER / TRANSFORMERS & RECTIFIERS INDIA LIMITED / VOLTAMP

SANDWICH BUS TRUNKING (BUS DUCT)	ABB / L&T / SCHNEIDER / SIEMENS
PANEL CRCA / MS / GI PLATES & SHEET	ARCEL OR MITTAL / ASIAN / ESSAR / JINDAL / SAIL / TATA
ALUMINIUM BUSBAR MATERIAL	BANCO / HINDALCO / JINDAL / STERLITE
COPPER BUSBAR MATERIAL	HINDALCO / JINDAL / STERLITE
LV SWITCHBOARD - DRAWOUT / FIXED TYPE (PCC-LVDB / PMCC / MCC / MLDB / MPDB / MOVDB / APFC)	ABB / ALPHA NIPPON / INDUSTRIAL CONTROLS / L&T / SCHNEIDER / SIEMENS / ALSTOM / JYOTI / G SONS POWER / ELEMICA / SWATI SWITCH GEAR
ACTIVE HARMONIC FILTER SOLUTION / PANEL	ABB / AMTECH / AB LIFASA / CONSULE NEOWATT / DANFOSS / EPCOS / FUJI ELECTRIC / NEPTUNE / SCHNEIDER / SCHNEFFER / SUBODHAN / SHREEM / TRINITY
APFC PANEL	ABB / ASIAN / ALSTOM / DATAR / EPCOS / L&T / SCHNEIDER / SIEMENS / ALL APPROVED VENDORS FOR LT PANEL
DETUNED SERIES REACTORS WITH TEMPERATURE MICRO SWITCH (HARMONIC FILTER REACTOR)	ABB / EPCOS / NEPTUNE / SUBODHAN / VISHAY / YESHA / WHEPL
DYNAMIC POWER FACTOR CORRECTION THYRISTOR MODULE	ABB / EPCOS / NEPTUNE / SUBODHAN / SCHNEIDER
CAPACITOR DUTY CONTACTOR	ABB / EPCOS / L & T / SCHNEIDER / SIEMENS
AC/DC POWER & AUXILLARY CONTACTOR	ABB / BCH / GE / INDO ASIAN / L&T / SCHNEIDER / SIEMENS
MV CAPACITORS	ABB / EPCOS / SHREEM / UNIVERSAL / VISHAY
LV CAPACITORS/ POWER CAPACITOR	ABB / ASIAN / BHEL / EPCOS / GE / HAVELLS / KHATAU JUNKER / MADHAV / MALDE / NEPTUNE / PRABODHAN / POWER MATRIX / SCHNEIDER / SUBODHAN / SHREEM / SIEMENS / UNIVERSAL /VISHAY
SOFT STARTER (MICRO PROCESSOR BASED)	ABB / DANFOSS / ROCKWELL / SCHNEIDER / SIEMENS / L&T
VVVF DRIVES (VFD)	ABB / DANFOSS / ROCKWELL / SCHNEIDER / SIEMENS / YASKAWA
SEMICONDUCTOR FUSE	BUSSMANN / FERRAZ / GE / SIEMENS
HRC FUSE (POWER & CONTROL)	ABB / GE / INDO ASIAN / L & T / SCHNEIDER / SIEMENS / TECHNOELECTRIC
AIR CIRCUIT BREAKERS	ABB / LEGRAND / L&T / MITSUBISHI / SCHNEIDER / SIEMENS
MCCB'S	ABB / GE / LEGRAND / L&T / MITSUBISHI /

