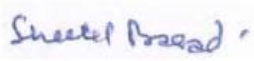


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**Technical specification
for
Supply of Balance of System items and Installation and Commissioning
of
20MW (AC) Solar Photovoltaic Grid-connected Power plant
at
NTPC Gandhar, Gujrat**

Revision details: R01 dated 06-11-2020 Clause 1, 1.4, 5.5, 5.7, 5.17 to 5.23, 5.25, 5.27, 5.30, 5.36, 8.0 and Annexure 1 (clause 5) modified. The changes are highlighted wherever made.	Prepared  Sheetal Prasad	Approved  Prachi Rao V	Date: 26.10.2020
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1.0 Introduction

1.1 Overall project outline of 20MW (AC) solar photovoltaic power plant

Bharat Heavy Electricals Limited (BHEL), Electronics Division, Bangalore is setting up a Solar photovoltaic (SPV) power plant for NTPC at Gandhar, Distt Bharuch, Gujarat within Gas Based Power Plant Installation.

Solar PV modules employed at the plant generates DC electricity that in turn is inverted to AC in the range 600-700 V. **DC installation is 29MW approximately.** Output of each solar block (5MW) with independent Inverter station (IR) / transformer yards shall be stepped up to 33kV. Solar plant comprises of 4 no of Inverter stations (Containerized PCUs) with each associated 5 MW PV array and 1 no. of Main Control Room (CMCS/ CR). All the blocks are combined to achieve the 20MW output as per the power plant rating at main pooling switchgear.

Power evacuation is at 220KV level. From main pooling switchgear, cable/ transmission line shall be run upto Power transformer in 220KV Switchyard bay proposed for solar plant in existing NTPC Switchyard. The 220 kV Switchyard shall be with Double Main Bus & Transfer Switching Scheme as indicated in Tender SLD.

Details are given in subsequent clauses

The plant is envisaged to have several other infrastructural support systems such as module cleaning system for SPV modules, plant illumination system, fire alarm system, boundary fencing, approach roads, pathways, drainage system etc.

1.2 Scope of this tender specification

Vendor scope includes supplies and activities but not limited to design, engineering, drafting of drawings, obtaining approval from BHEL/NTPC/STU/PGCIL/GETCO/ GEDA/ CEIG /CEA whichever is applicable for the drawings, manufacture/ testing/ inspection at manufacturer's works, packing, supply, transportation, transit insurance, delivery to site, unloading, storage, erection, coordination / liaison with concerned state / central authorities such as GETCO/ CEIG/ CEA/ GEDA etc, and commissioning for the following activities of the project as detailed in this specification.

Solar plant installations as detailed in this specification upto main pooling switchgear is in scope of vendor. 33KV cabling from main pooling switchgear to power transformer and 220KV installations till power evacuation point in 220KV switchyard is in scope of 220KV Switchyard contractor's scope.

Note: The above is only a broad outline of vendor scope for the sake of introduction. The detailed vendor scope is elaborated under various other sections of this specification.

1.3 Enclosures to this tender specification (Tender purpose only)

1	Tentative AC single line diagram of overall Solar PV power plant
2	Tentative SPV plant layout with solar array, control/ inverter rooms
3	Tentative Quality Assurance plants
4	Tentative Manufacturing and Field Quality plans
5	NTPC Approved Vendor List

2.0 Location/ address of power plant:

The 20 MW Solar PV Plant shall be setup at NTPC Gandhar Gas Power Plant in Gujarat.

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District	Bharuch, Gujarat
Nearest Highway	NH 64 (10 km)
Nearest Railway Station	Bharuch Jn (25 km)
Nearest Commercial Airport	Vadodara (78 km)
Indicative Coordinate	21°49'19.0"N 73°06'53.0"E

3.0 Vendor scope of supply, Installation and Commissioning

The table below indicates the scope of work for the vendor, as briefly outlined. Note that this is not an exhaustive list, supplies and activities will be in line with detailed specification clauses.

#	Scope of work (as briefly outlined)	Qty
1	Supply of MC4 and Y connectors, cable ties, HDPE conduits, cable lugs, hardware etc	1 set
2	Supply of LT control / instrumentation cables with cable installation accessories, hardware, termination kits etc	1 set
3	Supply of UPS panels, ACDB, UPS DB, Batteries, ONAN Aux transformer, Dry Type Aux transformer etc with all related accessories and hardware	1 set
4	Supply of items for module cleaning system	1 set
5	Supply of items of earthing system for solar array field, inverter/CMCS room panels, transformer yard / pooling yard equipment etc including earthing electrodes, Copper flats, earthing cables, GI wires, MS rods (earth mat), earth chamber lids and all related miscellaneous hardware etc	1 set
6	Supply of lightning arrestors along with poles/masts, down conductors, all related accessories and hardware for the complete solar power plant	1 set
7	Supply of items for plant lighting system such as electric poles, bend pipes, luminaires/lamps, ballasts, junction boxes, cable conduits, fittings/clamps, other related accessories and hardware etc	1 set
8	Supply of miscellaneous items such as SMB mounting hardware, weather monitoring system, cable route markers, cable tags, danger boards, hoarding boards, sign boards, display boards, electrical insulation mat, air conditioners, SCADA office furniture etc	1 set
9	Supply of safety related items including fire alarm systems for inverter station /CMCS rooms, fire extinguishers, safety gadgets etc	1 set
10	Supply of spare items	1 set
11	I&C: Electrical works in Inverter station, pooling yard, transformer yard etc	1 AU
12	I&C: Interconnection of SPV modules, erection of SMB mounting structures, installation of string monitoring boxes including power cable terminations etc.	1 AU

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13	I&C: Underground cable trenches & laying of cables for LT AC/DC power cables, HT (33kV) cables, data communication / control / SCADA / OFC cables etc.	1 AU
14	I&C: Erection of indoor / outdoor electrical panels (PCU containers, VCB breaker panels, SCADA etc) at the inverter station laying & fixing of cable trays, routing and terminations of DC/AC cables (HT, LT, data / control) at the electrical panels up to LV side of inverter/auxiliary transformers, laying of earth grids (external underground / internal within the rooms), earthing connections etc.	1 AU
15	I&C: Erection of indoor outdoor electrical panels (VCB breaker panels, SCADA, ACDB/DCDB panels, UPS panels, Aux transformers etc) in the main CMCS control room, 33KV pooling yard laying & fixing of cable trays, routing and terminations of HT, LT, data/control at the electrical panels, auxiliary transformers cabling, laying of earth grids (external underground / internal within the rooms), earthing connections etc	1 AU
16	I&C: Erection of 33kV transformer yards attached to the 4 inverter stations with necessary land leveling within the yards, laying of underground earth mat grid, erection of inverter transformers, underground cable trenches, routing and terminations of 33kV/LT/ data/ control cables at inverter transformers etc	1 AU
17	I&C of module cleaning system	1 AU
18	I&C: Installation works of Weather monitoring station and SCADA system laying and terminations of OFC/ instrumentation/ data cables etc at SCADA panels of inverter station and CMCS room	1 AU
19	I&C: Earthing system for solar array field including laying of underground earth mat grids and interconnection to the module mounting structures, I&C of lightning protection system (lightning arrestors) with earthing provisions as per respective clauses	1 AU
20	I&C of lighting system for illumination of the complete power plant including cable terminations at the yard lighting poles as well as ACDB panels of inverter station / main control room etc as.	1 AU
21	I&C of miscellaneous and safety items such as cable tags, danger boards, cable markers, hoarding board, sign boards, display boards, electrical insulation mat, checkered plates, air conditioners, SCADA office furniture, fire extinguishers, fire alarm system, firefighting system, LED display for SCADA system, grouting of electrical panels in inverter station/CMCS rooms etc	1 AU
22	I&C: Pre-commissioning inspections / checks / tests, MRT tests and coordination with state / central departments / CEA/ CEIG etc for necessary approvals / clearances for commissioning, synchronization with grid and post-commissioning operation of the plant (Trial run and site cleaning)	1 AU

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NOTE- It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning for safe and satisfactory operation of the plant shall be included under scope of the bidder.

4.0 BHEL scope of supplies and works

For clarity to the vendor, other items and activities within BHEL scope of solar PV plant end of the project are listed below:

	Solar PV Modules	~29 MW eq
1	Supply of 1C x 4 sqmm Solar Cable	~180 KM
2	Supply of DC cable, 3.3KV 1C x 400 sqmm, Al, XLPE, armoured as per IS: 7098 (from SMB to PCU)	~55 KM
3	Supply of LT cable, 3.3KV 1C x 400 sqmm, Al, XLPE, armoured as per IS: 7098 (from PCUs to Inverter transformers)	~3.5 KM
4	Supply of 33kV cable, 1C x 240, Al, XLPE, armoured as per IS: 7098 (for all 33kV connections within solar plant including Aux transformer HV side)	~9 KM
5	Supply of containerized power conditioning units (PCUs) of 2 x 2.5 or 1 x 5 MW with Dry type Auxiliary transformer, UPS, ACDBs for Inverter stations	4 Sets
6	Supply of String Monitoring Box	104 Sets
7	Supply of inverter transformer 5.3MVA, 33kV/xxx-xxx V, ONAN	4 Nos
8	Supply of 33kV breaker panels	5 Sets (12 Nos)
9	Supply of SCADA system including PLC panels, computers, software systems and related peripherals & accessories	5 set
10	Supply of GI earthing strips for PV array, Inverter station, 33Kv pooling yard, control room	1 Set
11	33KV cabling/ Line work from main pooling switchgear to Power transformer	1 set
12	220KV Switchyard works	1 set
13	Supply and Installation of Module mounting structure including module mounting	~1616 Sets
14	Construction of Inverter and aux transformer foundations including fencing	1 Set
15	Construction of foundation for Inverter station, 33KV pooling yard	1 Set
16	Unloading/ storage/ security for BHEL supplied items.	-
17	Construction of RCC main control room except those vendor scope supply/I&C activities defined under this specification.	1 room
18	Construction of civil works such as approach roads, pathways, drains, overall plant boundary fencing, soak pit, septic tank.	-

5.0 Technical specification for supply, installation and commissioning

#	BHEL specification
5.1	Temporary site office for vendor use Vendor shall make necessary office arrangements such as porta cabin, furniture, electrical points/ fittings etc. on their own for their use/ occupation at site during the period of project execution. Note: Site offices for BHEL and NTPC shall be arranged by BHEL.

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5.2	Electrical power / water for construction Vendor shall organize, on their own, necessary electrical power supply such as DG sets and water supply etc. required for construction activities.
5.3	Construction of temporary yards for safe storage of vendor supplied items Vendor shall, at a suitable location at the site, as decided based on discussions with BHEL site engineer, construct temporary yards for safe storage of vendor supplied items.
5.4	Unloading, safe storage and movement of supply items received at site: A. Items supplied by vendor (1) Vendor shall organize all necessary resources such as labour, machinery and tools (cranes, hydra, forklifts, transportation trucks/ trolleys, lifting accessories etc.) for unloading the items (supplied by the vendor) received at site and subsequent movement to storage yards. (2) Similar arrangements shall also be made by vendor for movement of the stored items from storage yards to the exact construction locations within the project site. Vendor shall bring the unused material back to stores on daily basis. (3) Vendor shall maintain proper documentation / compilation of all the records related to shipping (invoices, LRs, delivery challans, material receipt certificates etc.) and shall take approval from BHEL site engineer for every consignment. The documents shall be suitably preserved for further handing over to BHEL. (4) Registers shall be maintained for the yard to keep track of incoming/outgoing items. (5) Safety of items shall be in vendor scope. Accordingly, suitable watch and ward shall be deployed on round-the-clock basis. B. All other items (supplies from BHEL and other vendors) (1) Receipt, unloading, storage, security guards shall be in scope of BHEL/ other vendors. (2) However, movement of these items from their respective storage locations to the points of construction is in scope of vendor (excluding modules and MMS). Accordingly, vendor shall organize all necessary resources such as labour, machinery and tools (cranes, hydra, forklifts, transportation trucks/ trolleys, lifting accessories etc.) for this purpose as and when required. Vendor shall bring the unused material back to stores on daily basis. (3) Vendor shall maintain proper documentation / compilation of all the records related to shipping (invoices, LRs, delivery challans, material receipt certificates etc.) and shall take approval from BHEL site engineer for every consignment. The documents shall be suitably preserved for further handing over to BHEL.
5.5	Series interconnection of SPV modules to form strings Supply of SPV modules is in BHEL scope. Type of module: L24270 (~330Wp). Total quantity = ~90,000 Nos Vendor shall interconnect the SPV modules as follows: (a) Each module is fitted integrally with a junction box having positive and negative polarity cables (4 sq-mm). (b) Positive cable of one module shall be connected to the negative cable of adjacent module. The cables have MC4 type of connectors. One polarity cable has male type connector, while the other has female type connector. (c) This way, 30 modules shall be connected in series. Each set of connections is called as a sub string. (d) There are two types of tables-Full table with 60 modules and half tables with 30 modules. Sets of series strings (of 30 modules) will be formed via leap-frog method. After placing the purchase order on vendor, BHEL will provide layout drawings that will describe the exact way in which the series strings are formed. Vendor shall implement the interconnection as per these drawings.

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5.6	Routing of 1Cx 4 sqmm cable below the SPV modules (1) 1Cx4 sq-mm cables connecting the SPV module strings to SMBs suitably routed below the SPV modules and along the horizontal C-lip purlin member of MMS structure. These cables shall be dressed properly and fastened to the purlin using UV resistant cable ties of suitable length. (2) Cable ties shall be in vendor scope of supply. (3) Cable ties, nylon polyamide 6.6 UV stabilized black, UL94 flammability rating V2, operating temperature up to 85 deg C, shall be used to arrest any possibility of movement or sagging. Cable ties shall be of make: 3M, Phoenix contact, Weidmuller, Hellermannntyton, Panduit or other reputed equivalent subject to approval of BHEL/NTPC. Width and Length shall be so appropriate as to ensure that the bunched cables are held firmly to the mounting structure. Spacing between two adjacent cable ties shall be so appropriate as to ensure that there is no loose hanging of cables. During detailed engineering, BHEL/NTPC approval shall be obtained for the selected brand and sizes of cable tie. (4) Spacing between two adjacent cable ties shall be so appropriate as to ensure that there is no loose hanging of cables. (5) Solar cables, wherever exposed to direct sunlight (including gaps between tables) and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.
5.7	Interconnection of SPV module strings to 1Cx4sqmm cable and Supply MC4 & Y-connectors (1) Vendor shall connect two series sub-strings of 60 SPV modules (each of 30 SPV modules) to 1Cx4sqmm cable (copper, XLPO insulation cable) using Y-connector and MC4 connectors. For full tables of 60 modules, the same can be done through Y connector. For half tables, 4sqmm cables will run from one half table to another half table for formation of 60 modules string. These cables shall run underground through HDPE pipe. Supply of additional MC4 connectors and HDPE pipe towards this will be in vendor's scope. (2) Vendor shall supply ~1500 sets (1 set = 2 nos) each of Y-connectors and ~3000 sets (1 set = 1 male + 1 female connector) MC4 connectors. Supply of additional MC4 connectors towards formation of 60 module string for half tables will be informed during detailed engineering. These quantities are excluding spares requirement. (3) Extra quantity shall be procured for any damages / pilferage during the installation by vendor at site. Such additional quantities will not be paid for. Vendor shall ensure that there shall not be any shortage during execution time. (4) Four sets of tool kits shall be supplied. This shall include crimping plier MC4, open end spanner set MC4, stripping plier MC4, socket wrench insert to tighten, socket wrench insert to secure, inserts for 4 sq-mm. (5) MC4 and Y connectors to be supplied and installed shall be In accordance with IEC 62852: 2014. Rated Current, IEC (85 degC) - 30A Rated Voltage- 1500 V Connector design- Snap in Locking Type Protection degree- IP68 (mated) Ambient Temperature- (-) 40 degC to (+) 85 degC Protection/Safety Class- Class II Contact material- Cu Contact Surface material- Silver/ Tin Contact resistance for plug connector- <= 0.5 milli-ohms Stripping length- 10 mm Inflammability Class acc to- UL 94-V0

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	Insulating material- PPE/ PPO/ Polyamide Pollution degree- 3 Certification- UL/TUV/CSA/EAC or equivalent The MC4 and Y connectors proposed shall have type test certificates for the following- I. Protection Degree (IP) II. Operating Temperature III. Inflammability IV. Pollution Degree V. Voltage Withstand (Rated Voltage/Test Voltage) VI. Product Certification (7) vendor shall ensure that MC4 and Y connectors to be mated shall be of same make and model as in SMB and PV modules. In case other make/ models are offered, vendor shall type test for Inter-compatibility as per clause no.6.3.11 of IEC 62852:2014 for offered make(s). Mating of connectors of different makes/model shall not be acceptable if not tested for inter-compatibility by any accredited lab. (6) Approved make: Multicontact, Bizlink, Sunlont, Elmex or other reputed equivalent subject to BHEL/ NTPC approval during detailed engineering. (7) In addition, any other required tools and tackles for crimping of cable etc. shall be arranged by vendor.
5.8	Installation of string monitoring boxes including supply/erection of mounting structures (1) Supply of string monitoring boxes (SMB) with wireless communication, 104 sets, is in BHEL scope. These are 16-in/ 1- out type. SMBs will be supplied along with transmitter and receiver antennas and communication setup for SCADA. (2) SMB shall be mounted with fixing frame on the Module Mounting structures. Provision will be provided in the Module mounting structure to mount the SMB. Frame for mounting of SMBs will be supplied separately by BHEL. However, necessary hardware like nuts, bolts, washers etc shall be in the vendor scope of supply. SMB antenna will be installed with necessary accessories. All hardware like nuts bolts washer etc are in scope of bidder. Antenna fixing on/ near each Inverter room/ MCR is also in scope of vendor. All required structure/foundation/grouting/ hardware supply and work is in scope of vendor. Fixing of accessories and cabling upto SCADA is in scope of vendor. (3) Vendor shall install the SMBs on the module mounting structures. (4) All necessary labour, tools, machinery etc for erection work shall be in vendor scope.
5.9	Routing of 1Cx4sqmm cable in DWC HDPE pipes underground between the rows of solar array (1) Where 1Cx4sqmm cables run vertically along MMS leg or between two rows of structure (or) where the cables cross over the pathway separation between two adjacent solar array blocks, HDPE double walled corrugated (DWC) pipe shall be provided to route the cables underground from one row/ block to the other. HDPE DWC pipe together with necessary HDPE couplers/ joints (T-joints, elbows, bends etc.) shall be within scope of vendor supply. Where cables run vertically along MMS leg, HDPE pipes shall be routed properly and tied/ clamped to leg. For this, necessary UV protective cable ties of suitable length or clamps shall be in vendor's scope of supply. (2) Specification of HDPE DWC pipe: As per relevant IS; ID shall be selected to accommodate the number of 1Cx4 cables to be guided. A maximum of 4 circuits can be run through single HDPE pipe. Fill ratio will be considered max 40%. However, exact ID shall be selected to ensure that only a maximum of 40% of the ID space is occupied by the cables. Vendor to ensure that there is no gap and proper packing at the junction of two

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	pipes, in which DC cable is laid, using proper method and accessories, like bell mouth. Make, part number, sizes/ dimensions shall be submitted for BHEL/NTPC approval during detailed engineering. (3) Cables with HDPE pipe (and couplers/joints etc.) shall be directly buried underground as per IS: 1255. Continuous trenches shall be excavated on either side of the SMB. In addition, for each SMB, there shall be minimum one pathway crossing, for which trench shall be excavated. - Trench depth = 600 mm minimum - Trench width = As per conduit size and number of conduits - Trench shall, then, be filled with refill soil and compacted. Excavation, laying of pipes, routing of 4 sqmm cables through HDPE pipe, fixing of couplers, sealing end of the HDPE pipes, trench backfilling shall be vendor's scope. Trenches shall be backfilled, compacted and the area shall be neatly levelled. (4) Total length of HDPE DWC pipe and quantity of couplers/joints shall be as required. (5) Bending radii for cables shall be as per IS: 1255. (6) At road crossings, cables shall be routed through Hume pipe of class NP3 of appropriate size that shall be in vendor scope of supply and technical details/ brand etc. shall be submitted for BHEL/ NTPC approval during detailed engineering. (7) All cable entry openings of conduit pipes, after laying/ termination of the cables, shall be sealed using appropriate sealant (single component thermoplastic insulating compound) to ensure water proof tightness. The sealant supply will be vendor's scope of supply. (8) Solar cables, wherever exposed to direct sunlight and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.
5.10	Termination of 1Cx4sqmm cables on input side of SMBs 1Cx4 sqmm cables of positive and negative polarities originating from SPV module strings shall be terminated at the input side of SMBs using 4 sqmm cable with MC4 connectors. MC4 connector are already fixed in cable entry/exit of SMBs as part of BHEL scope of supply. However, supply and fixing of MC4 connectors required for connecting 4 sqmm cables to strings and SMBs and Y connectors shall be done by Vendor (2) Vendor scope includes removal of sleeve at the cable end, fixing of Y and MC4 connectors of the appropriate type/size and connecting the MC4 connector to the SMB. These cables shall be supported suitably and dressed neatly. (3) 4 sqmm cable will be supplied by BHEL, MC4 connectors shall be supplied by vendor. (4) All necessary tools such as pliers, strippers, crimping tool etc shall be within vendor scope
5.11	Ferruling for 1Cx4sqmm cable 1) For 1Cx4 sqmm DC solar array cable, vendor shall supply and provide UV resistant ferrules printed with source/destination identification of cable. Printing details shall be given by BHEL after placement of order. Printing shall be of appropriate size to ensure readability. 2) Supply of ferrule shall be in vendor scope. 3) Ferrules shall be provided on all termination ends: module end and SMB ends for all 4 sqmm cables.
5.12	Underground cable trenches and laying of 3.3 KV 1Cx400 sqmm in solar array field (1) DC power cable 3.3 KV 1Cx400 sqmm, Al conductor, XLPE, armoured (from SMB to PCU) shall be laid underground by way of direct burying as per IS:1255. Supply of above the cables shall be in BHEL scope. Cable laying shall be carried out as per "Cable installation methodology" defined in this specification. (2) Typical trench details/dimensions are below only for tender purpose. - Total trench depth = 1015 mm minimum - Trench width = As per number of cables laid. - Trench shall have layers one over the other as below (from bottom to top):

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	1. Bottom layer shall be sand of IS: 383 with 75mm minimum thickness 2. 1Cx400 sqmm cable shall be laid over the sand layer 3. Another layer of sand of 75 mm minimum thickness. 4. Single layer of brick as protective cover covering all cables 5. Trench shall, then, be filled with refill soil and compacted (3) Communication from SMB to SCADA shall be through wireless medium. (4) Bending radii for cables shall be as per IS:1255. At road crossings, cables shall be routed through Hume pipe (Class NP3, 300 dia) of appropriate size that shall be in vendor scope of supply. Any damage/repair work to existing road or drain during trench work will be done by vendor. At Nallah crossings, cables shall be routed through Hume pipe (Class NP3, 300 dia) of appropriate size or Covered cable trays/ structures as shall be approved by NTPC. Hume pipe and cable trays/ structures of appropriate size shall be in vendor scope of supply, fabrication, grouting and erection. Vendor shall take utmost care in laying the cables in order to prevent wastages and damages on outer sheath and inner insulation. Cable shall be drawn with rollers only to ensure no damage to cable during laying. In case cables found to be damaged/ cut after the laying in trenches, vendor shall implement suitable corrective action such as cable jointing, or re-lay a new cable in consultation with BHEL.
5.13	Laying of 1Cx400sqmm in inverters rooms and terminations at PCU (1) 1Cx400 sqmm cables (Al conductor, XLPE insulation, armoured: BHEL scope of supply) running from SMBs (through outdoor cable trenches) shall be routed into the Containers at Inverter stations. (2) Vendor shall carry out drilling of holes in cable gland plates of the PCUs for the 13 positive and 13 negative DC inputs of 1Cx400sqmm cable. Gas cutting method is strictly not allowed. Vendor shall organize hole-saw cutters of appropriate size for this purpose. All necessary drilling machines / tools etc. shall be made available at site. (3) Prior to termination, each cable shall be checked for continuity and megger. In case any cable found defective, vendor shall implement suitable corrective action such as cable jointing, replacement/re-laying of cable etc. as applicable. (4) Vendor shall carry out glanding of the cables following which the glands shall be fitted to the respective holes of gland plates. (5) Vendor shall carry out the 1Cx400 sqmm cable terminations for the 13 positive and 13 negative inputs that include tasks such as unsleeving, crimping, connecting to the tinned copper bus bars, tightening using torque wrench etc for all PCUs (7) Vendor shall arrange torque wrench of appropriate range. Torque setting shall be as per the bolt size and property class. For the setting, approval shall be obtained from BHEL site engineer. (8) All tools/accessories such as crimping tools etc. required to carry out the termination shall be within scope of vendor.
5.14	Termination of 1Cx400sqmm DC power cables at SMBs (1) Cables of 1Cx400 (Al conductor, XLPE insulation, armoured) shall be terminated at the output side of SMBs (positive, negative terminals). Supply of this cable is in BHEL scope. (2) Vendor scope includes removal of sleeve at the cable end, crimping with suitable cable lug of appropriate type/size and connecting the lugged end to the tinned copper bus bar within the SMB. Cables shall enter the SMB through the metallic cable glands that are also supplied by BHEL along with SMBs. (3) Bi-metallic lug / Al lug with bi-metallic plate shall be in vendor scope of supply. Make shall be Dowell, or equivalent subject to approval of BHEL/NTPC Lug shall match the cable conductor material /size and also the tin plated copper bus bar of SMB. (4) Quantity of lug and hardware shall also include contingency requirements arising out of shortage due to various reasons (damage, theft etc) during installation.

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	(5) All necessary tools such as pliers, strippers, crimping tool etc shall be within vendor scope.
5.15	Laying and Termination of 1Cx400 LT AC power cables at PCU and Inverter Transformer (1) LT Cables 5 runs of 1C x 400 sqmm Al conductor, XLPE, armoured per phase shall be laid between AC side of the PCU and the LT side of the Inverter transformer over the cable trays. Supply of these cable trays along with the cable support structure shall be in vendor's scopes. Cables shall be laid in trefoil arrangement. Trefoil clamps supply and fixing in in vendor's scope. AC side of cables will be terminated overhead as per design of Containerised Inverter solution. (2) Vendor scope includes removal of sleeve at the cable end, crimping with suitable Bimetallic Lug or Aluminium Lug with Bimetallic washer/ strip. Cables shall enter the PCU and Transformer through the metallic cable glands. Supply of Lugs and Glands required for Inverter Transformer side termination shall be in vendor's scope. (3) Cable lug make shall be Dowell, or equivalent subject to approval of BHEL/NTPC. (4) Cable gland metallic type shall be of COMET make or equivalent subject to approval of BHEL/NTPC. (5) Quantity of lug and hardware shall also include contingency requirements arising out of shortage due to various reasons (damage, theft etc.) during installation. (6) All necessary tools such as pliers, strippers, crimping tool etc. shall be within vendor scope.
5.16	Identification marking of cables using cable tags 1) Cable tags shall be provided on all power cables at both ends just before entering the equipment enclosure and every 5 m on cable tray or trench run. 2) Cable tags shall be of rectangular shape. 3) Cable tag shall be of 2mm thick aluminum with number punched (embossed) on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. 4) ID numbering scheme shall be provided to vendor after Purchase order placement. Vendor shall submit the technical details of cable tags for BHEL/NTPC approval during detailed engineering.
5.17	Installation of electrical panels / Container at Inverter Station, main control room and 33KV Pooling yard I. Panel installation at Inverter Station Containerized PCU solution is supplied by BHEL. Vendor shall organize necessary resources such as labour, cranes, hydra, forklifts, transportation trucks / trolleys and other accessories for movements and positioning of the panels as below (Quantities mentioned are per inverter room): (a) 2x 2.5 MW or 1 x 5 MW PCU Container consisting of PCU, aux transformer, AC distribution board, UPS, batteries, PCU ducts, PCU cable ducts: 1 sets (This shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) (b) 33kV outdoor VCB panels: 1 No. (This shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) (c) SCADA panel : 1 No (This shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) Panel installation within main control room: (a) ACDB main panel with provision of two inputs source: 1 set

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	(b) Distribution boards (wall mounted): DCDB, UPS DBs, CR DB (room utilities), LDB (plant lighting), PDB (power DB): 1 No each + any extra boards as required (c) SCADA panel: 2 Nos (d) HMI SCADA control desk with PCs and accessories: 1 set (e) UPS with battery bank – 2 Sets Outdoor Panel installation in 33KV pooling yard near Control room: (a) 33kV outdoor VCB Switchboard: 1 sets. (1 set shall consist of 8 nos 33KV VCB panels. These shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) (b) Outdoor ONAN 63KVA, 33KV/415V Auxiliary Transformer (on foundation or DP structure including accessories as per design)- 1 no (c) Outdoor Dry type 63KVA, 660V*/415V Auxiliary Transformer- 1 no (* Voltage in range of 600V to 700V, same shall be finalized during detailed engineering) (d) SCADA panel: 2 Nos (1) Panels shall be moved to the respective positions and placed over the cable trenches in control room, in the exact sequence and locations as per drawings. Drawing shall be provided after placement of purchase order. (3) Panels / Container shall be suitably grouted using welding/ bolting methods as per relevant standards and recommendation of OEMs. BHEL approval shall be obtained for the grouting arrangement. All necessary hardware for the same shall be within vendor scope of supply.
5.18	Supply and Installation of UPS Vendor shall supply, install and commission UPS, UPS battery and UPS DB panels in main CMCS room. UPS system shall comprise of 2 x 100% UPS. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing 30 minutes backup. Bypass Line static switch, manual bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories. UPSDB shall have two incomer fed from two separate UPS as mention above. At a time one incomer shall be in service. Suitable auto changeover logic shall be provided. Indicative capacity of UPS shall be 5kVA for main CMCS room. The UPS shall have back up of 30 minutes. Vendor shall, however, submit exact sizing calculations at load factor of 0.8 lagging inclusive of 10% design margin at 50 deg C considering (but not limited to) the loads as below: • Data logger / SCADA • Fire Detection/ Alarm Panel • HMI of SCADA • Emergency Lighting • WMS • Other loads UPS sizing calculation will be submitted for approval. Detailed specification of UPS and batteries is as mentioned in Annexure 1

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5.19.	Laying, termination of LT/HT/aux supply cables/ inverter station/ main control rooms and in associated 33KV yards (1) For all electrical panels viz. PCUs/ VCB panels/ ACDB panel/ UPS/ battery bank /DB boards/ aux transformer and inverter transformers of the inverter rooms, laying and termination of LT/HT/Aux power cables shall be in vendor scope. (2) DC supply will be arranged from existing substation upto CMCS room through cable by BHEL. Vendor shall supply 1 no of DCDB with required feeders for supply to HT panels, SCADA etc. DCDB supply and installation, incoming cable routing, cable laying to loads, DCDB and terminations will be in vendor's scope. All termination accessories will be in vendor's scope. (3) For all electrical panels viz. PCUs/ VCB panels/ ACDB panel/ UPS/ Battery bank / DB boards / aux transformers/ inverter transformers, laying and termination of LT/HT/Aux power cables etc shall be in vendor scope. (4) 400 sqmm AC cables in transformer yards in inverter room shall be routed on ladder type cable tray overhead as per containerized inverter solution design requirement. The same will be informed during detailed engineering. Support structure required for cable tray shall be in vendor scope. (5) Cable glands, cable lugs, 33kV HT cable termination kits (indoor/ outdoor types as applicable), Cable jointing kits, lugs, clamp & connectors, cable support structure for termination of 33KV cable at the evacuation point , bolts, nuts, washers etc. shall be in vendor scope of supply. (6) It is the responsibility of the vendor to assess the actual length requirements duly considering all applicable clearances as per relevant standards, Indian electricity rules, CEA/CEIG requirements etc. For this purpose, tentative (indicative) locations of inverter/Control rooms are enclosed along with tender. (7) For marshalling box of transformer/ UPS/ SCADA/ DB boards, single compression nickel plated brass glands shall be provided by vendor. Make shall be COMET or reputed equivalent subject to approval of BHEL/NTPC. (8) HT termination kits (indoor/ outdoor as applicable) shall be of 3M/ Raychem make as shall be approved by BHEL/NTPC. HT termination shall be carried out by certified jointers. Credentials / certification of experience from 3M/ Raychem for the proposed jointers shall be submitted for BHEL/NTPC approval during detailed engineering. (9) Quantity of 33KV End termination and straight through jointing kits shall be supplied by vendor as follow: - Indoor 33KV End termination kit for 1Cx300 sqmm (E) cable = As per SLD (tentatively 54 nos) - Straight through jointing kit for 1Cx300 sqmm (E) cable = as per site requirement These quantities are excluding spares requirement. (10) The scope of HT cable laying and termination at Control room incomer panels and Inverter room ICOG panel for the cables between Control room and Inverter room shall be in the scope of the vendor. (11) The scope of HT cable laying and termination at from Inverter transformer and HT panels at Inverter rooms shall be in the scope of the vendor. (12) The scope of HT cable laying and termination at Control room Auxiliary transformer to HT panel shall be in the scope of the vendor. (13) Interconnection between ACDB between IR1 to IR2 and between IR3 to IR4. Cable sizing, supply (including termination accessories), laying and termination is in scope of vendor. The scope of LT cable laying and termination from Nearest Inverter room to Outdoor Dry type 63KVA Auxiliary transformer at CMCS shall be in the scope of the vendor. Vendor shall supply and install a DB with min 36KA MCB/SFU on PCU end and similar
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	MCB/SFU before dry type transformer in CMCS. Cable sizing, supply (including termination accessories), laying and termination is in scope of vendor. (14) All trench excavations, cable laying, sand and brick layer, backfilling etc as per IS 1255 shall be in vendor's scope. (15) Vendor shall make appropriate holes in the gland plates of PCUs, HT VCB panels, ACDBs, SCADA panels, Inverter transformers, Marshaling boxes, Auxiliary transformer, Distribution boards etc. for fixing the cable glands. Gas cutting is strictly prohibited. Hole-saw cutters of appropriate sizes with suitable drilling machines shall be made available at site for this purpose. (16) Bimetallic lugs or aluminium lugs with bimetallic strip/washer shall be used for connecting Cu bus bar and Al cables or vice-versa wherever applicable. (17) Terminations with M10 and above shall be tightened using torque wrench. Torque setting shall be as per size, property class of bolt. BHEL approval shall be obtained for the settings prior to tightening. (18) Approximate (indicative) specifications of certain power cables are as follows. Exact specification shall be based on design calculations that shall be submitted for BHEL/NTPC approval during detailed engineering. Quantity shall be appropriately selected. (a) PCU to 5.3MVA transformers: Cable supply in BHEL scope 3-phase 3-wire system, 5Rx1Cx400 sqmm per phase, 1.1kV grade, aluminium conductor, XLPE insulation, armoured, PVC sheathed as per IS: 7098. (Note: cables from inverter transformer shall be laid on ladder type cable tray in trefoil arrangement). (b) HV (33kV) side connections in VCB panels, 5.3MVA transformer, 33KV pooling yard near control room auxiliary transformer: Cable supply in BHEL scope 3-phase 3-wire system, 3Rx1Cx240 sqmm, 33kV, aluminium conductor, XLPE insulation, armoured, PVC sheathed as per IS: 7098. (c) Interconnection between ACDB between IR1 to IR2 and between IR3 to IR4. Cable sizing, supply (including termination accessories), laying and termination is in scope of vendor. (c) LV side connections from Nearest Inverter room to Outdoor Dry type 63KVA Auxiliary transformer at CMCS and further to ACDB in Control room shall be in the scope of the vendor. Cable supply in vendor scope. (d) ONAN Auxiliary transformers to ACDB panel in 33KV pooling yard near CMCS room: Cable supply in vendor scope (e) LT AC aux power supply cables from ACDB panels in Inverter/control room to the related utility loads such as battery charger, UPS, MCB DB boxes for room appliances, PCU, transformers aux supply, SCADA, VCB panels aux supply, fire alarm system, panel illumination lamps, space heaters of VCB panels etc. Cable supply in vendor scope (g) LT DC aux power supply cables from DCDB panels in inverter /CMCS rooms to the utility loads such as DCDB panels, VCB panel tripping/closing circuits, SCADA, VCB panel spring charge motors in 33kV pooling yard etc. Cable supply in vendor scope (19) Supply of all cable accessories (for the above requirements) such as cable trays, cable glands, cable lugs, ferrules, nuts/bolts/washers, cable dressing ties etc shall be in vendor scope. (20) Laying of above cables, fixing of cable glands, cable termination at the respective terminal bus bars shall be in the scope of vendor (21) All resources such as labour, machinery, tools and accessories to carry out the above electrical works shall be in vendor scope. (22) All applicable/relevant clauses under Annexure 1 for "General specification of LT cables" and "Cable installation methodology" sections of this specification shall be adopted for all aspects of these cables.
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5.20	Laying and installation of Control / data / instrumentation / OFC cables (1) Vendor shall supply all the control/ data/ instrumentation / communication cables except OFC, RS485 and Ethernet LAN cables for SCADA. (2) All the cable installation accessories such as cable trays, cable conduits, cable glands, cable lugs, ferrules, cable ties, bolts, nuts, washers etc. shall be in vendor scope of supply. Cable laying and cable terminations shall be in vendor scope. All necessary resources such as labour, tools and accessories required to carry out laying and termination works etc. shall be in vendor scope. (3) OFC cable termination kits shall be in BHEL scope of supply. Vendor scope includes laying of the OFC cable underground in the conduit from inverter station SCADA panels to main control room SCADA panel. Termination of the OFC cables at both the ends shall be in Vendor's scope. Supply of conduits for OFC cable is in scope of BHEL. Supply of conduits for RS485 and LAN Cables is in scope of vendor. (4) Vendor shall lay and terminate the RS485 cables to SCADA from all plant equipment e.g. HT panels, ACDBs, transformers, FCBC, UPS etc. These cables shall be laid between the panels of respective inverter station/ main control rooms. (5) Vendor shall lay and terminate the Ethernet cables to SCADA from (a) PCUs, (b) numerical relays of VCB panels. These cables shall be laid between the panels of respective inverter station/ main control rooms. (6) Vendor shall lay and terminate control and instrumentation cables from inverter transformers to SCADA and from HT breakers to SCADA. (7) Electrical Interconnections of HT breaker panels e.g. outgoer, incomers, Bus PT panels for 33KV pooling yard HT breakers. (8) Suitable size ferrules with details shall be provided on either side on either side of each control/ data/ instrumentation cable. (9) Vendor shall submit cable schedules for approval of BHEL/NTPC. (10) All applicable/relevant clauses under "Cable installation methodology" sections of this specification shall be adopted for all aspects of these cables.
5.21	Erection of 33kV yard Equipments (1) Near each Inverter station there shall be one transformer yard having one 5.3 MVA inverter transformer, one HT ICOG Panel and one SCADA Panel. (2) Near control room there shall be 1 no of ONAN 63 KVA, 33KV/415V aux transformer, 1no of Dry type 63KVA, 660V*/415V aux transformer, 1 no of SCADA panel and one set of HT panels (8 VCB panels) at 33KV pooling yard. (3) Construction of transformer RCC foundations, fencing and gates for these transformers yard and pooling yard near control room and inverter station is in BHEL scope. Trenches, Levelling, cable support structures fabrication & cable tray support foundation works, all earthing related works-excavation etc shall be in vendor's scope. NOTE- ONAN transformer shall be preferably cable box design on LV and HV. The foundation will be made by BHEL as per detailed design. In case cable boxes are not provided, vendor shall install the transformer on Dipole structure as shall be approved during detailed engineering. Foundation will be dne by BHEL however supply and erection/ installation of all accessories e.g. poles, cross arms, base support structure, Isolator, insulators, LA etc as applicable will be in scope of vendor. TRANSFORMER ERECTION- (1) Vendor shall erect the inverter and auxiliary transformers on RCC foundation as per transformer GA details. Vendor scope of I&C of transformers shall include: a) Movement of transformers and its accessory parts such as radiators, cable boxes, hardware etc from storage yard and placement on foundation pedestal. b) Assembly of transformer parts. c) Cable laying and terminations at LV/HV/Marshalling boxes of transformers.