	SCHNEIDER / SIEMENS
MPCB	ABB / INDO ASIAN / L&T / MITSUBISHI / SCHNEIDER / SIEMENS
MCB / RCCB / RCBO / ISOLATORS	ABB / GE / HAVELLS / INDO ASIAN / LEGRAND / L&T / MITSUBISHI / MOELLER / SCHNEIDER / SIEMENS
SWITCH DISCONNECTOR FUSE UNIT (SDF) AND SWITCH DISCONNECTOR ISOLATOR	ABB / GE / INDOASIAN / L&T / MITSUBISHI / SCHNEIDER / SIEMENS
CHANGE OVER SWITCH	ABB / BCH / GE / HAVELLS / HPL / KRAUS & NAIMER / L & T / SCHNEIDER / SIEMENS
TEMPERATURE SCANNER WITH RS 485 MODBUS COMMUNICATION	ELECTRONET / MULTISPAN / MASIBUS / NIVAM / NISHKO / REDIX / SELEC
KWH / LOAD MANAGER / MULTI FUNCTION METER	ABB / CONZERV / ENERCON / IMP / KRYKARD / L&T / MECO / RISHABH / SCHNEIDER / SECURE
DIGITAL AMMETER / VOLTMETER / POWER FACTOR METER	ABB / ALSTOM / AE / ASIAN / CONZERV / IMP KRYKARD / L&T / MECO / MASIBUS / MULTISPAN / NEWTEK ELECTRICALS / RISHABH / SCHNEIDER / SECURE / SIEMENS
ANALOG (ELECTROMECHANICAL) METERS – AMMETER & VOLTMETER	AE / IMP / MECO / RISHABH / SELEC
HANDHELD DIGITAL MULTIMETER / CLIP-ON METER / MEGGER	FLUKE / IMP / MECO / MOTWANE / RISHABH
CONTROL / SELECTOR SWITCH	ABB / ALSTOM / BCH / EE / GE / HAVELLS / JYOTI KAYCEE / L&T / RECOM / SCHNEIDER / SIEMENS / SULZER
INDICATING LAMPS	ABB / BCH / EE / IEC / L&T / SCHNEIDER / SIEMENS / TEKNIC CONTROLS / VAISHNO
PUSHBUTTONS	ABB / BCH / L & T / RASS / SCHNEIDER / SIEMENS / TEKNIC / VAISHNO
CONSTANT VOLTAGE TRANSFORMER/CONTROL TRANSFORMER	AE / ASHMORE / G & M / INDCOIL / NEC / PRAGATI / PRECISE / SILKAANS
MICROPROCESSOR BASED MOTOR PROTECTION RELAY WITH RS 485	ABB / EXCEL-TECH INDIA / L & T / PROK DEVICES / SCHNEIDER / SIEMENS
BI-METAL / ELECTRONIC / MICROPROCESSOR BASED OVERLOAD RELAY	ABB / ALSTOM / CG POWER / GE / INDO ASIAN / L&T / SCHNEIDER / SIEMENS
THERMISTER RELAY	ALSTOM / INSTA CONTROLS / MINILEC / SELEC
SINGLE PHASING PREVENTER WITH UV/OV PROTECTION	ABB / GE / L&T / MINILEC / SCHNEIDER / SIEMENS