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	d) All activities applicable to oil filling and filtration including measurement of oil BDV and PPM. Particularly for inverter transformers, filtration of oil shall be carried out to such an extent as to obtain the desired BDV (>60 kV) and PPM (< 15ppm) values. e) Testing of transformers as per “pre-commissioning checks” section of this section. After installation of transformers at the transformer yards of each inverter station/ pooling yard near control room, vendor shall level/ compact the ground with an appropriate magnitude and direction of slope to facilitate draining of rain water away from transformer yard. General Notes- Vendor shall provide applicable earthing connections to transformers, fencing / gates etc. in the yard as per relevant clauses under the “Earthing system” section of this specification. All other items (if any, other than the above) that are required to meet the technical requirements of transformer yard as per applicable standards / electricity rules shall be incorporated by the vendor.																																																						
5.22	Supply, erection and commissioning of two auxiliary transformer- Dry type and ONAN ONAN Transformer Qty required- 1 No Technical parameters and specifications: <table><tr><th>#</th><th>Technical parameter</th><th>Specification</th></tr><tr><td>1</td><td>Transformer type</td><td>Outdoor, oil-immersion type</td></tr><tr><td>2</td><td>IP class</td><td>Transformer, including cable box and marshalling box shall be of IP55</td></tr><tr><td>3</td><td>Type of cooling</td><td>ONAN</td></tr><tr><td>4</td><td>Governing Standard</td><td>IS: 2026/1180</td></tr><tr><td>5</td><td>Rating in KVA</td><td>63 kVA</td></tr><tr><td>6</td><td>No. of phases</td><td>3</td></tr><tr><td>7</td><td>Frequency</td><td>50 Hz, +/- 3%</td></tr><tr><td>8</td><td>HV winding</td><td>33kV, 3-Ph, with Delta connection</td></tr><tr><td>9</td><td>LV windings</td><td>415V, 3-Ph, with Star connection</td></tr><tr><td>10</td><td>Winding material</td><td>Electrolytic grade copper for both HV and LV windings</td></tr><tr><td>11</td><td>Winding Insulation</td><td>Class A</td></tr><tr><td>12</td><td>Neutral on LV side</td><td>Neutral terminal shall be brought out separately to facilitate earthing connections.</td></tr><tr><td>13</td><td>Vector Group</td><td>Dyn11</td></tr><tr><td>14</td><td>Short circuit withstand time (thermal)</td><td>2 sec.</td></tr><tr><td>15</td><td>% Impedance</td><td>As per IS: 2026</td></tr><tr><td>16</td><td>Creepage distance</td><td>31mm/KV</td></tr><tr><td>17</td><td>Termination HV/LV/Orientation</td><td>Air insulated cable box with disconnecting chamber, for both HV and LV sides. Cable box / Cable box / 180°.</td></tr></table>	#	Technical parameter	Specification	1	Transformer type	Outdoor, oil-immersion type	2	IP class	Transformer, including cable box and marshalling box shall be of IP55	3	Type of cooling	ONAN	4	Governing Standard	IS: 2026/1180	5	Rating in KVA	63 kVA	6	No. of phases	3	7	Frequency	50 Hz, +/- 3%	8	HV winding	33kV, 3-Ph, with Delta connection	9	LV windings	415V, 3-Ph, with Star connection	10	Winding material	Electrolytic grade copper for both HV and LV windings	11	Winding Insulation	Class A	12	Neutral on LV side	Neutral terminal shall be brought out separately to facilitate earthing connections.	13	Vector Group	Dyn11	14	Short circuit withstand time (thermal)	2 sec.	15	% Impedance	As per IS: 2026	16	Creepage distance	31mm/KV	17	Termination HV/LV/Orientation	Air insulated cable box with disconnecting chamber, for both HV and LV sides. Cable box / Cable box / 180°.
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18	Cable entry on HV side	Bottom entry of cables.
19	Cable entry on LV side	Bottom entry of cables.
20	Cables and accessories	HV & LV Cables, termination kits (for HV), cable lugs (Dowell make), (Comet make) and connecting hardware shall be in vendor scope of supply. Vendor shall provide hole on the bottom-side gland-plate of HV & LV side cable box for cable entry as per the final outer diameter of cable provided by BHEL during detailed Engg.
21	Tapping on HV winding	Off circuit tap changer (OCTC) switch with five tap positions: +5%, +2.5%, 0, -2.5%, -5%.
22	Loading Capability	Continuous operation at rated KVA on any tap with voltage variation of +/-10%. Transformer shall be capable of being loaded in accordance with IS: 6600 / IEC 60076-7.
23	Ambient temperature	Max 50 deg C
24	Temperature rise	For top oil: Max. 50 deg C by thermometer method For winding: Max. 55 deg C by resistance method Both rises shall be over an ambient temperature of 50 deg C irrespective of tap position.
25	Flux density	Not to exceed 1.9 Wb/sq.m at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over-fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds Vendor shall furnish over-fluxing characteristics up to 150%
26	Air Clearance	As per CBIP
27	Load loss principal tap at 75°C, with IS tolerance	This shall be provided by vendor.
28	No Load loss at rated voltage on principal tapping and at rated frequency, with IS tolerance	This shall be provided by vendor.
29	No load current at rated voltage and rated frequency	This shall be provided by vendor. To be indicated as percentage.
30	Efficiency at 75°C, UPF	As per IS 1180 and CBIP
31	Regulation at full load, 75 °C	< 2 % for UPF For 0.8 PF lagging, to be indicated by vendor.

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32	Harmonics	Shall be designed to suppress harmonics especially 3 rd & 5 th .
33	Vibration & noise	Noise level shall be according to NEMA TR-1 standard
34	Highest system voltage	LV side: 1.1kV HV side: 36 kV
35	Insulation levels as per IS:2026 Rated Lightning Impulse withstand voltage / Short duration power frequency withstand voltage	LV side: -- kVp / 3 kV rms HV side: 170kVp / 70kV rms
36	Overall dimensions in mm Length x Breadth x Height	This shall be provided by vendor.
37	Oil capacity (in Litres)	This shall be provided by vendor.
38	Weight of transformer in Kg	This shall be provided by vendor.
39	Constructional features	As per relevant clause of this specification
40	Fittings and accessories	As per relevant clause of this specification
41	Painting	RAL 7032

6.0 CODES AND STANDARDS

Transformers	IS:2026, IS:6600, IEC:60076
Bushings	IS:2099, IEC:60137, IS 3347, IS 12676
Insulating oil	IEC 60296
Bushing CTs	IS:2705, IEC 60185
Indian Electricity Act 2003, BEE Guideline 1 star or better & CEA notifications	

6.1 General Construction

Transformer shall be constructed in accordance to IS:2026 and IS:3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.

The other important construction particulars shall be as below.

- The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- A double float type Buchholz relay conforming to IS: 3637 shall be provided.
- Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

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d. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site

e. The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.

f. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.

g. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator (WTI applicable for transformer above 50 KVA) with accuracy class of +/-2 deg.

h. For Transformers above 100KVA, radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.

i. M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level (for transformer above 100 KVA).

6.1.1 Windings

a) The bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.

b) The conductors shall be of electrolytic grade copper/Aluminum free from scales & burrs.

c) All windings of the transformers shall have uniform insulation.

d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

6.1.2 Core

a) The core shall be constructed from non-ageing, cold rolled, super grain oriented silicon steel laminations equivalent to M4 grade steels or better.

b) Core isolation level shall be 2 kV (rms.) for 1 minute in air.

c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.

6.1.3 Insulating oil

No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm ² /s	≤ 12 at 40 ° C ≤ 1800.0 at (-)30 ° C
2.	Flash Point, ° C	≥ 140° C
3.	Pour point, ° C	≤ (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm ³ at 20 ° C	≤ 0.895
6.	Interfacial Tension N/m at 25° C	≥ 0.04
7.	Neutralisation value, mgKOH/g	≤ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	≤ 1.2 ≤ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	≥ 30 ≥ 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	≤ 0.005
14.	PCA content	≤1%
15.	Impulse withstand Level, kVp	≥ 145
16.	Gassing tendency at 50 Hz after 120 min, mm ³ /min	≤ 5

Subsequently oil samples shall be drawn. BDV 60 KV (min), PPM 10 (max)

6.1.4 Bushings

- Bushing below 52 kV shall be oil communicating type with porcelain insulator.
- No arcing horns to be provided on the bushings.
- Inverter Transformer LV bushing palms shall be silver/tin plated.

6.1.5 Bushing CTs

Shall be of adequate rating for protection as required, WTI (WTI CT applicable for transformer above 50 KVA) etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

6.1.6 Valves

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies. Sampling & drain valves should have zero leakage rate.

6.1.7 Gaskets

- Gasket shall be fitted with weather proof, hot oil resistant, rubberized cork gasket.
- If gasket is compressible, metallic stops shall be provided to prevent over compression.
- The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same

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& establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

6.1.8 PAINTING

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

6.1.9 Neutral Earthing Arrangement

Neutral earthing shall be done as per system requirement.

6.1.10 Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above)

(a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)

(b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.

(c) A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box

(d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron

(e) The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.

(f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.

(g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

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6.1.11 FITTINGS

Following fittings shall be provided with Transformers covered under this sub section.

DRY TYPE AUXILIARY TRANSFORMERS:

Qty required- 1 no

Rating- Outdoor Dry type 63KVA, 660V*/415V Auxiliary Transformer- 1 no (* Voltage in range of 600V to 700V, same shall be finalized during detailed engineering)

Dry Type Transformer shall be constructed in accordance to IS:2026, IS:11171 or equivalent to any other international standard, Indian Electricity Act 2003, BEE Guideline . Transformer rating and all related technical parameters including tap changer (if applicable) shall be as per system requirement/SLD and relevant standards. Transformer shall be suitable for continuous outdoor duty application. Transformer shall be complete & functional in all respect. The other important construction particulars shall be as below.

- The transformers shall be housed in a metal protective housing. The enclosure shall be provided with suitable hardware (as required).
- The conductors shall be of electrolytic grade copper free from scales & burrs.
- Dry Type Transformer windings shall be of class F insulation or better. Cooling shall be AN.
- The Transformers are of High efficient type made of High grade CRGO steel or amorphous material . Scrap CRGO material shall not be used for manufacturing The fittings/accessories including protection/monitoring device (temperature scanner) generally required for satisfactory operation of the transformer, are to be provided.

Rating- Outdoor Dry type 63KVA, 660V*/415V Auxiliary Transformer- 1 no (* Voltage in range of 600V to 700V, same shall be finalized during detailed engineering)

Type- Epoxy cast resin/resin encapsulated

Tap- As per system requirement and SLD.OCTC +/-5% (min.)

Type of cooling- **AN**

Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance guarantee shall correspond to air natural (AN) cooling.

Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method) with Air Natural (AN) cooling- 90 deg.C. (class F), 115 deg.C. (class H)

SC withstand time (thermal)- 2 sec

PD Level (max. Allowable)- 10 pc

Loading- Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due combined voltage and frequency fluctuations:

- 110% for continuous rating.
- 125% for at least one minute.
- 140% for at least five seconds.

7.0 CODES AND STANDARDS

Dry type transformers IS: 11171, IEC 60076-11

Indian Electricity Act 2003 and Indian Electricity Rules, BEE notification & CEA guidelines

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8.0 DESIGN AND CONSTRUCTIONAL FEATURES

8.1 The core shall be constructed from high grade non-ageing cold rolled grain oriented silicon steel laminations of M4 grade or better quality. The insulation of core to clamp-plates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.

8.2 The transformers shall be housed in a metal protective housing, having a degree of protection of IP-42. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

8.3 Winding conductor shall be electrolytic grade Copper/ Aluminum. Windings shall be of class F insulation or better. All windings are to be uniformly insulated.

8.4 Transformer HV bushings and LV bushings can be either solid porcelain or epoxy type. Bushing shall be suitable for satisfactory operation in the high ambient temperature inside Bus Duct enclosure (if applicable). LV flange area shall be of non-magnetic material.

8.5 Bushing CTs shall be provided in the LV neutral side of adequate rating for REF protection, WTI, etc.

8.6 For Marshalling Box the sheet steel used shall be at least 1.6 mm thick cold rolled. The box shall be tank mounted type. The degree of protection shall be IP-54 in accordance with IS-13947. Wiring Scheme shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

8.7 Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance shall correspond to air natural cooling.

9.0 PAINTING

The inside of enclosure and accessories (except M. Box) shall be painted with two coats of fully glossy white colour with total DFT of 25 to 60 microns. The external paint colour of transformer & accessories shall be blue corresponding to RAL 5012. The external surface of transformer & accessories shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of polyurethane finish paint with total DFT of 80 to 150 microns. The internal surface of M.Box shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of chemical & thermal resistant epoxy enamel white paint with total DFT of 80 to 150 microns.

10.0 Tests and Inspection

Bidder shall offer type tested transformer(s) including short circuit test (as per IEC 60076 part-5) for the project.

In case the bidder/contractor has conducted type test(s) specified in the specification within last ten years, he may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

In case short circuit test has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, Bidder /main contractor to meet project schedule shall take suitable steps quite in advance to ensure successful conduction of short circuit test within three months time from date of LOA failing which the offered make of the transformer shall not be considered.

In case the Bidder is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the Employer and submit the reports for approval.

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5.23	Auxiliary AC/DC power supply system 1. Each PCU container shall have 1 no aux transformer for aux supply requirement. Vendor shall provide a small AC distribution board to cater the aux supply requirement like lighting, UPS, transformer aux supply, module washing pump etc. 2. Interconnection between ACDB between IR1 to IR2 and between IR3 to IR4. Cable sizing, supply (including termination accessories), laying and termination is in scope of vendor. 3. For Control room vendor shall supply the ACDB which shall be fed from two sources. One no of ONAN 63 KVA Aux transformer in CMCS and 1 no of Outdoor Dry type 63KVA Aux transformer in CMCS. Vendor shall connect ONAN Aux transformer to HT panel in Main pooling switchgear through 33KV Cable. Vendor shall connect Dry type Aux transformer to PCU AC busbar in nearest Inverter room. All arrangements and supplies for the same is in in scope of vendor. There shall be a changeover arrangement of suitable source for selection of the transformer. Installation, testing and commissioning is in vendor's scope. Following DB boards for application in main control room shall be in vendor scope of supply, installation and commissioning: • UPS DB for 230V AC UPS supply to SCADA, weather monitoring system, fire alarm system, emergency loads - 1Nos • DCDB for DC supply distribution to HT panels, SCADA etc. i. SLD will be shared after PO placement. ii. Above DBs shall be wall-mounted board, of reputed make such as Legrand, Siemens, Schneider or any other reputed make as approved by BHEL/NTPC. iii. Installation of all the above items including all necessary cable terminations/ installation shall be in vendor scope.
5.24	Supply and Installation of Weather monitoring system As a part of weather monitoring station, Bidder shall provide following measuring instruments with all necessary software & hardware required to integrate with SCADA so as to enable availability of data from meteorological instrument in SCADA. Each instrument shall be supplied with necessary cables, transmitters and accessories (Trackers, Mounting and base stand etc.) provided by OEM of the sensors only. Aux. power required by instruments and data logger shall be from UPS only. Data logger shall have provision to receive redundant power supply. Scope of vendor shall also include supply and erection of all the mounting arrangements including all necessary civil works/ foundations, clamps arrangement etc. as recommended by manufacturer and required at site. Communication cables shall be laid and terminated at both SCADA station at main control room and data logger at weather monitoring station end. Similarly, power supply cables shall be laid between WMS and DB boards in main control room. Exact location of the weather monitoring station shall be decided during detailed engineering. All the instruments to be supplied shall have valid calibration certificate. Single sensor for measuring combination of Wind Speed, Wind Direction, Relative humidity and Rainfall is also acceptable however offered sensor shall meet the specification as mentioned in following sections. 11.0 SOLAR RADIATION SENSORS Contractor shall provide Solar Radiation Sensors as per specification given in following section. Contractor has the option to provide these sensors on separate base or on a single base (radiation monitoring station) with tracker, shadow ring and transmitter etc provided by the OEM. Calibration certificate with calibration traceability to World Radiation

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Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with solar radiation sensors. Bidder shall provide Instrument manual in hard and soft form.

11.1 Pyranometer

Bidder shall provide Secondary Standard Pyranometers as per ISO 9060 for measuring incident solar radiation as per below mentioned requirement and quantity.

Global Horizontal Irradiance (GHI) – 1 No.

Global Inclined Irradiance (GII) -1 No.

Diffuse Horizontal Irradiance (DHI)- 1No.

Technical Requirement of Pyranometer

Details	Values
Principle	Thermopile
Spectral Response.	310 to 2800 nm
Sensitivity	Min 7 micro-volt/w/m2
Time response (95%):	Max 15 s
Non linearity:	±0.5%
Temperature Response:	±2%
Tilt error:	< ±0.5%.
Zero offset thermal radiation:	±7 w/m2
Zero offset temperature change	±2 w/m2
Operating temperature range:	0 deg to +80 deg.
Uncertainty (95% confidence Level):	Hourly- Max-3%, Daily- Max-2%
Non stability:	Max ±0.8%
Response Time(95% of final value)	<5 sec

Shadow ring/ball for measuring DHI shall require no regular adjustment for of tracker and shadow ring/ball. Pyranometer shall be shaded throughout the day and shall be exposed to diffuse solar radiation only to provide DHI value without any calculation.

11.2 Pyrliometer (Qty -1no.)

Details	Values
Spectral Response (50 % Point)	200 to 4000 nm
Sensitivity	Min. 7 micro-volt/w/m2
Time response (95%)	Max 10 s
Non linearity	Max ±0.5%
Temperature Dependence of sensitivity	±1%
Full viewing angle	5deg + 0.2deg
Zero offset thermal radiation	±7 w/m2
Zero offset due to temperature change	±2 w/m2
Operating temperature range	0 deg to +80 deg.
Daily Uncertainty (95% confidence Level)	1%
Non stability	Max ±0.8%
Response Time(95% of final value)	<5 sec
Temperature Sensor	PT 100/Thermistor
Slope Angle	1deg + 0.2deg



Sun tracker accuracy

Max 0.5deg

Bidder shall provide 1 no. handheld portable data logger for offered Pyranometer supplied or endorsed by OEM of the Pyranometer.

12.0 TEMPERATURE SENSORS

12.1 Ambient Air Temperature Sensor (Qty -1 no.)

Details	Values
Principle	RTD (Platinum) Resistance proportional to temperature
Range	0-50 degC
Accuracy	+ 0.2 degC
Operating Temperature	0 to 50 deg C
Radiation Shield	Non-aspirated Radiation Shield

12.2 Indoor Air Temperature Sensor (Qty – 1 no. at each Inverter room)

Details	Values
Principle	RTD (Platinum) Resistance proportional to temperature
Range	0-70 degC
Accuracy	+ 0.2 degC
Operating Temperature and calibration	0 to 70 deg C

12.3 Module Temperature Sensor (Qty – 1 no. per 5 MW)

Details	Values
Principle	RTD (Platinum) Resistance proportional to temperature
Range	0-100 degC
Accuracy	+ 0.2 degC
Operating Temperature	0 to 100 deg C

Module temperature sensor shall be fixed on the back of module surface with adhesive or tape without using any mechanical fastener.

13.0 WIND SPEED SENSOR (Qty- 1no)

Details	Values
Principle	Frequency proportional to wind speed/Ultrasonic Sensor
Velocity range	0-60 m/ sec
Threshold	0.3 m/s
Operating Temperature	0 to 50 deg C
Accuracy	3% (upto 35 m/s), 5% (Above 35 m/s) RMS

14.0 Wind Direction Sensor (Qty- 1no)

Details	Values
Principle	Potentiometric type sensor (Resistance proportional to Wind direction)/Ultrasonic Sensor
Range	0-360 deg



Accuracy	±5°
Operating Temperature	0 to 50 deg C

15.0 RAINFALL (Qty- 1no)

Rain Gauge shall be of Self Recording Type and recording facility shall be provided in Electronics. The Gauge shall be rugged having material of construction resistant to atmospheric corrosion. The Instrument shall have automatic functions for computing rainfall for pre set time periods.

Details	Values
Accuracy	5% or Below
Sensitivity	1.0 mm
Operating Temperature	0 to 50 deg C

16.0 RELATIVE HUMIDITY (Qty- 1no)

Details	Values
Range	0-100 %
Accuracy	±3%
Resolution	1%
Operating Temperature	0 to 50 deg C

In addition to above, measurement of **Cloud Cover (Okta), Sunset and Sunrise time** is also included in the scope of bidder.

17.0 METEOROLOGICAL MAST

One Meteorological Mast of telescopic type and of specified height to be placed on an existing structure (such as Buildings etc) so that height of the Meteorological Sensors from the Ground Level (GL) is 10 meters. The Mast is required for mounting the Meteorological Sensors. Necessary Hangers and Holders along with electrical Grounding Set shall be provided by the vendor for installation of the Sensors.