TIME SWITCH	GIC / LEGRAND / SCHNEIDER / SIEMENS / THEBEN
TIMERS / TIME DELAY RELAY	ABB / BCH / EAPL / ELICO / INDO ASIAN / LEGRAND / L&T / MINILEC / OMRON / PLA / SCHNEIDER / SIEMENS / TEKNIC / THEBEN
PANEL VENTILATION FAN	COOLTRON / HICOOL / NADI / REXNORD
TERMINAL BLOCK/CONNECTORS	CONNECTWELL / ELMEX / PHEONIX / TELEMCHANIQUE / WAGO
LIGHTING / SMALL POWER DISTRIBUTION BOARDS / ENCLOSURES	ABB / BCH / ELDON / ENCLOTEK / HENSEL / HAVELLS / INDO ASIAN / LEGRAND / L&T / RITTAL / SCHNEIDER / SIEMENS / STANDARD ELECTRIC / ALL APPROVED VENDORS FOR LT PANEL
PUSH BUTTON STATIONS / JUNCTION BOX (FOR CAST ALUMINIUM ONLY)	BALIGA / BCH / CEAG / EXPROTECTA / EXCEL / FCG FLEXPRO / HANSU / HENSEL / PUSTRON / SCHNEIDER / SIEMENS / SUDHIR
NON METALLIC ENCLOSURES (INCLUDING INDUSTRIAL RECEPTACLES / PB STATION)	BCH / HENSEL / LEGRAND / PUSTRON / RITTAL / SCHNEIDER / SIEMENS / SINTEX
MOTORS (LV)	ABB / BBL / BHEL / CG POWER / JYOTI / KEC / LHP / MARATHON / SIEMENS
CABLES HV - XLPE INSULATED	ASIAN CABLE / FINOLEX / GLOSTER / HAVELLS / KEI / POLYCAB / TORRENT CABLES / UNIVERSAL
CABLES LV - POWER & CONTROL CABLES / EARTHING CABLES	ASIAN CABLE / AVOCAB / FINOLEX / GLOSTER / HAVELLS / KEI / LAPP / POLYCAB / RR KABEL / TORRENT / UNIVERSAL CABLES
WIRES - FLEXIBLES (ALL TYPES)	AVOCAB / ANCHOR / ATLAS / FINOLEX / GLOSTER / HAVELLS / KEI / L&T / LAPP / POLYCAB / RR KABEL / UNIVERSAL
GI / FRP CABLE TRAYS, ANY OTHER FRP ITEMS	DUDHAT INFRA / FIBER TECH COMPOSITE / GLOBE / INDIANA / JACINTH / LEGRAND / KISMAT ENGITECH LLP / M.M. ENGINEERING / SHARDA / SILVERLINE POWER / SHREE KRISHNA ENGG. / SUPER ELECTRO / SUMIP / SATYAM COMPOSITES / VATCO
CABLE GLANDS (SINGLE / DOUBLE COMPRESSION, NI PLATTED BRASS)	BALIGA / BRACO / COMET / EX-PROTECTA / ELECTROMECH / FCG / HMI / JAINSON / SIEMENS / SUDHIR
CABLE GLANDS – POLYAMIDE	FIBOX / GEWISS / HENSEL / LAPP
CABLE LUGS	3D / 3M / COMET / CONNECTWELL / DOWELLS / JAINSON
CABLE TERMINATION/JOINTING KITS	3M / ABB / CCI / KABELDON / M SEAL / RAYCHEM / XICOM
UPVC CONDUIT & ACCESSORIES	AKG / BHAGYALAXMI PIPE INDUSTRY / CLIPSAL / L&T / POLYCAB / PRECISION / SALZER / ANY OTHER FOR UPVC PIPES AS PER MECHANICAL VENDOR LIST
MS / GI CONDUIT & PIPES	BEC INDUSTRIES / JINDAL / JK TUBE / SAIL / TATA

	STEEL / ZENITH / ANY OTHER FOR MS/GI PIPES AS PER MECHANICAL VENDOR LIST
HIGH MAST LIGHTING SYSTEM	BAJAJ / CGL / PHILIPS / SURYA / VALMONT
MS / GI LIGHTING POLES & BRACKETS (TUBULAR SWAGED / OCTAGONAL)	AMBICA POLES PVT LTD / BAJAJ / BOMBAY TUBES AND POLES / FABIRON /KISMAT ENGITECH LLP / GAYATRI ELECTRICALS / INDIA ELECTRIC POLES / UTKARSH INDIA
LIGHT FIXTURES	BAJAJ / CGL / GE / HAVELLS / L&T / PHILIPS / SCHREDER / WIPRO
DECORATIVE / MODULAR SWITCH & SOCKET	ABB / ANCHOR / CLIPSAL / CRABTREE / HAVELLS / INDO ASIAN / L&T / LEGRAND / MK-HONEYWELL / MDS / SIEMENS / SCHNEIDER / TOYAMA
CEILING / WALL MOUNTING /PEDASTAL/ EXHAUST FANS	ATOMBERG / ALMONARD / BAJAJ / CGL / HAVELLS / KHAITAN / ORIENT / USHA
CHEMICAL TYPE EARTHING INCLUDING COPPER BONDED ELECTRODE & BACK FILL COMPOUND	ASHLOK / CURSP / ECO TECHNOLOGY & PROJECTS/ ENNOV INFRA / ERICO / ISG GLOBAL / JEF / PRAGATI ELECTROCOM / SAARA EARTHING/ EQUIVALENT REPUTED MAKE SUBJECT TO CLIENT APPROVAL
DIESEL ENGINES	BAUDOUIN / CATERPILLAR / CUMMINS / KOEL / MITSUBISHI / PERKINS / VOLVO
ALTERNATORS FOR DG SETS	BHEL / CGL / JYOTI / KEC / KOEL / LEROY SOMER / NGEF / STAMFORD
AMF RELAY, SYNCHRONIZING RELAY (WITH RS 485)	DEEP SEA / DEIF / WOODWARD

Remarks:-The contractor shall distinctly understand that it will not be their prerogative to insist on a particular brand from the list, and final selection will be done with the approval of Engineer-in- charge.