Material of Construction of the Mast shall be metallic and robust and shall be resistant to atmospheric corrosion. Fencing shall be provided for weather monitoring station.

18.0 CALIBRATION

All the instruments to be supplied shall have valid and traceable calibration certificate.

19.0 DATA LOGGER

Weather Monitoring system shall be provided with standalone Data logger suitable for outdoor application with IP65 Protection and industrial grade hardware suitable for operating temperature up to 55 Deg C. Data logger shall be calibrated and proven in field for at least one year in outdoor environment. Data logger shall have following minimum features:

Processor	32 bits
Time synchronization	With Built in GPS Clock or with Solar SCADA GPS Clock
Wireless communication	GSM/GPRS Modem

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	Data storage	SD card, Min 2GB for storage of raw and processed data locally at resolution of 1 Second for retrieval whenever required. Data to be stored shall be in unencrypted CSV or equivalent format.
	Display	LCD display for easy maintenance and debugging for site engineer
	Scan resolution	1 Sec
	Analog to Digital Converter (ADC)	16 Bit, Sampling :10 Hz (Min)
	I/P Channel	As required with 20 % spare of each type of channel
	It shall have facility for arithmetic processing (Time Integration, Simple Average and Moving Average etc.) of incoming raw data. Data logger shall be interfaced with Solar SCADA on modbus TCP/IP. Vendor shall submit Factory Acceptance Test (FAT) report and procedure before dispatch of material to site. Data logger shall be provided with key-locked door access and all the cables (Power and Signal) to the data logger shall be protected with heavy duty HDPE pipes. Project file (software, settings and sample reports) shall be handed over to site on permanent storage media (CD/DVD) in two copies after data integrity is verified by site and weather monitoring is commissioned. Data logger shall have facility to allow the access authorized with user ID and password only for any configuration changes.	
5.25	Installation and commissioning of SCADA integration systems (1) SCADA system, supply of which shall be in BHEL scope, comprises of data station panels and PC based control desks with software to collect, store, process and report the data parameters of power plant and also to control the operations of the power plant by integrating the various equipment at the segments as follows: (a) String monitoring boxes (104 Nos) in solar array field (b) Weather monitoring equipment: with datalogger. (c) Power conditioning units (8Nos): DC input / AC output parameters of inverters, grid data, fault status and events logged, etc. (d) Inverter transformers (4 Nos): Alarm/Trip signals, WTI/OTI temperature values. (e) 33kV VCB breaker panels (as per SLD): status of VCB breakers, status of protection relays of transformers, oil / winding temperatures, AC parameters at every 5MW level of the plant. (f) ACDB multifunction meters: AC auxiliary utility consumption parameters (g) Fire alarm system (all inverter station/ main control rooms): status signals (2) BHEL scope of SCADA: (a) Supply of Data station panels with necessary data loggers / PLCs and other accessories such as power supply etc to integrate the data signals as listed below. This includes main panel at main control room and intermediate (linking) panels at inverter room. (b) Supply of Desktop PCs (HMI control desks) provided with necessary software packages and remote monitoring features. (c) Supply of OFC, RS485 and LAN cables for SCADA. (d) Supply of conduit for laying of OFC cables (e) deleted	

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	(3) Vendor scope of supply and installation of SCADA system: (a) Vendor shall install the BHEL supplied SCADA system in the SCADA room in main control room. Vendor shall also install SCADA panels in the inverter rooms. (b) Cable laying/ terminations of all SCADA cables (including OFC cables) at respective rooms/ panels / equipments including cable trench works shall be in vendor scope. BHEL will provide the necessary cabling schedule during detailed engineering. (c) Supply of all SCADA related control / communication cables except OFC, RS485 and LAN cables shall be in vendor scope. (d) INTERNET CONNECTION: (Broadband Internet at Plant with Static IP: Network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. SCADA system shall be capable of sending all plant data in real time to the Remote Server. All required hardware items such as Modem / Router / Wifi facility etc. shall be in vendor scope. Vendor shall arrange for installation charges (one time) and Internet usage charges (recurring) till handover of the plant. (e) SUPPLY and INSTALLATION OF OUTDOOR WIRELESS ACCESS POINT Vendor has to supply 2 (two) nos. of Industrial outdoor IEEE 802.11 b/g/n wireless access point with 2x10/100Base-T(X) having Far Distance Air Connectivity up to 7 KM and protection class IP-67 .It shall be suitable for pole mount with minimum operating temperature of 55 Deg C. (f) Data Communication to SLDC: Vendor shall provide required interface to integrate plant SCADA with GETCO/GEDA/TRANSCO-SLDC, in compliance with grid code, to send any parameters specified by SLDC. Note: The methodology and specification of SLDC interface will be provided separately by SLDC/TRANSCO/GETCO/GEDA and it shall be the responsibility of the vendor to obtain and implement the same as per SLDC/ TRANSCO/GETCO/GEDA requirements.
5.26	Supply and installation of lightning protection system (ESE type lightning arrestors) to protect the electrical equipment of SPV power plant and Buildings from lightning. 1.0 GENERAL REQUIREMENTS This specification is intended to outline the requirement of external lightning protection (ELP/Lightning protection) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of external lightning protection system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of Lightning protection system for safe and satisfactory operation of the plant shall be included under scope of the bidder. 21.1 LIGHTNING PROTECTION DESIGN REQUIREMENT The object of a lightning protection system is to protect buildings/structure and equipment from direct lightning strikes, potential fire as well as the effects of injected lightning currents (non-incentive flash). It consists of termination systems for direct lightning, down conductors and an earth-termination system. Care must be taken for while designing the lightning protection that surges are prevented in the electrical system to reduce failure of electrical and electronic equipments. 21.2 CODES AND STANDARD The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IS/IEC 62305	PROTECTION AGAINST LIGHTNING
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
NFC 17 -102	Early streamer emission lightning protection systems
	CEA regulations for electrical safety-2010
	Indian Electricity Rules/ Indian Electricity Act.

Type test report of ESE LA shall be strictly in line with NFC 17-102.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The lightning protection system includes lightning terminal, Down conductor, test link, earth electrode, installation of lightning terminal, down conductor and earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with lightning terminal. Detail specification of earthing system has been mentioned elsewhere in the specification.

22.0 DOWN CONDUCTORS

Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.

Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.

All joints in the down conductors shall be welded type.

Down conductors shall be cleated on outer side of building wall, at 750 mm interval or welded to outside building columns at 1000 mm interval.

Lightning conductor on roof shall not be directly cleated on surface of roof.

Supporting blocks of PCC/insulating compound shall be used for conductor fixing at an interval of 1500 mm.

All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.

Lightning conductors shall not pass through or run inside GI Conduits.

Testing link shall be made of galvanized steel of size 25x 6mm.

23.0 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY

23.1 Codes and Standard

IS/IEC 62305 : PROTECTION AGAINST LIGHTNING

NF C 17-102 : LIGHTNING PROTECTION WITH EARLY

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	STREAMER AIR TERMINATION ROD 23.2 Complete Solar Array with associated structure shall be protected from Direct Lightning Stroke. Lightning Protection for solar array shall be achieved with any or both of the following two systems as per specification provided in the following section. Single Rod Air Terminal (Faraday Rods) Early Streamer Emission (ESE) Air Terminal Suitable earthing and equipotential bonding shall be ensured for the lightning protection Air Terminal as per applicable standard/Equipment manufacturer guidelines. Current carrying parts and accessories such as clamps, fasteners, down conductor, test links and earth termination etc. shall be preferably procured from OEM of Air Terminals if it is supplied by them as part of lightning protection system. 23.3 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY WITH SINGLE ROD AIR TERMINAL Solar array of plant shall be protected from direct lightning strike with straight or angled air termination rods of suitable class as per IS/IEC 62305 to be fixed with the module mounting structure (MMS). Air termination rods shall have minimum two clamps to be fixed with MMS and must be capable of carrying full lightning current. Contractor shall ensure proper fixing of the clamps with MMS to allow lightning current to pass through the clamp without damage and to sustain the rods during high velocity wind. Suitable arrangement/ modification required in MMS, if required for fixing of lightning rods will be in scope of bidder. Contractor shall submit the calculation to determine the no. and location of air termination rods to be fixed on structure to provide the lightning protection to each solar module and structure. Earth riser shall be connected to that part/pole of MMS which is nearest to air termination rod. 23.4 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY WITH E.S.E AIR TERMINAL Solar array shall be protected from direct lightning stroke with Early Streamer Emission air terminal in accordance to NF C 17-102. Location and layout of ESE terminal shall be in such a manner that it cast no shadow on the PV Modules during 08:30 AM to 04:30 PM. Number and location of ESE air terminal shall be decided during detail engineering. For this purpose, design calculation considering protection level III (minimum) and Autocad drawing of the layout of ESE terminal shall be submitted to NTPC for approval. ESE air terminal shall be type tested as per Annexure- C of NF C 17-102 (Latest Revision) in the manner as mentioned in the standard. ESE Air terminal shall be supplied with test link, counter, down-conductor, Tripod Earthing, support mast and accessories required for completeness for ESE Lightning protection system. BHEL/NTPC shall test ESE terminal (Each terminal/Sample basis) before installation with suitable instrument for functionality of terminal. Vendor shall replace the terminal free of cost if found defective. Support mast for ESE Air terminal shall be heavy duty hot dip galvanized material and shall be suitable to withstand dynamic and static forces acting on it without failure. Foundation for the mast shall be M20 Grade concrete or better with minimum depth of 1200 MM. 24.0 LIGHTNING PROTECTION SYSTEM FOR BUILDING AND ENCLOSURE Contractor shall provide lightning protection for Inverter room/shelter/enclosure, main control room, Switchgear Room/shelter and similar housing per IS/IEC 62305.
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5.27	EARTHING SYSTEM 25.1 GENERAL REQUIRMENTS This clause is intended to outline the requirement of earthing (grounding) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of earthing system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthing system for safe and satisfactory operation of the plant shall be included under scope of the bidder. 25.1.1 EARTHING DESIGN REQUIRMENT The object of protective earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrences take place. Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system. 25.1.2 CODES AND STANDARD The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.
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IS: 3043	Code of practice for Earthing.
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
IS: 2309	Code of Practice for the protection of building and allied structures against lightning.
IS: 802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 4736	Hot-dip Zinc coating for MS Tubes.
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
	CEA regulations for electrical safety-2010
	Indian Electricity Rules/ Indian Electricity Act.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable. The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

25.2 EARTH ELECTRODE

The earth electrode is in direct contact with the ground provides means for conducting earth current with ground. Earth Electrode material should have good electrical conductivity and mechanical strength and should not corrode in wide variety of soil conditions. For an effective earthing system, following type of vertical earth electrodes can be used.

I. MS Rods

Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm and diameter of 40 mm.

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II. Copper Bonded Rods High tensile-low carbon steel rod having diameter not less than 14/17 mm of Length 3000 mm to be selected based on earth fault current. The Rod shall comply with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more in conformity to UL-467. Its surface shall be clean, free from mechanical defect and any visible oxide layer or foreign material. 25.2.1 EARTHING ENHANCEMENT COMPOUND A low resistance earth electrode system is important to provide a low impedance path for the better dissipation of lightning/fault currents, and to protect personnel and equipment by minimizing and equalizing voltage potential differences. Earthing (ground) enhancement materials shall be used to improve the ground electrode resistance. Earth enhancement material shall be a superior conductive material which improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It shall be tested and should conform to the requirements of IEC 62561-7. It shall have the following characteristics:- a) High conductivity, improves earth's absorbing power and humidity retention capability, non-corrosive in nature having low water solubility but highly hygroscopic. b) Carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties. Cement shall not mix separately & shall not have Bentonite. c) Resistivity of less than 0.2 ohms -meter. d) It shall not depend on the continuous presence of water to maintain its conductivity and shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time. e) It shall not dissolve, decompose or leach out with time and shall be environmental friendly, suitable for soils of different resistivity and any kind of earth electrode. The Earth enhancement material shall be supplied in sealed, moisture proof bags, marked with Manufacturer's name or trade name, quantity etc. The minimum quantity of earth enhancement compound to be used with each earth-pit shall be 25 Kg. 25.2.2 EARTHING CONDUCTOR Earthing conductor is the conductor for buried below the ground at the depth of 600 mm connecting earth pits to make interconnection of earth pit. To interconnect earth pits, following type of conductor can be used. Application of specific conductor and its size has been mentioned in relevant clause: I. Galvanised Steel Flat (GS) Flat GS/GI Flat (Strip) conductor shall comply to IS 2026 with Galvanization of 85 Micron as per IS. Material shall be clean and free form mechanical defects. II. Copper Clad Steel (CCS) Earthing Conductor The Copper Bonded Steel Grounding Conductor shall be made of steel with the coating of 99.99% pure copper complying to ASTM B 869-96 and ASTM B 452-93 standards. Each strand of CCS shall have continuous, uniform coating and the conductor surface shall be smooth and free from mechanical defects. III. MS Rod Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm and diameter of 40 mm. 25.2.3 EARTHING TECHNICAL AND INSTALLATION REQUIREMENT Careful consideration should be given to installing an earthing system that meet or exceed statutory requirements. Contractor shall select certified product and ensure good workmanship for installation for satisfactory performance to fulfill the designed parameters all the times. Following care shall be taken while installation of earthing. I. Metallic frame/ structure of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal
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	pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed as per requirement mentioned elsewhere in the specification. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable. Metallic column for Inverter/Switchgear shelter/E-house shall be earthed with two distinct connections at minimum two column. All the wall cladding section shall be earthed at minimum two location with flexible copper cable of not less than 50 sq. mm. II. Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground. III. Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level. IV. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects. V. Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti-corrosive paint/compound. VI. Suitable earth risers as approved shall be provided above finished floor/ground level, if the equipment is not available at the time of laying of main earth conductor. VII. Connections between earthing leads/risers and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding. Resistance of the joint shall not be more than the resistance of the equivalent length of conductors. VIII. Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm. IX. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover. X. A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same. Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively. XI. Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded preferably below permanent moisture level. Minimum spacing between electrodes shall be 600mm. XII. Earth pits shall be treated with earth enhancement compound if resistivity is more than 20 ohm meter. XIII. On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by contractor.
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	XIV. Contractor shall obtain all necessary statutory approvals for the earthing system before charging of the plant and electrical equipments. 25.3. TECHNICAL DETAILS FOR AC EARTHING SYSTEM This section outlines the requirements of protective and functional earthing system to discharge AC fault current to earth and provide equipotential bonding for Transformer, HT and LT Switchgear Panel and other similar electrical equipments, Transformer neutral and shield. The Contractor shall furnish the detailed design and calculations as per IEEE 80/IS 3043 for Employer's approval for equipment earthing.. 25.3.1 Earthing System requirement for AC Earthing:	
	Conductors above ground level and in built up trenches	Galvanized steel
	Conductors buried in earth	Mild steel
	Earth electrodes	Mild steel rod of diameter 40mm or Copper bonded steel rod of dia not less than 17 mm
	Life Expectancy	25 years
	Fault Level	Mentioned Elsewhere
	Min. Steel corrosion	As per IS 3043
	Soil Restivity	Actual as per site condition

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The sizes of earthing conductors for various electrical equipment shall be as below:			
S No.	Equipment	Earth Conductor buried in Earth	Earth conductor above ground level and in built up trenches
1	33kV/11kV/6.6kV/3.3 kV/ switchgear equipment and 415V switchgear	--	65 x 8mm GS flat
2	415 V MCC/ Distribution boards / Transformers	--	50 x 6mm GS flat
3	LT Motors above 125 KW	--	50 x 6mm GS flat
4	LT Motors 25 KW to 125 KW	--	25 x 6mm GS flat
5	LT Motors 1 KW to 25 KW	--	25 x 3mm GS flat
6	Fractional House power motor	--	8 SWG GS wire
7	Control panel & control desk	--	25 x 3 mm GS flat
8	Push button station/Junction Box	--	8 SWG GI wire
9	Columns, structures, cable trays and bus ducts enclosures	--	50 x 6mm GS flat
10	Crane, rails, rail tracks & Other non-current carrying metal parts	--	25 x 6mm GS flat
25.3.2 Contractor shall ensure there at least two earth pits each dedicated for earthing of each Transformer, HT/LT Switchgear panel, transformer neutral, Battery Charger/UPS/Control Panel etc. shall be provided. Earth electrode shall be located near to the equipment and all earth electrodes shall be interconnected with parallel conductor buried in earth surrounding the equipment. 25.3.3 Earthing system of different locations such as Inverter room/Pooling Switchgear/Sub pooling switchgear/Inverter shelter etc. shall be interconnected in single network with buried conductor of the size 65X8 GS Flat laid at 600 mm depth. Contractor shall submit the calculation based on the system of earth conductor and electrode connected in single network. Location and manner of interconnection shall be approved during detail engineering. Bidder shall also interconnect Main Pooling Switchgear earthing/Metering Yard earthing with existing NTPC Main Plant Earthing if Solar Plant is being developed at NTPC Station. 25.3.4 For functional earthing of electronic component such as SCADA, contractor shall provide 1 no. (Min) isolated earth electrode near to the equipment connected with 2 run of			

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copper cable of size not less than 25 sqmm. Contractor shall comply with the recommendation of OEM (Original Equipment Manufacturer) for electronic earthing and electrode can be connected with other earth electrode as per recommendation of OEM.

25.3.5 Each inverter duty transformer having shield between HV and LV winding shall be provided with 2 nos. Isolated earth electrode connected with each other for functional earthing of transformer shield. Each electrode shall be connected with transformer shield with separate 50X6 Cu flat.

25.4. TECHNICAL DETAIL SOLAR ARRAY (DC) EARTHING

This section outlines the earthing requirement for discharging DC fault current to earth of Solar PV plant and provide equipotential bonding for Module Mounting Structure (MMS), SMB Mounting structure, Module Frames etc.

System Requirement for the solar array DC earthing:

Conductors buried in earth	GS Flat or CCS
Conductors above ground level	GS Flat or CCS
Earth Electrode	40 mm MS Rod or Copper bonded steel rod of dia. not less than 14 mm
Life Expectancy	25 Years
System fault level	5 KA for 3 Sec.
Soil resistivity	Actual as per site conditions
Min. Steel corrosion	As per IS 3043

25.4.1 Each Module mounting structure (MMS), SPV Module frames, mounting arrangement for String Monitoring Boxes, Metallic Junction Boxes, Metal frames/Panel, Metallic Pipes of the solar array shall be effectively earthed by two separate and distinct connections to earthing system. Earthing system for solar array shall consist interconnected earth pits electrodes connected by 25X6 GS flat (Min.) or Copper Clad Steel (CCS) earthing Conductor of size not less than 120 SQMM laid at the depth of 600 MM below the ground. Minimum size of riser conductor to connect the structures to buried earthing conductor and structure to structure in the solar farm shall be 25X3 GS Flat or CCS of Min. 70 SQ MM size.

25.4.2 Periphery fencing wherever provided shall be earthed at every 100 meter interval with 25X3 GS flat connected with DC or AC side nearest buried earthing conductor.

25.4.3 Earthing conductor for connection to structure and equipment may be kept on the ground below MMS. However, these conductor shall be laid 300 mm below the ground along the pathway and/or crossing the pathway.

25.4.4 Equipment and structure in the solar farm shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.

25.4.5 The Contractor shall furnish the detailed design and calculations for Owner's approval as per IS 3043 to determine the number of earth pit and size of earth conductor. However typically the minimum no. of earth pit electrodes for the DC earthing shall be 1No. earth pit at every 1 MW DC.

25.4.6 Buried earth conductor shall be laid all around periphery of solar array farm/blocks. GS flat above the ground for structure earthing shall be connected to the nearest buried conductor or electrode. All the earth electrodes shall be interconnected in single network/mesh and no electrode or group of electrodes shall be isolated/islanded. These electrodes shall be uniformly distributed in the solar farm at maximum practical extent and location of earth electrode shall be approved during detail engineering. A continuous earth path is to be maintained throughout the PV array.

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	25.4.7 Connection of DC earthing system and AC earthing system with location and manner of connection shall be approved during detail engineering. Contractor shall submit the design calculation of earthing system of AC and DC side as standalone (no interconnection) system. 25.4.8 Connection of riser to the structures shall be bolted or welded type. Portion of galvanized structure which undergoes welding at site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterwards. 25.4.9 Connections between earthing leads/riser and between main earthing conductors shall be of welded type. For rust protection, welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding. 25.4.11 Contractor shall seek owner's approval for connecting solar array earth mesh with any other earth mat/earth grid of the solar PV plant. 25.4.12 Earth strips shall be bend properly and taken along the support structure. 25.4.13 Size of earth conductor, nos. of earth pits given in this clause is applicable for solar array earthing only. Relevant method and practice of laying of earthing conductor, earth pits and riser not mentioned herewith but given elsewhere in this specification is applicable to solar array earthing also. General points: Stainless steel, nuts, plain washers shall be used. Spring washers shall be zinc/epoxy coated. Shield earthing of inverter transformers shall be separate and connected to two earth pits (connected together, isolated from earth grid) using copper flat 50x6mm Neutral of all aux transformers shall be connected to two earth pits (connected together, isolated from earth grid) using copper flat 50X6 mm. Earthing cables, all necessary hardwares like nut, bolts, bimetallic lugs etc. shall be in vendor's scope of supply. Supply of 25x3 and 25x6 GI earth strip shall be in BHEL scope. Flats GI 65x8 shall be supplied by BHEL. The earthing for PCU shall be done through 1Cx 70 flexible copper cable and for SCADA through 1Cx 25 sqmm copper cable. Supply of 1CX70 sqmm cable, 1CX16 sqmm cable, cable lugs and hardware is in scope of vendor. Supply and installation of all other materials related to Earth chambers shall be in vendor scope
5.28	Design, supply and installation of Plant lighting System This clause covers supply and installation of suitable illumination system anear Inverter stations, 33KV pooling yards and along the peripheral roads which is not adjacent to NTPC main plant boundary wall or road. However, Removal and refixing of any existing street light to avoid Shading on PV modules is in the scope of the bidder. 26.1 DESIGN PHILOSOPHY A comprehensive illumination system shall be provided in the entire project. 26.2 LIGHTING SYSTEM DESCRIPTION for CMCS and inverter room

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	Normal AC Lighting System: AC lighting system 415V, 3Phase, 4wire, will be fed from lighting panels Control Board (LPs) which in turn will be fed from the lighting distribution boards (LDBs) of AC Switch board MCC.. Scope of Supply is in vendor's scope. Emergency AC Lightning System: The emergency lighting system consisting of 20% of the lights shall be fed from UPS DB. Load of the same has to be considered for UPS sizing. Bidder shall provide outdoor emergency lighting at each inverter station, Main pooling station, security room and main gate. 26.3 Lighting Fixture, Lamps & Accessories a. All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site. b. AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of +/-10%, frequency variation of +/- 5% and combined voltage and frequency variation (absolute sum) of 10% DC lighting fixtures and accessories shall be suitable for operation on 220 V, with variation between 190 V & 240 V. c. All lighting fixtures shall be complete with lamp(s), lamp holder(s), LED chip assembly, terminal blocks, clamps, locking arrangements, fixing brackets etc. Driver circuit/Control gears shall be provided as applicable / specified. The fixtures shall be fully wired upto terminal block. The internal wiring of the fixtures shall be done with suitable low smoke halogen free thermo-plastic or silicon rubber insulated or fire retardant PTFE copper conductor wires of suitable size and type. Further fuse protection of suitable rating in input side shall also be provided specifically for LED luminaires. However, the normal cross section of conductor shall be not less than 0.5 Sq. mm and minimum thickness of insulation shall be 0.6 mm. The wiring shall be capable of withstanding the maximum temperature to which it will be subjected under specified service conditions without deterioration and affecting the safety of the luminaire when installed and connected to the supply. All fixing /locking screws, washers, nuts, brackets, studs etc, shall be zinc plated and passivated. d. All lighting fixtures shall be provided with an external, brass/GI earthing terminal suitable for connecting 14 SWG, GI earthing wire. All metal or metal enclosed parts of the housing and accessories shall be bonded and connected to the earthing terminal as so to ensure satisfactory earthing continuity throughout the fixture e. The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection f. The reflectors shall be manufactured from CRCA sheet steel or aluminium as specified. The aluminium reflectors shall be made of high purity aluminium sheet, polished electrochemically brightened and anodized or proven alternate arrangement of anodizing g. Starters shall have bi-metal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without use of any tool. Starter shall have brass contacts and radio interference suppressing capacitor. h. LED luminaires body shall such designed that heat sink/heat dissipating housing shall be mounted outside the overall luminaires fixture housing, and shall be suitably clearing the driver circuit. Further for outdoor type LED luminaires, the exposed heat sink shall be suitably designed to avoid dust/foreign particles accumulation on the same. i. LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified alongwith finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere. 26.4. LED Luminaires: 26.4.1 CODES AND STANDARDS All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of technocommercial bid opening. In case of conflict between this specification and those (IS codes, standards etc.) referred
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	to herein, the former shall prevail. All work shall be carried out as per the following standards & codes. 16101:2012 General Lighting. LEDs and LED modules Terms and definitions 16102(Part-1 Safety Requirements):2012 Self Ballasted LED Lamps for General Lighting Services. 16102(Part-2 Performance Requirements.):2012 Self Ballasted LED Lamps for General lighting Services. 16103(Part I):2012 LED modules for General lighting Safety Requirements. 15885(Part 2/Sec. 13) :2012 Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules 16104:2012 d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements. 16105:2012 Method of Measurement of Lumen maintenance of Solid-state Light (LED) Sources. 16106:2012 Method of Electrical and photometric Measurements of Solid State Lighting (LED) Products 16107:2012 Luminaire Performance 16108:2012 Photobiological safety of Lamps and Lamp Systems IS 513 Cold rolled low carbon steel sheets and strips IS 12063 Classification of degree of protection provided by enclosures. IS 14700(Part 3/Sec. 2): Electro magnetic compatibility (EMC) – Limits for Harmonic emission – THD < 15% (equipment, input current < 16 Amps. per phase. IS 9000 (Part 6) Environment testing: Test Z – AD: composite temperature/humidity cyclic test. IS 15885(Part 2/Sec. 13)/ IS 16004 (1 and 2)- Lamp control gear: particular requirements for (Part 2/Sec. 13) DC or AC supplied electronic control gear IS 16004 – 1 and 2) for LED modules. IS 4905 Method for random sampling IEC 60598 Ingress protection, luminaire performance and safety IEC 61000-3-2 Total Harmonic Distortion IEC 61000-4-5 Surge Protection IES-LM 80 along with Lumen Depreciation and Rated life of LED chip TM 21/ IS 16105 IES-LM 79 / IS 16106 Luminaire optics and color parameter and electrical parameter 26.4.2 LED LIGHTING SYSTEM LED Luminaires shall be used for the lighting of all the outdoor areas. However for DC lighting & hazardous areas conventional type luminaires shall be used. The individual lamp wattage for LED shall be upto 3 watt for outdoor type luminaires. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall not be less than 80 Lm/W. Heat sink/heat dissipation arrangement shall be provided in the luminaires. The LED used in the luminaires shall have colour rendering index (CRI) of Min 70 for outdoor luminaires. Colour designation of LED shall be “cool day light” (min 5700K) type for indoor type LED luminaires. Further for outdoor type luminaires, the colour designation shall be 5000K, except for well glass type LED luminaires, where the colour designation shall be 4000K. The LED luminaires shall have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life. For highbay & flood light type outdoor luminaires the LED chip with suitable beam angle shall be used to deliver better lumen-output. The maximum junction temperature of bare LED without heat sink shall be limited to 85 deg C, further the lumen maintenance at this
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	temperature shall be min 90%. The THD of tube light based LED Luminaires shall be less than 20%. For other type of luminaries, it shall be minimum 10%. #1 Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink/ heat dissipation arrangement, with proper thermal management shall be designed for the luminaires. Driver Circuit: LED modules and drivers shall be compatible to each other. The LED module driver's ratings and makes shall be as recommended by corresponding LED manufacturer. LED Drivers may have following control & protections:- • Suitable precision current control of LED. • Open Circuit Protection • Short Circuit Protection • Over Temperature Protection • Overload Protection • Surge Protection Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have IP55 degree of protection. Wires of different phase shall normally run in separate conduit. Power supply shall be fed from 415 / 240 V normal AC supply through suitable number of conveniently located lighting distribution boards (LDB) and at least one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc. Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location. Incandescent lamps may be used only with DC Lighting. Electrification of all building shall be carried out as per IS 732-1989, IS 4648-1968 and other relevant standards. All luminaries and their accessories and components shall be of type readily replaceable by available Indian makes. Following test reports to be submitted for LED chip/LED luminaires: a) LED parameters like Lumen per watt, CRI, Beam angle from manufacturer. b) LM 80/IS: 16105 report. c) LM 79/IS: 16106 report 27.0 JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES Junction boxes for street lighting poles and lighting mast as applicable, shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55. All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate. Conduits, Pipes and Accessories: Pull out boxes shall be provided at suitable interval in a conduit run .Boxes shall be suitable for mounting on Walls, Columns, etc. Pull-out boxes shall have cover with screw. Pull out boxes used outdoor shall be weather proof type suitable for IP: 55 degree of protection and those used indoor shall be suitable for IP: 52 degree of protection. 28.0 LIGHTING POLES The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. Height of the poles should be chosen so as not to affect working of Solar panels. The poles shall be hot-dip galvanized as per relevant IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall be min. 70 micron. The System shall be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.
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	The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB. The luminaries used shall be minimum 32 W with minimum pole height of 2.5 m with 35 m inter-pole spacing for peripheral roads & 50 m for internal roads respectively. For internal roads, the spacing shall be 50 m with same specification. Hot dipped Galvanized with 80 mm thickness hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable 28.1 EARTHING Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends. 28.2 AVERAGE ILLUMINATION LEVEL <table><tr><th>Location</th><th>Average Illumination Level (Lux)</th><th>Type of Fixture</th></tr><tr><td>Switchgear Room, HT Breaker, Transformer</td><td>150</td><td>LED Luminaries</td></tr><tr><td>Street lighting-Roads</td><td>Refer Cl. 6.0 LED Luminaries</td><td>LED Luminaries</td></tr></table>	Location	Average Illumination Level (Lux)	Type of Fixture	Switchgear Room, HT Breaker, Transformer	150	LED Luminaries	Street lighting-Roads	Refer Cl. 6.0 LED Luminaries	LED Luminaries																																													
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5.29	Fire Alarm and Firefighting systems The SPV plant shall be equipped with suitable fire protection & fire fighting systems for protection of entire plant & control room as per CEIG requirements. 29.1. Bidder shall comply with recommendation of Tariff Advisory Committee to incurring minimal premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection. 29.2 The fire fighting system for the proposed power plant for fire protection shall be supplied and installed by bidder and shall consist of: a) Sand buckets b) Portable fire extinguishers c) Microprocessor based fire alarm panel. 29.2.1 Portable Fire Extinguishers and Sand Buckets Bidder to provide following numbers of type tested portable fire extinguishers as per relevant code in the room/location as per scope of the specification as mentioned below. <table><tr><th>Rooms</th><th>DCP Type (ABC type) (10 Kg. Capacity)</th><th>CO2 Type 9 kg capacity</th><th>Foam Type Hand 9 kg</th><th>Hand Portable pressurized water CO2 9 Litre</th><th>Sand Buckets</th></tr><tr><td>Main Control Room</td><td>2</td><td>2</td><td>1</td><td>1</td><td>1</td></tr><tr><td>Each Inverter Station/Location</td><td>1</td><td>1</td><td></td><td></td><td></td></tr><tr><td>ACDB/SCADA Room</td><td>1</td><td>1</td><td></td><td></td><td></td></tr><tr><td>Each Transformer yard</td><td>1</td><td>1</td><td>1</td><td></td><td>1</td></tr><tr><td>132KV Switchyard</td><td>2</td><td>2</td><td></td><td></td><td>1</td></tr><tr><td>Main Pooling Yard</td><td>2</td><td>2</td><td></td><td></td><td>1</td></tr><tr><td>Security Room</td><td></td><td>1</td><td></td><td>2</td><td></td></tr><tr><td>Pantry</td><td></td><td></td><td></td><td>2</td><td></td></tr></table> 29.2.2 Microprocessor based fire alarm panel	Rooms	DCP Type (ABC type) (10 Kg. Capacity)	CO2 Type 9 kg capacity	Foam Type Hand 9 kg	Hand Portable pressurized water CO2 9 Litre	Sand Buckets	Main Control Room	2	2	1	1	1	Each Inverter Station/Location	1	1				ACDB/SCADA Room	1	1				Each Transformer yard	1	1	1		1	132KV Switchyard	2	2			1	Main Pooling Yard	2	2			1	Security Room		1		2		Pantry				2	
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	Bidder to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions in each loop. Fire detection alarm system shall include) but not limited to the following items 1. Fire Alarm control Panel 2. Multi Sensor smoke detector 3. Heat Detectors 4. Hooter cum strobe 5. Manual call Point 6. Hooter 7. Fault isolation modules 8. Control Modules 9. Cables from Sensors to Fire panels. 10. Digital output from the fire detection system shall be integrated with SCADA, necessary cables will be in scope of bidder 11. Network Control Module 12. Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA, necessary cables will be in scope of bidder Multi sensor type smoke detectors and heat detectors shall be provided for below false ceiling areas of control room and ACDB and/or inverter rooms. One (01) sensor shall be provided for each 20 sqm of area. All the cable trench inside the control room and inverter room shall be provided with Multi Sensor smoke detector. Bidder shall prepare and submit the layout and scheme indicating fire protection system for approval. Fault Isolation module shall be provided in every room and for every 15 sensors at location proposed by Bidder to be approved by employer during detail engineering. 29.2.3 Fire Alarm Control Panel Indication i. Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information. ii. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged. iii. If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated. iv. All alarm signals shall be automatically "locked in" at the control panel until the operated device is returned to its normal condition and the control panel is manually reset There shall be weather proof Hooter cum strobe outside and strobe inside each Inverter room and control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. All the hardware, relay and accessories required for completeness of fire alarm system is in Bidder scope. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Each Inverter room and control room shall be also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only. Bidder shall submit document to BHEL/NTPC for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report. Bidder shall consider 30 % design and aging margin for selection of nos. of sensors in each loop and length of each loop. Bidder shall submit the certificate or technical datasheet from OEM indicating maximum nos. of sensors in single loop and maximum length of single loop allowed with offered panel and type of cable to be used. Each Fire Alarm Control panel shall have
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	provision for minimum 10 (Ten) % rounded to next higher integer but not less than 2 (two) nos. spare loops for future use of employer. Bidder shall submit Site Acceptance Test (SAT) for approval by employer. Complete fire alarm system shall be checked at site for verification of faithful performance and completeness of the system. Bidder shall carry out necessary modification and supply hardware/accessories if required free of cost at site.
5.30	Design, Supply and installation of Module Cleaning System 30.1 Bidder shall provide permanent arrangement for module washing in the SPV Plant. This shall include supply and installation for drawl and discharge of water from existing Reservoir (within 300m from plot A4 boundary), requisite storage arrangement and laying network of HDPE pipe conforming to IS 4984 and other relevant codes. The module washing shall be complete in all respect and the details shall conform to the relevant IS codes. The complete scheme shall be subject to approval of BHEL/NTPC including inputs points, design and drawings for the system. Opening from the HDPE pipe with manual isolating valves should be provided at regular intervals. The opening pipes for fixing the movable/Hose pipes for spraying water on module shall be made of GI pipe. Bidder shall install flow meter for measurement of water consumption. 30.2 Design of solar PV module cleaning system shall be such that complete solar plant shall be cleaned with fresh water twice in a month. Module cleaning system piping network shall be closed looped pipe network configuration consists of Main pipe, sub-main and branches. Minimum 5 tapping /washing point shall be functional at same time. In array layout, if solar blocks is separated from main plot due to water body, Nallah, roads, etc; Module cleaning system piping network may be design for dead end/tree pipe network configuration. Minimum 2 tapping /washing point shall be functional at same time. Cut-off valves shall be provided at suitable junction point so that the repair works may be conducted at a particular area without disturbing the whole area. The water used for cleaning should be of appropriate quality fit for cleaning purpose as per the recommendations of module manufacturer. 30.3 Bidder shall provide the piping and the instrumentation diagram (P&ID) of water washing arrangement including the physical sequence of branches, reducers, valves, pressure gauge, cleaning points with location of pump(s) and water storage tanks to NTPC for approval during detailed engineering. 30.4 The HDPE pipe shall be suitably protected against any impact load. The HDPE pipes shall be covered higher diameter GI pipe at roads crossing for protection against any heavy loads etc. at roads section. The same protection shall also be provided wherever higher loads are expected. The bidder may also propose some other protection system for HDPE pipes. 30.5 These pipes shall be buried in ground by at least 150 mm deep from NGL/FGL. Only in case of rock at surface and difficulty in cutting the surface rocks pipe may be accepted at surface at some location. The same shall be subject to approval from the owner. 30.6 Maximum length of hose pipe shall be 50 meter from tapping point. Tapping point shall be place above PCC slab/block. 30.7 After laying and jointing, Testing of main pipe, service pipe and fitting shall be checked by charging with water. The test pressure shall be minimum 0.5 N/mm² or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or, in the case of long mains or mains of a large diameter, by a power-driven test pump, provided the pump is not left unattended. 30.8 End of the branch pipes/tapping points to be bent horizontal/downward to avoid entry of foreign materials like, earth, sand leaf, gravels, etc. 30.9 Bidder to ensure interconnection between the sub-systems of module washing system through isolating valve, so as module cleaning may be continued in case of outage of any sub-system.

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	30.10 Bidder shall ensure that the complete module washing system is integrated suitably with water source (existing reservoir within 300m from plot A4 boundary), check dam, motor and water pipe line coming at the periphery of the plant. 30.11 Any additional item, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of cleaning system for satisfactory operation of the plant shall be included under scope of the bidder.																										
5.31	Identification marking using painting Following items shall be identified by way of artistic painting in black letters with yellow background. For danger symbol/text, white letters in red background. Identification number/ text to be painted shall be submitted for BHEL/NTPC approval during detailed engineering for the following. (1) Solar array structures: ~1616 Nos (2) String monitoring boxes: 104 Nos (3) Size/ source/ destination of DC cable 1Cx400 with arrow mark (power flow direction) to be painted on SMBs and PCUs (4) PCUs front side: PCU ID number (1 to 8) with rating 2500KW, AC chamber/ DC chamber, Danger text/symbol. (5) PCUs DC chamber back side: SMB ID numbers, cable size (1Cx400 +,-) with upward arrow mark, danger text/symbol (6) PCUs AC chamber back side: Inv Trnfmr ID, cable size (5Rx1Cx400 / ph) with downward arrow mark, danger text/symbol (7) Same way as above, the corresponding panel ID with rating, cable destination with arrow mark in power flow direction, danger text/symbol shall be painted for all VCB panels, Inverter transformers (HV and LV sides), Aux transformer (HV and LV sides), ACDB panel. (8) For UPS/ FCBC/ SCADA/ all DB boards/ fire alarm panels ID number shall be painted. Cable size/ destination/ arrow marks not required to be painted as cable tags shall be adequate. (9) For earth chambers of inverter rooms, main control room, transformer yards, Main pooling switchgear yard, array, ESE LA, ID number with resistance value and due date shall be painted. All switchboards shall be painted with ID number.																										
5.32	Cable markers and cables tags (1) Cable markers and joint markers for underground cables shall be provided along the route of the cables as per section “Cable installation methodology” of this specification. (2) Cable tags shall be provided at either of the cable (at the entry point to the panel / equipment to which it is connected / terminated) shall be provided as per section “Cable installation methodology” of this specification. (10) Cable tags details shall be provided by BHEL during detailed engineering.																										
5.33	Display boards and sign boards <table border="1"> <thead> <tr> <th>Sl. No</th><th>Description</th><th>Qty for Inverter Station</th><th>Qty for Control room</th></tr> </thead> <tbody> <tr> <td>1</td><td>Board displaying instruction chart for restoration from Electric Shock</td><td>1 No</td><td>1 No</td></tr> <tr> <td>2</td><td>Board displaying instruction chart for artificial respiration</td><td>1 No</td><td>1 No</td></tr> <tr> <td>3</td><td>Board displaying dos and don'ts.</td><td>1 No</td><td>1 No</td></tr> <tr> <td>4</td><td>Board displaying fire extinguishers details and operations</td><td>1 No</td><td>1 No</td></tr> <tr> <td>5</td><td>“No smoking” board</td><td>2 Nos</td><td>5 Nos</td></tr> </tbody> </table>			Sl. No	Description	Qty for Inverter Station	Qty for Control room	1	Board displaying instruction chart for restoration from Electric Shock	1 No	1 No	2	Board displaying instruction chart for artificial respiration	1 No	1 No	3	Board displaying dos and don'ts.	1 No	1 No	4	Board displaying fire extinguishers details and operations	1 No	1 No	5	“No smoking” board	2 Nos	5 Nos
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	6	Danger boards: 33000V with danger symbol in Hindi, Telugu, English	As required	As required
	7	Identification boards, of suitable sizes, within and outside control room such as Inverter room, Main control room, Executive lounge, Store room, Gents toilet, Ladies toilet, SCADA room, Battery room, Pantry room etc. BHEL will provide list.	1 set	5 set
(a) 5mm thick sun board with LG make vinyl sticker (computerized cutting and pasting) shall be used for SI Nos 5, 6 and 7. (3) (b) For others, flex banner with design & printing shall be used.				
5.34	Electrical insulation mat (1) Vendor shall supply electrical insulating mats as follows: (a) Reputed make as shall be approved by BHEL/NTPC (b) As per IS: 15652:2006 (c) Class C (d) Thickness 3 mm minimum (e) Size = 2m x 1m minimum, exact size shall be as approved by BHEL/NTPC during detailed engineering. (f) Colour: to be approved by BHEL/NTPC (g) Max use voltage = 33 kV (h) Marking of IS standard on the mat (2) Test certificate shall be provided by vendor Vendor shall lay the mats in front of all the indoor electrical panels viz. PCUs, VCB panels, ACDB panels, SCADA panels, UPS panels, battery banks etc.			
5.35	Supply and Installation Miscellaneous Items (1) Split Air conditioner of 1.5 tonne 5 star rating (2 Nos) of split type for SCADA room of Voltas/ Hitachi/ Samsung/LG make. (2) Furnitures for SCADA room as below • Table with drawer for desktop PC – 3 Nos Table shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the TFT monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. Telephone sets, very few PB stations and lamps shall be mounted on the control desk on mosaic grid structure and same shall be decided during detailed engineering. ASCII Keyboard shall be capable of being pulled out through a tray. • Chair, industry standard, revolving type, with wheels, arm rest, provisions for adjustment of height (hydraulic/ gas lift):5 Nos			

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	Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators, unit in-charge & other personnel. These shall be designed for sitting for long duration such that these are comfortable for the back. Arm-rests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon. • Storage almirah: 3 No • Filing cabinet: 2 No • Printer table: 1 No Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer. (3) Furniture for security room and security cabins • Table with drawers – 2Nos • Chairs revolving type with arm rest – 10 Nos (4) Note : Make of the above mentioned furniture shall be Godrej or equivalent.				
5.36	Pre-commissioning inspections/ checks/tests, Quality checks, MRT tests, coordination/liaison with state /central departments/CEIG etc. for necessary approvals/clearances for commissioning, synchronization with grid/ plant commissioning <table border="1"> <thead> <tr> <th>#</th><th>Scope description</th></tr> </thead> <tbody> <tr> <td></td><td> Vendor shall be responsible for carrying out following minimum tests/ checks for the respective Inverter stations, transformer yard, CMCS, Main pooling yard and any other tests as per requirements of NTPC / concerned state / central departments / TRANSCO/ GETCO/GEDA/ CEIG/ CEA etc. Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and pre commissioning trials start up tests, trial operation and performance and guarantee tests. Relay setting calculations shall be prepared by vendor for approval. The vendor shall be responsible for all site/commissioning tests. The vendor shall maintain all tests, calibration records in BHEL/NTPC approved formats, and these shall be countersigned by authorized quality assurance personnel of the vendor, BHEL and NTPC. The vendor shall maintain master checklists to ensure that all tests and calibration for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the vendor. The site / commissioning tests shall be categorized under following categories: - Start up tests - Calibration and configuration checks - Pre-commissioning tests - Trial Operation - Availability Tests Point-to-point testing of all the I/O signals under the present scope of work shall be done by the vendor at the plant and protection equipment end and the terminal end. Point-to-point testing shall include: - Verification of all status indications by operating the plant - Verification of event / alarm indications by simulating alarm conditions - Verification of all analogue indications by injection testing </td></tr> </tbody> </table>	#	Scope description		Vendor shall be responsible for carrying out following minimum tests/ checks for the respective Inverter stations, transformer yard, CMCS, Main pooling yard and any other tests as per requirements of NTPC / concerned state / central departments / TRANSCO/ GETCO/GEDA/ CEIG/ CEA etc. Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and pre commissioning trials start up tests, trial operation and performance and guarantee tests. Relay setting calculations shall be prepared by vendor for approval. The vendor shall be responsible for all site/commissioning tests. The vendor shall maintain all tests, calibration records in BHEL/NTPC approved formats, and these shall be countersigned by authorized quality assurance personnel of the vendor, BHEL and NTPC. The vendor shall maintain master checklists to ensure that all tests and calibration for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the vendor. The site / commissioning tests shall be categorized under following categories: - Start up tests - Calibration and configuration checks - Pre-commissioning tests - Trial Operation - Availability Tests Point-to-point testing of all the I/O signals under the present scope of work shall be done by the vendor at the plant and protection equipment end and the terminal end. Point-to-point testing shall include: - Verification of all status indications by operating the plant - Verification of event / alarm indications by simulating alarm conditions - Verification of all analogue indications by injection testing
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		- Verification of all controls by operating the plant		
	1	Pre-commissioning inspections / checks / tests, MRT tests and coordination / liaison activities with state / central departments / GETCO/ GEDA/ Transco/ DISCOM/ CEIG/ CEA etc for necessary approvals / clearances for commissioning, synchronization with grid and post-commissioning operation of the plant. (Clearances shall include obtaining prior approvals for all applicable drawings/ documents etc from concerned state / central departments / GETCO/ GEDA/ Transco/ DISCOM/ CEIG/ CEA etc.). Vendor shall coordinate with and support existing 220KV switchyard contractor in obtaining necessary approvals/ clearances.		
		A Basic checks		
		A1 Tightness checks:		
		1) Terminations of AC/DC power cables at SMBs, PCUs, Inverter transformers, Aux transformer, ACDB panel, UPS/ Battery banks, Aux AC/DC DB boards, 33kV VCB panels, Inverter transformer, SCADA panels etc. 2) Terminations of Control/ Instrumentation/ Data/ Communication cables wherever applicable. 3) Terminations of earthing at all electrical equipment/ panels of inverter station/ control room/main pooling yard 4) Terminations of earthing of inverter transformers, aux transformer 5) Terminations of earth chambers of vendor scope. Note: For M10 and above, torque wrench settings shall be followed for reference.		
		A2 Electrical continuity checks		
		A3 Megger (5kV) checks for all HT (33kV) cables		
		A4 Hi-pot testing for all HT (33kV) cables prior to connection to the panels/ transformers.		
		A5 Megger (1kV) checks for all 1.1kV grade cables		
		A6 AC/DC supply checks at TBs of all electrical panels/ DBs/ Transformers.		
		B Pre-commissioning electrical tests:		
		B1 Power conditioning units (with the support of PCU service engineer at site)		
		1) DC side open circuit voltage and verification with SMB side measurements 2) Vendor to provide technician support to PCU service engineer for all other pre-commissioning tests as per OEM checklist 3) Functioning of duct fans (operation, direction of rotation)		
		B2 Inverter transformers and Aux transformer		
		1) Oil filtration: Equipment of adequate evacuation/ heating/ oil circulation capacity shall be deployed at site for this purpose. Filtration shall be carried out adequately in order to achieve the BDV (min 60kV), ppm (max 10) values within the limits as per relevant standards and as measured by NABL accredited laboratory. The machine shall have built-in BDV measuring set		

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		up for in-situ checking of BDV during filtration process. DG if required for oil filtration shall be arranged by vendor.		
		2) IR tests LV-HV, HV-E, LV-E		
		3) Vector group		
		4) Voltage ratio		
		5) Magnetizing current		
		6) Magnetic balance		
		7) Winding resistance at all taps		
		8) Fault simulation checks (at VCB breaker panels): Buchholz, OTI, WTI, PRV, LOLA etc		
		9) Alarm, trip settings (S1, S2) for WTI, OTI		
		10) Oil level at conservator (to be topped up, if required)		
	B3	CTs 33kV at VCB panel		
		1) IR tests (all cores): Pri-Sec, Sec-Sec, Pri-E, Sec-E		
		2) Ratio tests / primary injection		
	B4	PTs 33kV at VCB panel		
		1) IR tests (all cores): Pri-Sec, Sec-Sec, Pri-E, Sec-E		
		2) Voltage ratio test		
		3) Polarity test		
	B5	33KV VCB breakers		
		IR tests		
		Contact resistance measurement (CRM)		
		Timing test: close/ open/ close-open		
		Functional checks: breaker open/close, spring-charged motor		
		Remote operation from SCADA panels: open/close, command/ status, lamp indications		
	B6	Numerical relays at 33KV breaker		
		1) Relay calibration using applicable kit/ software		
		2) IDMT, DT curves with timing/pickup settings in all relays based on gradation across from downstream to upstream taking into account settings at substation		
		3) Overcurrent/ earth fault pickup/ tripping time tests		
		4) Undervoltage/ overvoltage protection test		
	B7	CT ratio / PT ratio to be set in meters/relays		
		i. All MFM meters		
		ii. Protection relays		
	B8	ACB breaker settings (with the help of PCU service engineer)		
		1) Over load, Short time fault, ground fault		
	B9	Earth resistance measurements for all chambers of vendor scope		
		1) With electrode connected to grid		
		2) Without connecting electrode to grid		
	B10	UPS/ Battery banks		
		1) All functional checks: battery charging/ discharging, battery output parameters etc. as per OEM checklists		
	B12	Tests on 30KV LA in VCB panel		
	C	Testing agency		
		Credentials of testing agency shall be submitted to BHEL for approval prior to awarding of work.		

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			D	Coordination and Liaison activities to be carried out by vendor:		
				1) Vendor shall lead in the process of obtaining approval from GETCO/GEDA/Transco/ DISCOM/ CEIG/ CEA etc as applicable for plant charging/ grid synchronization/ plant commissioning. 2) Liaison responsibility for getting the approvals rests with the vendor. Wherever technical clarifications are required by the approving agencies with regard to SPV portions (including solar array) up to Main pooling switchgear, vendor shall suitably coordinate/liaison with the concerned state/central approving agencies to make the approval process successful. Accordingly, vendor shall participate in direct discussions with the approving agency whenever necessary. Also, all the necessary payments/expenditures to be incurred with ref to such coordination/ liaison in this regard shall be borne by the vendor. 3) Vendor shall coordinate with and support existing 220KV switchyard contractor for successful commissioning of plant. 4) Following are the areas of approval, as applicable (a) GTP/ datasheets/ GA drawings/ Bill of materials, MQP etc of all (BHEL's/vendor's) supply items. (b) Site test reports of transformers, transformer oil, VCB breakers, CTs, PTs, LAs, resistance of earth mat grids etc (c) Interaction with supervising/ inspection agency such as GETCO, GEDA, Transco, CEIG, CEA etc, as applicable, for applying to them/ inviting them for supervision/ inspection at site. (d) Interaction/ coordination with customer in the above process as and when required. (e) All necessary testing kits/ instruments shall be arranged as per the requirements of inspection agency. Basic instruments such as digital multimeter, 5kV digital megger with PI feature, earth resistance meter, VCB open/close timing test kit, clamp meters etc shall be organized at site at the time of inspection. Competent electrical technician shall also be made available at the site. (f) Subsequent to site inspection by the concerned agency, vendor shall obtain the clearance for grid synchronization after implementation of all the observations of CEIG. (g) Vendor shall also coordinate with DISCOM for obtaining approvals such as grid connectivity approval etc.		
			E	Commissioning of Solar Power Plant		
				1) Vendor shall organize all necessary tools/ measuring instruments required to operate the various electrical equipment at the time of commissioning: Digital megger 5KV with PI feature, Earth resistance tester, Phase sequence meter, Clamp meters etc., discharge rods, PPE safety gadgets (helmets, shoes etc.). 2) It is the responsibility of the vendor to successful charge solar plant from solar array to main pooling switchgear and grid synchronization of inverters/ plant commissioning for full DC capacity. 3) Vendor shall participate actively in the commissioning until it is established that there is successful export of power from all the strings, PCUs. 4) Vendor shall coordinate with and support existing 220KV switchyard contractor for successful commissioning of plant.		
			F	Trial run, module cleaning (1 cycle), grass cutting and module cleaning (1 time activity) and Handing over of the Plant		

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		Vendor shall participate actively in the commissioning until it is established that there is successful export of power from all the strings, PCUs. After commissioning and completion of all works including clearing of all punch points, trial run of the plant will be commenced for trouble free operation for cumulative 24 hours (effective solar generation hours) during which functionality of all plant components shall be demonstrated and the system shall be in Generating Mode. During trial run vendor shall deploy manpower, operate and maintain the plant and ensure that there are no breakdowns in any equipment. All required tools and instruments during this period will be provided by vendor. In case of extension of trial run schedule/ period, it is vendor's responsibility to ensure that vendor's teams are available at site till successful completion of trial run. Prior to trial run, vendor shall do one cycle of module cleaning and demonstrate the operation and functionality of module cleaning system in full. After successful completion of trial run and acceptance by NTPC, SPV Plant shall be deemed to be successfully erected & commissioned. Vendor shall propose for handover of the plant supplies and installations. Before handover of the project, vendor shall clean entire plant facility for the scrap/ unused material and remove the shrubs/ bushes/ Grass including uprooting of rank vegetation, brush wood, trees and saplings of girth upto 30 cm measured at a height of 1 m above ground level and removal of rubbish. The same shall be disposed at a remote location as shall be informed during execution. The contractor shall hand over the plant and equipment back to the owner in completely safe and healthy condition and without any pending defect.	
5.37	Spares required to be supplied along with main consignment: 1) Fuses of all types: 1 % of total population of respective items 2) MCB of all types: 1% of total population of respective items 3) Indicating lamp set of all types: 1% of total population of respective items 4) Surge protection devices/ MOV: 1% of total population of respective items 5) Lamps for peripheral lighting- 10 Nos 6) MC4 connectors: 150 sets (1 set = 2 nos) 7) Y connectors: 150 nos 8) 33KV, 1C, 300 sqmm (E) Indoor End termination kits- 3 Nos 9) 33KV, 1C, 300 sqmm (E) Straight through jointing kits- 1 Nos 10) Spares of aux transformers: a) HV bushings with metal parts and gaskets: 1 set b) LV bushings with metal parts and gaskets: 1 set c) Neutral bushing with met metal parts an gaskets: 1 set d) Gaskets : 2 sets e) Silica gel breather with charge: 1 set f) Diaphragm of explosion vent: 1 set g) Prismatic oil level gauge: 1 set h) Valves: 1 set		

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Notes:
(a) 1 set refers to total quantity of the item used in one transformer.
In case quantity arrived based on percentage is a decimal figure, it shall be rounded off to next higher integer.

6.0 SAFETY MANAGEMENT

6.1 Vendor shall follow the site safety plan at site.

6.2 During the execution of the contract, the bidder and it's sub-vendor(if any) shall follow safety procedures for the safety of the personnel and the equipments during erection, testing, commissioning during the contract period as per NTPC/BHEL safety plan, as per the regulatory requirements and the as per the original equipment manufacturer's recommendations.

6.3 All the expenses, charges towards compliance of the safety norms by the bidder as per the Safety Plan, Safety Policy, and the Safety Coordination Procedures are deemed to be included in the bid price. No additional claims shall be entertained towards meeting the safety requirements

6.4 Safety sign board to be provided near all construction area/ installations.

7.0 General conditions applicable during supply, installation and commissioning

7.1	As already mentioned in previous clauses, vendor shall organize power supply on their own. Accordingly, DG sets of suitable capacity shall be deployed by the vendor for construction works.
7.2	Similarly, water required for construction works shall be organized by vendor (tankers etc).
7.3	All machinery such as cranes, hydra, JCBs, forklifts, transport trucks, trolleys etc necessary for movement and installation of materials / panels / equipment etc shall be organized by the vendor.
7.4	All necessary tools and tackles such as crimping tool (including heavy duty tools for crimping copper/ aluminium cables up to 630 sq-mm), screw driver set, power screw drivers, cutting pliers, nose pliers, spanner sets, adjustable spanners, hole-saw cutter set, bending tools, torque wrenches, hack saw blades, pipe wrenches, flat / round files, HV termination tools, drilling machines, welding machines, concrete mixers, steel bar bending tools / templates/ shuttering materials for RCC works, spade, shovel, hammer etc shall be organized by the vendor.
7.5	All necessary measuring instruments such as digital multimeters, measuring tapes, vernier calipers, electrical testers, digital meggers (1kV, 2.5kV, 5kV), earth resistance meters, clamp meters, transformer oil BDV kit, relay testing kit (secondary injection), primary injection kit, infrared thermal imaging handheld temperature meter etc. All these instruments shall possess valid calibration certificate issued from approved NABL laboratory.
7.6	Vendor shall make their own arrangements for necessary food, drinking water and accommodation for their labour and employees posted at the site. Similarly, food and drinking water required at the site, during the construction operations, shall also be in scope of vendor.
7.7	Vendor shall organize all necessary steps to meet statutory requirements such as labour license, PF, ESI etc and also ensure compliance with relevant acts such as minimum wages act, income tax act, employee insurance act etc for their labour deployed at site.
7.8	Vendor shall maintain updated labour register, with name, age, qualification, salary, attendance details etc. at the site.
7.9	Vendor shall use danger boards, wherever required, to ensure safety of the persons during the work at site.
7.10	Vendor shall adhere to all necessary safety norms such as use of helmet, goggles, hand gloves, gumboots, aprons etc. It is the ultimate responsibility of the vendor in all respect to prevent accidents at the site and safeguard their labour from accidents.

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7.11	Vendor shall, at the completion of every work, clear off the debris, which resulted out of the work. In case of excavation work such as cable trench etc, vendor shall finish the land neatly with necessary leveling, rolling etc.
7.12	Vendor shall carry out the work without causing inconvenience to other contract groups at the site. In case of conflicts with other groups, vendor shall ensure that the matter is resolved at once amicably so that the progress of work is not affected.
7.13	Any damages on the building, structures etc. attributable to the acts of labour / employees of vendor shall be rectified and made good by the vendor at their own cost.
7.14	No child labour shall be employed for execution of the present contract.
7.15	Any miscellaneous materials, which are found essential for technical completion of the contract but not mentioned explicitly in this specification, shall be deemed to be included in the specification. Accordingly, such materials shall be included by the vendor as part of the offer.
7.16	Special instruction for earthing: In compliance with Rule 33 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode. Accordingly, all cases such as cable support structures, cable ladders, cable trays (control room) etc. shall be earthed.
7.17	BHEL/NTPC shall witness routine/ acceptance/ type tests performed at manufacturer works for the items supplied by vendor. Vendor shall accordingly provide inspection call to BHEL with submission of quality assurance plan in advance. For the items bought out from dealers, test certificates, as per relevant IS / IEC standards, as issued by manufacturer shall be submitted to BHEL. However, prior approval shall be obtained from BHEL/NTPC for procurement of the item from dealers.
7.18	Field Quality Plan / Quality control system (if applicable) Vendor shall set up a field quality control laboratory with full set up to facilitate testing of all construction materials in accordance with FQP (Field quality control plan) as approved by BHEL/NTPC. Vendor shall deploy a well experienced quality control engineer to monitor all QC activities at site as per approved FQP. Specifically with reference to civil works, vendor shall submit all concrete mix designs and bituminous mix designs for BHEL/NTPC approval before starting of the work. All the third party testing should be conducted in NABL approved laboratories only. Vendor shall submit the FQP for the civil construction works before starting of the works for approval of BHEL/NTPC.
7.19	Any deviations shall be discussed with BHEL/NTPC site engineers and implementation shall be taken up only after approval from BHEL /NTPC.
7.20	Vendor shall submit periodic status report, on daily as well as weekly consolidated basis, to BHEL on the progress of the contract.
7.21	Vendor shall, as and when required by BHEL/NTPC, participate in the review meetings conducted by BHEL/NTPC at project site, BHEL-EDN (Bangalore), BHEL-Corporate office (New Delhi), NTPC office, New Delhi etc
7.22	General Guidelines a) Any civil or electrical work which is not mentioned or included in this tender document but necessary for functional requirements of the plant shall be carried out by vendor. b) Vendor shall prepare all designs / drawings based on the specifications given in the tender and in light of relevant BIS/IS/ equivalent standard. c) Vendor shall provide type test reports and datasheet/ GTP for all equipments covered under vendor scope of supply. d) BHEL reserves right to modify the design at any stage to meet local site conditions / project requirements. e) All work shall be carried out in accordance with the latest edition of the Indian Electricity Act and rules formed thereunder and as amended from time to time.

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7.23	For all current carrying parts and earthing, S.S hardware shall be provided and all other places, G.I hardware shall be provided. M.S hardware shall not be used in any place.
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8.0 Documents to be submitted for BHEL/NTPC approval during detailed engineering

8.1	BHEL/NTPC approval shall be obtained for the following technical documents, which shall be submitted to BHEL in phased manner based on priority sequence of activities during detailed engineering (after receipt of purchase order from BHEL).
8.2	Name of vendor/ make, model number/ part number, specification/ sizes/ dimensions/ drawings/ datasheets shall be submitted for all the vendor supplied items.
8.3	Design calculations/ general arrangement drawings/ single line diagrams/ GTP particulars/ datasheets/ schemes/ layouts/ cable schedules/ bill of materials etc., as applicable.
8.3a	Relay setting calculations
8.4	Manufacturing Quality Plans for all the vendor supplied items
8.5	Field quality plan for the field work: civil works, electrical works
8.6	Detailed activity-time chart for project implementation
8.7	Detailed manpower deployment schedule

ANNEXURE-1

1. LT SWITCHGEAR

• CODES AND STANDARDS

The design, materials, and method of LT switchgear shall conform to the applicable IEC standard. All equipment shall be installed and all work shall be carried out in accordance with relevant IEC standards. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice. All standards, specifications and codes of practice shall be the latest editions including all applicable official amendments and revisions.

As a minimum requirement, the following standards shall be complied with:

IS	Details
IEC 60947/IS 13947	Low-voltage switchgear and control gear
IS 2705	Current Transformers
IS 3043	Code of practice for earthing.
IS 3072	Code of practice for installation and maintenance of Switchgear
IS 3156	Voltage Transformers
IS 3202	Code of practice for climate proofing of electrical equipment.
IS 3231	Electrical relays for power system protection.
IS 13703 / IEC 60269	HRC Cartridge fuses
IS 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear.
IEC 60255	Electrical Relays

• TECHNICAL PARAMETERS

➤ POWER SUPPLY (AC SYSTEM)	
Voltage	415 V + 10 %, 3 Phase, 4 wire, Neutral Solidly Earthed
Frequency	50 Hz +/- 5%
Minimum system fault level	As per system fault current (for 1 sec)
Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	As per system fault current (for 1 sec)
Maximum ambient air temperature	50 deg. C
➤ BUS BARS	
Continuous current rating at 50°C ambient:	As Per Requirement
Temperature Rise allowed above ambient	400C for plain joints 550C for Silver plated joints
➤ MCCB	
Rated voltage	415V
Rated Insulation Level	690V
Rated ultimate and service SC breaking capacity(As per system requirement)	As per system fault current (for 1 sec)
Rated making capacity	2.1 times of System fault current

Utilization category	A
➤ DIGITAL MFM	
Accuracy class	0.5
MFM shall be provided at LT incomer feeder. MFM shall have suitable communication port for integration with SCADA system.	
➤ CURRENT TRANSFORMERS	
Type	Cast Resin Bar Primary
Voltage class and frequency	650V, 50HZ
CT Secondary Current	1 A
Class of insulation	E or better
Accuracy class & burden	
a) For Protection	5P20, 5VA
b) For Metering	Class 1.0, 5VA (min)
Instrument Security Factor for metering CT	5
➤ VOLTAGE TRANSFORMERS	
Type	Cast Resin
Voltage Ratio	415 / 110V for line PT 415/V3 / 110/V3V for Bus PT
Method of Construction	Vee Vee
Accuracy Class	0.5
Rated Voltage factor	1.1 continuous, 1.5 for 30 sec.
Class of insulation	E or better
One minute power frequency withstand voltage	2.5 KV
➤ HRC FUSES	
Voltage Class	650 Volts
Rupturing capacity	80kA (RMS) for AC circuits
➤ CONTACTORS	
Type	Air break electro magnetic
Utilising Category	AC3 of IS/IEC 60947 for non reversible AC4 of IS/IEC 60947 for reversible drives
➤ SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS	
Colour finish	
Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers) The paint thickness shall not be less than 50 microns
Cable entry	Bottom

The quantities/Nos. of the Feeders/MCCB shall be so as to meet the system requirements. 5% spare with minimum 01 No. to be provided on each board/switchgear having more than 5 MCCB. However, no spare Air circuit breaker panels are required.

• DETAILS OF INDOOR DISTRIBUTION BOARDS

Applicable for Auxiliary Power Supply system and String Inverter distribution board of rating upto & including 400A.

- Switchboards shall be of metal enclosed, indoor, floor-mounted, free-standing type.
- All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material.
- All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.
- The switchboards shall be of bolted design. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cutouts shall be true in shape and devoid of sharp edges.
- All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. All cutouts shall be provided with EPDM / Neoprene gaskets.
- All switchboards shall be of uniform height not exceeding 2450 mm.
- Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates.
- All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/ component shall be possible without switching off or isolating the other equipments/components.
- Each switchboard shall be provided with undrilled, removable type gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.
- The minimum clearance in air between phases and between phases and earth for the entire busbars shall be 25mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be at least ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / fuses/MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.
- All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.
- All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet molded compound or equivalent type polyester fiber glass molded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be

provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.

- All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All copper to aluminium joints shall be provided with suitable bimetallic washers.
- All busbars shall be colour coded as per IS: 375.
- Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.
- The Bidder shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.
- Panel space heaters shall be provided and the supply for this shall be tapped from incomer, before the isolating switch/circuit breaker. Incoming circuit to spaceheater shall have an isolating switch, HRC fuse and neutral link of suitable rating.
- Panel illumination and plug-socket shall also be tapped from the space heater supply.
- A galvanized steel / Copper / Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.
- The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth without exceeding the allowable temperature rise.
- All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.
- All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable.
- However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.
- VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.
- All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also be acceptable. The Contractor shall establish earth continuity at site also.
- All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.
- All auxiliary wiring shall be carried out with 650V grade, single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm² (min.) for control circuit wiring and 2.5 mm² (min) for CT and space heater circuits.
- Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.

- All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.
- All internal wiring terminations shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component to component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.
- Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.
- Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminum conductor, PVC/ XLPE insulated, armoured / unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the contractor, to suit the final cable sizes.
- All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.
- All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local pushbutton stations etc. shall be provided with prominent, engraved identification plates.
- All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Employer's approval.
- Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.
- The gaskets, wherever specified, shall be of good quality EPDM / neoprene with good ageing, compression and oil resistance characteristics suitable for panel applications.
- The bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per indian standards / specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.
- ON/OFF status and protection trip status of incomers and bus coupler (if available) be provided for SCADA system.
- Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler.
- It shall be the responsibility of the contractor to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type ii class of co-ordination as per IS:8544.
- All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "class-c" as specified in is: 6005. The phosphated surfaces shall be rinsed and passivated. After passivation, electrostatic powder coating shall be used. Powder should meet requirements of is 13871 (powder costing specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the employer. The paint thickness shall not be less than 50 microns.

- **MCCB**

- MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.
- MCCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc).
- MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door can not be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked.
- The MCCBs being offered shall have common/interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

- **FUSES**

- All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be rated for 80kA rms (prospective) breaking capacity at 415V AC and for DC circuits, 20kA rms breaking capacity at 240V DC.
- Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.
- Fuse shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchboard.
- The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

- **CABLE COMPARTMENT/CABLE ALLEY:** - A full-height vertical cable alley of minimum 250mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations located in cable alley of capacity more than 400 A shall be designed to meet the Form IVb (as per IEC 61439) for safety purpose. Wherever cable alleys are not provided for distribution boards, segregated cable boxes for individual feeders shall be provided at the rear for direct termination of cables. For circuit breaker external cable connections, a separately enclosed cable compartment shall also be acceptable. The contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged.

- **CONTROL COMPARTMENT:-** A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.
- All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. However, the busbar chambers having a degree of protection of IP: 42 are also acceptable where continuous busbar rating is 1600A and above. Provision shall be made in all compartments for providing IP: 5X degree of protection, when circuit – breaker or module trolley has been removed. All cutouts shall be provided with EPDM / Neoprene gaskets.
- Provision of louvers on switchboards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating is 1600 A and above.
- Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. EPDM / Neoprene gasket shall be provided between the panel sections to avoid ingress of dust into panels.
- The minimum clearance in air between phases and between phases and earth for the entire busbars. and bus-link connections at circuit-breaker shall be 25mm. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.
- After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.
- All switchgear (circuit-breaker) panels shall be of single-front type. The covers shall be provided with "DANGER" labels. All panel doors shall open by 90 deg or more.
- All circuit-breaker modules shall be of fully draw out type having distinct 'Service' and 'Test' positions. Suitable arrangement with cradle / rollers, guides along with tool / lever operated racking in / out mechanism shall be provided for smooth and effortless movement of the chassis.
- All switchboards shall be provided with three phase and neutral busbars. Two separate sets of vertical busbars shall be provided in each panel of double front DBs. Interleaving arrangement for busbars shall be adopted for switchboards with a rating of more than 1600A. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked.
- The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear switchgear also.
- **Temperature raise test of LT switchgear of rating more than 400A:-** The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not

exceed 10deg. C for metallic & 15 deg.C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.

- The carriage and breaker frame shall get earthed while being inserted in the panel and positive earthing of the breaker frame shall be maintained in all positions, i.e. SERVICE & ISOLATED, as well as throughout the intermediate travel.
- Electrically controlled circuit breaker boards shall be provided with DC control supply.

• **CIRCUIT BREAKERS**

- Circuit breakers shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameters of continuous current rating and fault making / breaking capacity only after provision of cooling fans or special device shall not be acceptable.
- Circuit breakers along with its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.
- There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "Test" position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLY WITHDRAWN" position. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition.
- Separate limit switches, each having required numbers of contacts shall be provided in both "SERVICE" and "TEST" position of the breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240 V AC and 1 Amp (Inductive) at 240 V DC respectively.
- Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE", "TEST" AND "SPRING CHARGED" positions.
- Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half a cycle of rated frequency.
- Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed circuit breaker shall preferably not trip the circuit breaker. In case the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exists between the fixed and drawout contact at the time of breaker trip so that no arcing takes place even with the breaker carrying its full rated current.
- Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.
- Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.
- Breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.
- Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.
- Circuit breaker shall be provided with anti-pumping feature and trip free feature, even if mechanical anti-pumping feature is provided.
- Mechanical tripping shall be possible by means of front mounted Red "trip" pushbutton. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

- Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels the busbar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live. Dummy panels if required to achieve the above feature shall be included in the Bidder's scope of supply.
- Circuit breaker open/close shall be possible from SCADA and open/close status and all other important signal status shall be provided for SCADA monitoring.
- Power operated mechanism shall be provided with a Universal motor suitable for operation on DC Control supply. In case of DC supply motor should satisfactorily operate with voltage variation between 85% to 110% nominal control supply voltage. Motor insulation shall be class "E" or better.
- The motor shall be such that it requires not more than 30 Seconds for fully charging the closing spring at minimum available control voltage.
- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.
- The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.
- Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.
- All circuit breakers shall be provided with closing and trip coils. The closing coil shall operate correctly at all values of voltage between 85% to 110% nominal control supply voltage. The trip coil shall operate satisfactorily at all values of voltage between 70% to 110% nominal control supply voltage.
- Provision for mechanical closing of the breaker only in "Test" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.
- The ACB Panel door shall not be possible to open in breaker closed condition. Further, the racking mechanism shall be accessible only after opening the breaker panel door.
- Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle at each location. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn /inserted of particular switchgear.

- **Electrical Parameter of Circuit Breaker**

Type	Air break spring charged stored energy type
Operating duty	O - 3 M I N - O C - 3 M I N -OC
Symmetrical interrupting	As per system fault current (for one sec)
Short circuit rating	2.1 times of System fault current peak)
Short Circuit Breaking current	
a) AC Component	As per system fault current (for one sec)
b) DC Component	As per IS:13947
Short time withstand	As per system fault current

- **DERATING OF COMPONENTS**

The Bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the

permissible temperature as per Indian Standards / Specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.

The Bidder shall indicate clearly the derating factors if any employed for each component and furnish the basis for arriving at these derating factors duly considering the specified current ratings and amb. temperature of 50 deg C.

2. LT POWER & CONTROL CABLES

LT Power & control cables shall be of minimum 1100 volts grade XLPE / PVC insulated conforming to IS 1554 for utilization voltages less than equal to 415 V.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).

• LT POWER CABLES

- The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.
- All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.
- If cables are to be laid underground, laying shall be as per latest relevant IS code. Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.
- XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg.C and short circuit conductor temperature of 250 deg C.
- PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.
- The cable cores shall be laid up with fillers between the cores wherever necessary.
- It shall not stick to insulation and inner sheath. All the cables, other than single core cables, shall have distinct extruded PVC inner sheath of black colour as per IS:5831. Single core cables shall have no Inner sheath as per IS: 7098 Part-I

- For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires.
- For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia. of cable under armour	Size and Type of armour
Up to 13 mm	1.4mm dia GS wire
Above 13 & up to 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & up to 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & up to 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & up to 70 mm	1.4mm thick GS formed wire /3.15mm dia GS wire
Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

- The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm² per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.
- The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wire / formed wire.
- Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
 - Oxygen index of min. 29 (as per IS 10810 Part-58).
 - Acid gas emission of max. 20% (as per IEC-754-I).
 - Smoke density rating shall not be more than 60 % (as per ASTM D-2843).
- Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:
 - 1 core - Red, Black, Yellow or Blue
 - 2 core - Red & Black
 - 3 core - Red, Yellow & Blue
 - 4 core - Red, Yellow, Blue and Black
- For reduced neutral conductors (in case of power cable), the core shall be black.

• CONSTRUCTIONAL FEATURES FOR LT POWER CABLES

- KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer-sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armoured.
- 1.1KV grade PVC power cables shall have aluminium/copper conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

• TESTS

- Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of LT power and control cables enclosed at relevant section.
- All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
- All cables to be supplied shall be of type tested design.

- **LT CONTROL CABLES**

- The cables shall be suitable for laying on racks, in ducts, trenches, conduits and under ground (buried) installation with chances of flooding by water.
- All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.
- Conductor of control cables shall be made of stranded, plain annealed copper. Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
 - Oxygen index of min. 29 (as per IS 10810 Part-58).
 - Acid gas emission of max. 20% (as per IEC-754-I).
 - Smoke density rating shall not be more than 60 % (as per ASTM D-2843).
- Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core - Red, Black, Yellow or Blue

2 core - Red & Black

3 core - Red, Yellow & Blue

4 core - Red, Yellow, Blue and Black

- For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.
- In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.
 - Cable size and voltage grade - To be embossed
 - Word 'FRLS' at every 5 metre - To be embossed
 - Sequential marking of length of the cable in metres at every one metre to be embossed / printed
 - The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.
- All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.
- Allowable tolerances on the overall diameter of the cables shall be ± 2 mm maximum, over the declared value in the technical data sheets.
- Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

- **CABLE SELECTION & SIZING**

- Control cables shall be sized based on the following considerations:
 - (a) The minimum conductor cross-section shall be 1.5 sq.mm.
 - (b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

- For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

• CONSTRUCTIONAL FEATURES FOR LT CONTROL CABLES

- KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I).
- Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of LT power and control cables enclosed at relevant section.
- All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
- All cables to be supplied shall be of type tested design.

• CABLE DRUMS

- Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection.
- However, For Single core cables upto 6 Sq. mm size, supplier can do alternative packaging of whole Drum/Spool to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.
- Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

3. Instrumentation Cables

- Common Requirement

Property	Requirement
Voltage grade	225 V (peak value)
Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification.
Continuous operation suitability	At 70 deg. C for all types of cables
Progressive automatic on-line sequential marking of length in meters	To be provided at every one meter on outer sheath.
Marking to read 'FRLS	To be provided at every 5 meters on outer sheath
Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the
Variation in diameter	Not more than 1.0 mm throughout the length of cable.
Ovality at any cross-section	Not more than 1.0 mm
Others	a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name, insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacturer to be provided. b) Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground-buried installation c) Repaired cables shall not be acceptable.
Color	The outer sheath shall be of blue Blue

- Specific Requirement

	Property	Requirement
	Type of cable	F and G Type cables
➤ Conductors		
	Cross section area	0.5 sq. mm
	Conductormaterial	High conductivity Annealed bare copper
	Colour code	As per VDE-815
	Conductor Grade	Electrolytic
	No & dia of strands	7x0.3 mm (nom)
	No. of Pairs	4,8,12,16,24,48
	Max. conductor resistance per Km (in ohm) at 20 deg. C	73.4 (loop)
	Reference Standard	VDE 0815
➤ Insulation		
	Material	Extruded PVC type YI 3
	Thickness in mm (Min/Nom/Max)	0.25/0.3/0.35

	Volume Resistivity(Min) in ohm-cm	1 x 10 ¹⁴ at 20 deg. C & 1x10 ¹¹ at 70 deg. C.
	Reference	VDE 0207 Part 4
	Core diameter above insulation	Suitable for cage clamp connector
➤ Pairing and Twisting		
	Single layer of binder tape on each pair provided	Yes
	Bunch(Unit formation) for more than 4P	To be provided
	Conductor /pair identification as per VDE081	To be provided
➤ Shielding		
	Type of shielding	Al-Mylar tape
	Individual pair shielding	To be provided for F-type cable
	Minimum thickness of Individual pair shielding	28 micron
	Overall cable assembly shielding	To be provided
	Minimum thickness of Overall cable assembly shielding	55 micron
	Coverage Overlapping	100% coverage with 20% overlapping
	Drain wire provided for individual shield	Yes (for F-type) Size=0.5mm ² , No.of strands=7, Dia of strands =0.3 mm, Annealed Tin coated copper
	Drain wire provided for overall shield	Yes. Size=0.5 mm ² , No.of strands=7,Dia of strands=0.3mm Annealed Tin coated copper
➤ Fillers		
	Non-hygroscopic, flame retardant	To be provided
➤ Outer Sheath		
	Material	Extruded PVC compound YM1 with FRLS properties
	Minimum Thickness at any point	1.8 mm
	Nominal Thick-ness at any point	>1.8 mm
	Resistant to water, fungus, termite & rodent attack	Required
	Minimum Oxygen index as per ASTMD-2863	29%
	Minimum Temperature index as per ASTMD- 2863	250 deg.C
	Maximum acid gas generation by weight as per IEC-60754-1	20%

	Maximum Smoke Density Rating as per ASTMD-2843	Maximum 60% To be provided (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as per ASTMD- 2843)
	Reference standard	VDE207 Part 5,VDE-0816
➤ Electrical parameters		
	Mutual Capacitance Between Conductors At 0.8khz (max)	120 nF/km for F type 100 nF/km for G-type
	Insulation Resistance(Min.)	100 M Ohm/Km
	Cross Talk Figure (Min.) At 0.8 Khz	60 dB
	Characteristic Impedance (Max) At 1 Khz	320 OHM FOR F-TYPE 340 OHM FOR G-TYPE
	Attenuation Figure At 1 Khz (Max)	1.2 db/km
➤ Complete Cable		
	Complete Cable assembly	Shall pass Swedish Chimney test as per SENSS 4241475 class F3.
	Flammability	Shall pass flammability as per IEEE-383 read in conjunction to this specification
➤ Tests		
	Routine & Acceptance tests	Refer Type Test requirement of Specification for C & I System
	Type tests	
➤ Cable Drum		
	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.
	Outermost layer covered with waterproof paper	Yes
	Painting	Entire surface to be painted
	Length	1000 m + 5% for up to & including 12 pairs 500 m + 5% for above 12 pairs

4. CABLE INSTALLATION METHODOLOGY

• CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

IS:513	Cold rolled low carbon steel sheets and strips.
IS:802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS:1079	Hot Rolled carbon steel sheet & strips
IS:1239	Mild steel tubes, tubulars and other wrought steel fittings
IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanising of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:3063	Fasteners single coil rectangular section spring washers.
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
IS:9537	Conduits for electrical installation.
IS:9595	Metal - arc welding of carbon and carbon manganese steels - recommendations.
IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6kv upto and including 33kv performance requirements and type tests.
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
DIN 46267 (Part-II)	Non tension proof compression joints for Aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring type ,for Aluminium conductors
VDE 0278	Tests on cable terminations and straight through joints

BS:6121	Specification for mechanical Cable glands for elastomers and plastic insulated cables.
	Indian Electricity Act.
	Indian Electricity Rules.

Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

- **General**

- The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.
- Sizing criteria, derating factors for the cables shall be met as per respective chapters. However for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.
- Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:
 - Meet all safety requirements
 - Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc
- All cables shall be supported by conduits or cable tray run in air or in cable channels. These shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turn made of symmetrical bends or fittings. When cables are run on cable trays, they shall be clamped at a minimum intervals of 2000mm.
- Each cable, whether power or control, shall be provided with a metallic or plastic tag of an approved type, bearing a cable reference number indicated in the cable and conduit list (prepared by the Contractor), at every 5 meter run or part thereof and at both ends of the cable adjacent to the terminations. Cable routing is to be done in such a way that cables are accessible for any maintenance and for easy identification.
- Sharp bending and kinking of cables shall be avoided. Installation of other cables like high voltage, coaxial, screened, compensating, mineral insulated shall be in accordance with the cable manufacturer's recommendations. Wherever cables cross roads and water, oil, sewage or gaslines, special care should be taken for the protection of the cables in designing the cable channels.
- In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop fault at a later date.
- Control cable terminations shall be made in accordance with wiring diagrams, using identifying codes subject to the Employer's approval.
- Multicore control cable jackets shall be removed as required to train and terminate the conductors. The cable jacket shall be left on the cable, as far as possible, to the point of the first conductor branch. The insulated conductors from which the jacket is removed shall be neatly twined in bundles and terminated. The bundles shall be firmly but not tightly tied utilising plastic or

nylon ties or specifically treated fungus protected cord made for this purpose. Control cable conductor insulation shall be securely and evenly cut.

- The connectors for control cables shall be covered with a transparent insulating sleeve so as to prevent accidental contact with ground or adjacent terminals and shall preferably terminate in Elmex terminals and washers. The insulating sleeve shall be fire resistant and shall be long enough to over pass the conductor insulation. All control cables shall be fanned out and connection made to terminal blocks and test equipment for proper operation before cables are corded together.

- **EQUIPMENT DESCRIPTION**

- **Cable trays, Fittings & Accessories**

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.

Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm

- **Support System for Cable Trays**

Cable tray support system shall be pre-fabricated similar or equivalent to "Unistrut make".

Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types : (i) C1:- having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder:

a. Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

b. The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fittings and accessories shall be prefabricated factory galvanised.

c. The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanised surface shall be

brushed and red lead primer, oil primer & aluminium paint shall be applied

d. All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drill ing and other machining operation.

e. Support system shall be able to withstand

- ✓ weight of the cable trays

- ✓ weight of the cables (75 Kg/Metre run of each cable tray)
- ✓ Concentrated load of 75 Kg between every support span.
- ✓ Factor of safety of minimum 1.5 shall be considered.

➤ **PIPES, FITTINGS & ACCESSORIES**

Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria GI Pipes shall be of medium duty as per IS:1239

Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.

Hume pipes shall be NP3 type as per IS 458

➤ **Junction Boxes**

Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of thickness 2mm. Top of the boxes shall be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanised as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation.

Terminal blocks shall be 1100V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size upto 2.5 sq mm each. All internal wiring shall be of minimum 1.5 sq. mm cu. Conductor PVC wire.

➤ **Terminations & Straight Through Joints**

Termination and jointing kits for 33kV, 11kV, 6.6 kV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be premoulded type, taped type or heat shrinkable type. 33kV, 11kV and 6.6 kV grade joints and terminations shall be type tested as per IS:13573. 3.3kV grade joints and terminations shall be type tested as per VDE0278. Critical components used in

cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard.

Straight through joint and termination shall be capable of withstanding the fault level for the system.

1.1 KV grade Straight Through Joint shall be of proven design.

➤ **Cable glands**

Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation.

Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene or better synthetic material and of tested quality.

Cable glands shall be suitable for the sizes of cable supplied/erected.

➤ **Cable lugs/ferrules**

Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipments. Cable lugs and ferrule shall conform to relevant standard

➤ **Trefoil clamps**

Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current.

➤ **Cable Clamps & Straps**

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, selflocking, de-interlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment

➤ **Receptacles**

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanised or of die-cast aluminium alloy of thickness not less than 2.5 mm.

The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position.

Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polyimide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

➤ **Galvanising**

Galvanising of steel components and accessories shall conform to IS:2629 , IS4759 & IS:2633. Additionally galvanising shall be uniform, clean smooth, continuous and free from acid spots.

The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367 . The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified

➤ **Welding**

The welding shall be carried out in accordance with IS:9595. All welding procedures and welders qualification shall also be followed strictly in line with IS:9595

• **INSTALLATION**

➤ **Cable tray and Support System Installation**

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.

Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray

installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the

support system along with tray, spacing etc in line with relevant standard.

The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated.

The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor.

In certain cases it may be necessary to site fabricate portions of trays, supports and other non standard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

➤ **Conduits/Pipes/Ducts Installation**

The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/ roof/ wall/ cable tunnel/ cable trenches made for conduit installation shall be sealed and made water proof by the Contractor **either with any proven fire sealing system rated for one hour or** Modular multi-diameter cable sealing system consisting of frames, blocks, Compression wedge and its accessories. **The Cable sealing system should have been tested for fire insulation for min. 1 hr as per BS 476 and shall also provide water sealing. System shall be anti- rodent and anti- termite. #1** GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.

Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material

Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit /pipe size (dia).	Spacing
Upto 40 mm	1 M
50 mm	2.0 M
65-85 mm	2.5 M
100 mm and above	3.0 M

For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.

➤ **Junction Boxes Installation**

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

➤ Cable Installation

Cable installation shall be carried out as per IS:1255 and other applicable standards.

For Cable unloading, pulling etc following guidelines shall be followed in general :

Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends.

Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.

While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer.

Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.

Cables shall be laid on cable trays strictly in line with cable schedule Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two meter. All multi core cables shall be laid in touching formation.

Power and control cables shall be secured fixed to trays/support with self-locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multi core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by aluminium strips at every five meter interval and at every bend.

Bending radii for cables shall be as per manufacturer's recommendations and IS: 1255.

Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe.

No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.

In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.

Wherever few cables are branching out from main trunk route troughs shall be used.

Wind loading shall be considered for designing support as well Cable trays wherever required. Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.

The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time

➤ Separation

At least 300mm clearance shall be provided between:

- HT power & LT power cables,
- LT power & LT control/instrumentation cables

Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:

No. of cores in cable	No. of spare cores
2C,3C	NIL
5C	1
7C-10C	2
14C and above	3

➤ Directly Buried Cables

Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255.

RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 5 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate.

Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

➤ Cable Terminations & Connections

The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site.

Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.

The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.

Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.

All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.

All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

5. AUXILLARY POWER SUPPLY SYSTEM

• GENERAL

- Auxiliary power supply arrangement shall be in line with tender SLD. Each Inverter Room/local pooling/sub-pooling/CMCS room shall have its own auxiliary power supply system comprising of AC distribution board (ACDB) which shall be fed from LV side of Inverter transformer through suitably rated auxiliary transformers. All ACDB's shall have two incomer (100% rated) fed from two different sources. At CMCS, auxiliary transformer directly feed from 33kV switchgear are also acceptable. Following consideration shall be taken while arriving kVA capacity of auxiliary transformer,
 - 20% design margin.
- All non-critical auxiliary loads shall be fed directly from ACDB. However, emergency and important load shall be fed from suitable sized Uninterrupted Power Supply (UPS) or Battery Charged. Input AC supply for Uninterrupted Power Supply (UPS) and Battery Charger shall be fed from ACDB. Bidder shall consider the following one of the supply option for feeding different equipment loads:

Equipment Name	Option-1 ACDB	Option-2 UPS
SCADA including remote RTU/IO panel		✓
SCADA HMI		✓
Data logger		✓
Fire Detection /Alarm Panel		✓
Emergency Lighting		✓
HMI of SCADA		✓
Energy Meter/MFM		✓
Sub and Local Pooling Switchgear control & protection		✓
Main Pooling Switchgear (CMCS) control & protection		✓
Switchgear spring charging motor		✓

switchgear space heater	√	
Illumination, Fan supply etc	√	
Module washing system	√	
Other non-critical auxiliary loads	√	

- UPS system shall comprise of 2 x 100% UPS. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing 30 minutes backup. Bypass Line static switch, manual bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories. UPSDB shall have two incomer fed from two separate UPS as mention above. At a time one incomer shall be in service. Suitable auto changeover logic shall be provided. ~~In place of UPS, bidder can provide DC supply system (2 x 100% Battery Charger) of 12V or above upto 220V DC if the auxiliary power supply requirement of loads are in DC.~~
- The rated AC output capacity shall be taken for UPS battery size calculation. However the tentative UPS rating shall be 5KVA and the battery sizing shall be calculated on a minimum load of 1 KW (DC) for 30 minute backup. All UPS having rating 5KVA or more shall have three phase input.
- ~~➤ The Bidder can provide alternate arrangement with suitable redundancies such as power pack with 30 minute backup for switchgears.~~
- ~~➤ Each Battery charger system shall consist of 1 x 100% charger and 1 x 100% Battery bank for min 30 minutes back up and 1 x 100% DCDB, and other necessary protective devices and accessories. DC supply system voltage shall be 12V or above upto 220V DC.~~
- ~~➤ It is mandatory to use Battery charger system for control and protection supply of main pooling HT switchgear.~~
- Bidder shall submit configuration diagram, power supply distribution scheme, single line diagram and data sheets, all calculations such as Rectifier Modules/UPS Charger/Inverter rating calculations, battery sizing calculation etc. for UPS, Battery Charger & Battery system during detailed engineering stage for employer's review and approval.
- Size and rating of UPS, Battery Charger and Battery shall be finalized during details Engineering stage.

• UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

- The minimum capacity of the UPS at load factor of 0.8 lagging inclusive of 10% design margin at 50 deg C. The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The overall efficiency of UPS shall be at least 80% on full load.
- The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.
- For UPS capacity 5 kVA or more, in addition to indications/display on UPS panel, important alarms along with important analog signal shall also be provided for use in SCADA. For UPS capacity less than 5 kVA bidder shall provide status, common alarm and trip DI (soft or hard) signal to SCADA
- The UPS chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates. The charger should be capable to fully charge the required batteries as well

as supply the full rated load through inverter. The charger shall be able to re-charge the fully discharge battery within 8 hours. The charger shall be design for input supply variation of $\pm 10\%$ and frequency variation of $\pm 5\%$. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The detailed specification for the battery charger for UPS rating of 5kVA and above has been mentioned in the battery charger section below in this specification.

- The UPS inverter shall be of continuous duty, solid state type using proven Pulse Width Modulation (PWM)/Quasi square wave/step wave technique. Ferro-resonant types Inverters are not acceptable. The nominal voltage output shall be 230 Volts single phase ,50 Hz. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, etc. The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum.
- The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from faulty inverter to standby AC source. Manual bypass switch shall be employed for isolating the UPS during maintenance.
- Contractor has the option of supplying either Nickel Cadmium type batteries or Lead Acid Plante type batteries. The detailed specification for the batteries has been mentioned in the battery and charger section below in this specification.
- Equipment enclosures shall match and line up in assemblies of freestanding floor mounted cabinets designed for indoor service.
- Individual enclosure shall be ventilated switchboard type fabricated from not less than 1.6-mm thick sheet steel. Enclosures shall be furnished with concealed hinges. Front and rear doors shall be designed to permit easy access to all components for maintenance or replacement. The enclosures shall be reinforced with formed steel members as required to form a rigid self-supporting structure. Doors shall have three point latches.
- Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings.
- The cabinets shall be IP-42 protection class for indoor application and IP65 for outdoor application.
- The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.
- The Contractor shall also carry out the site tests on UPS as required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.
- One set of tool shall be provided for maintenance and testing purposes.
- Battery shall be Nickle Cadmium battery or Lead Acid Plante Battery. Specifications are as mentioned below-

- **BATTERY: NICKEL-CADMIUM BATTERY**

BATTERY PARAMETER

- a) Battery Voltage- To be decide during Detail Engineering
- b) No. of Cells- To be decide during Detail Engineering
- c) Battery type- Nickel-Cadmium
- d) Nominal discharge voltage per Cell- 1.2
- e) Float voltage- 1.42V/Cell

Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein, shall be the latest editions including all applicable official amendments and revisions as on date of opening of techno-commercial bid. In case of conflict between this specification and those (IS codes, Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:

IEC 60623/ IS 10918 Specification for vented type Nickel Cadmium Batteries.

IS 106 Quality tolerances for water for storage batteries

IEC 60993 Electrolyte for vented Nickel-Cadmium cells

Indian electricity rules

Indian electricity acts

Equipment complying with other internationally accepted standards such as IEC., BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

DC Batteries shall be stationary Nickel Cadmium Pocket plate type conforming to IS:10918. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

DC batteries shall be suitable for standby duty. The batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

- **Construction Features:-**

- **Containers**

Containers shall be made of polypropylene plastic material. Containers shall be robust, heat resistance, leak proof, non-absorbent, alkali resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of translucent containers.

- **Vent Plugs**

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

➤ **Plates**

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS:10918. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminal posts shall be clearly marked.

➤ **Sediment Space**

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

➤ **Electrolyte**

The electrolyte shall be prepared from battery grade potassium hydroxide conforming to IEC 60993. The cells can be shipped either in charged condition or in dry condition. Necessary electrolyte for make-up shall be supplied separately.

➤ **Connectors and Fasteners**

Nickel plated copper connectors shall be used for connecting adjacent cells and PVC insulated flexible copper cables shall be used for inter-row / intertier / inter-bank connections. Bolts, nuts and washers shall be Stainless Steel / Nickel coated steel to prevent corrosion. The thickness of Nickel coating of connectors should be not less than 0.02 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds.

g) Battery racks

Mild steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Testing

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146(for all applicable tests for containers) / IS-10918 (for NI-CD batteries).The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

● **BATTERY : LEAD-ACID PLANTE BATTERY**

➤ **BATTERY PARAMETER**

- a) Battery Voltage To be decide during Detail Engineering
- b) No. of Cells To be decide during Detail Engineering
- c) Battery type Stationary Lead Acid Plante
- d) Nominal discharge voltage per cell 2.0V
- e) Float Voltage 2.25V/Cell

➤ **CODES AND STANDARDS**

- IEC 60896 Stationary Lead Acid Batteries
- IS : 266 Specification for sulphuric acid
- IS : 1069 Specification for water for storage batteries
- IS : 1146 Specification for rubber & plastic containers for lead acid storage batteries.
- IS : 1652 Specification for stationary cells and batteries, lead acid type (with plante positive plates).
- IS : 3116 Specification for sealing compound for lead acid batteries.

IS : 8320 General requirements and methods of tests for lead acid storage batteries.

IS : 6071 Specification for synthetic separators for lead acid batteries.

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➤ Equipment complying with other internationally accepted standards such as IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

➤ DC Batteries shall be stationary lead acid Plante positive plate type conforming to IS:1652. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

➤ DC Batteries shall be suitable for standby duty. The Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.25 V/cell.

➤ Construction Features:-

➤ Containers

Containers shall be made of transparent glass, hard rubber, suitable robust, heat resistance, leak proof, non absorbent, acid resistant, non bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of transparent containers. Float type level indicator shall be provided in case of opaque containers. The stem portion of the float should be long enough to prevent falling of the float inside the container even if there is no electrolyte in the container. The marking for the electrolyte level should be for the upper and lower limits. The material of level indicator shall be acid proof and oxidation proof. Container shall be closed/sealed lid type. Lid and sealing compound shall be non-cracking type. The container made of hard rubber and plastics shall be type tested as per IS : 1146. All type tests shall be carried out for sealing compound as per IS:3116. The pole sealing arrangement should be such that no acid particle get entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

➤ Vent Plugs

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte sample.

➤ Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS : 1652 as applicable. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative post shall be clearly marked.

➤ **Sediment Space**

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

➤ **Cell Insulator**

Each cell shall be separately supported on PVC/porcelain/hard rubber insulators fixed on the racks with adequate clearance between adjacent cells. Minimum distance between adjacent cells shall be more than the bulge allowed for two cells in accordance with IS:1146.

➤ **Electrolyte**

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS:266 and distilled water conforming to IS:1069. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately.

➤ **Connectors and Fasteners**

Lead or Lead coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. The thickness of lead coating of connectors should not be less than 0.025 mm. The lead coating thickness shall be measured in accordance with APPENDIX F of IS:6848 (latest edition). All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied by the contractor.

➤ **Battery racks**

Wooden racks for all the batteries shall be provided. These racks shall be made of good quality first class seasoned teak wood in line with CPWD specification. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries rack and wooden support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

➤ **Testing**

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for rubber & plastic containers for lead acid storage batteries)/IS-1652 (for lead acid plate batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

➤ **AUXILIARY EQUIPMENTS**

Manual discharge resistance bank suitable for each type of battery bank of UPS/Battery Charger has to be provided by contractor.

Following shall be provide (as per applicability) for maintenance purpose

a Hydrometer 2 Nos.

b Set of hydrometer syringes suitable for the vent holes in different cells 2 Nos.

c Thermometer for measuring electrolyte temperature 2 Nos.

d Specific gravity correction chart 2 Nos.

e Wall mounting type holder made of teak wood for hydrometer & thermometer 2 Nos.

f Cell testing voltmeter (3-0-3 V) 2 Nos.

g Alkali mixing jar 2 Nos.

h Rubber aprons 5 Nos.

i Pair of rubber gloves

j Set of spanners 5 Nos.

k No smoking notice for each battery room 2 Nos.

l Goggles (industrial) 2 Nos.

m Instruction card 2 Nos.

n Temperature indicator 1 No. per room

o Cell lifting facility 1 Set per room

- **SITE TESTS**

The contractor shall carry out the following site tests as applicable on UPS, Battery Charger and Battery system. However, any other site test is required to be conducted as a standard practice of the OEM or deemed necessary by the employer and mutually agreed between the contractor and the employer, the same shall also be carried out.

- **Light Load Test**

This test is carried out to verify that the UPS/Battery Charger is correctly connected and all functions operate properly. The load applied is limited to some percent of rated value. The following points should be checked:

- a) Output voltage, frequency and the correct operation of meters;
- b) Operation of all control switches and other means to put units into operation.
- c) Functioning of protective and warning devices.

- **C. Input Failure Test**

The test is performed in UPS/Battery Charger with a fully charged battery and is carried out by tripping input supply feeder or may be simulated by switching off all rectifiers and bypass feeder as at the same time. Output voltage variations are to be checked for specified limits with an oscilloscope/Recorder.

- **C Input Return Test**

AC input return test is performed in UPS/Battery Charger by closing AC input supply feeder, or is simulated by energizing rectifiers. Proper operation of rectifier starting and voltage and frequency variations are to be observed. This test is normally performed with a fully or partially charged battery.

- **Auto changeover Test**

This test shall be carried out in UPS ACDB fed from two separate UPS system. Auto changeover of one UPS source to standby UPS to be check by tripping the active UPS manually or by simulation condition. This test shall be check as per approved auto changeover logic.

- **Transfer Test (for UPS)**

This test is applicable for UPS with bypass, particularly in the case of an electronic bypass switch. Transients shall be measured during load transfer to bypass caused by a simulated fault and load retransfer after clearing of the fault.

- **Full load test**

Load tests are performed by connecting the actual load to the UPS/Charger output. Load tests are necessary for testing output voltage and frequency, rated stored energy, recharge time, ventilation, and temperature.

- **Rated Stored Energy Time (Battery test)**

This test is a load test to prove the actual possible time of battery operation. If rated load is not available in the case of large UPS/Battery charger, it is possible to apply a partial load to check the actual battery discharge characteristics and compare these with characteristics specified by the battery manufacturer. Discharge time with rated load shall then be calculated. The test shall be performed with a fully charged battery and also may be done under other battery conditions to be specified, if so agreed. Active power output of the UPS/Battery Charger and the battery voltage shall be recorded during the test. Since new batteries often do not provide full capacity during a starting up period, the discharge test may be repeated after a reasonable recharge time if the original test has failed.

- **Rated Restored Energy Time**

Restored energy depends on the charging capacity of the rectifiers and the battery characteristics. If a certain recharging rate is specified, it shall be provided by repeating the discharge test after the specified charging period.

- **Battery Ripple Current**

If battery ripple currents are specified, then the ripple current which depends on UPS operation shall be checked under normal operating conditions. Rough measuring methods are sufficient.