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A Mini Ratna Company

TENDER DOCUMENT

**FOR
DESIGN, ENGINEERING, PROCUREMENT & SUPPLY,
CONSTRUCTION & ERECTION, TESTING AND
COMMISSIONING
OF
GRID CONNECTED 70 MW (AC) SOLAR POWER PLANT
HAVING TEN YEARS COMPREHENSIVE O&M
FOR
WESTERN COALFIELDS LIMITED, NAGPUR**

**AT
NANDAN WASHERY
KANHAN AREA, WCL**

**VOLUME – II
[TECHNICAL]**



July, 2024

**Central Mine Planning and Design Institute Ltd.
(A Subsidiary of Coal India Ltd.)
Gondwana Place, Kanke Road,
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PROJECT SUMMARISED DATA

Sl. No.	Particulars	Description
1.	Owner of Project / Land	Western Coalfields Limited
2.	Location	Nandan washery, Kanhan Area
3.	Latitude-Longitude	20°10'58" N – 78°27'51" E
4.	Total Land Area Available (approx.)	160 Ha
5.	Plant Capacity (AC)	70 MW
6.	Nominal/system Power (DC) (Minimum)	98 MWp or higher
7.	PV Module	545 Wp (min.), Mono-PERC, Half-Cut
8.	No. of modules	As per requirement
9.	Inverter	String Inverters
10.	PV Power Plant Life	25 Years
11.	Comprehensive Operation & Maintenance period of the Plant	10 Years
12.	Feeding Substation	132 KV Khapaswami Substation, Chhindwara, MP
13.	Feeding Substation distance from proposed plant	6 KM (Approx.) to 132 KV Khapaswami substation.
14.	Power evacuation	At 132kV through 132 KV double circuit transmission line to Feeding Substation
15.	Accessibility to proposed site	Nearest State Highway: SH 19, Nearest Railway Station: Hirdagarh and Junnardeo Railway Station, Nearest Airport: Nagpur Airport
16.	Climatic Data	Average Max. Temperature: 45.9°C, Average Min. Temperature: 8.3°C, Average Annual Rainfall: 1125.2 mm

CHAPTER-I

INTRODUCTION

1.1 General

This tender document is for turkey execution of 70 MW (AC) Ground Mounted Solar Power Plant at Nandan washery, Kanhan area, WCL for captive consumption at various load centers of WCL at Maharashtra through open access which includes:

“Design, Engineering, Procurement & Supply, Construction, Fabrication, & Erection, Installation, Testing & Commissioning of grid connected ground mounted solar power plant of aggregate capacity of 70 MW (AC) with minimum 40 percentage DC overload capacity, at Nandan Washery, Kanhan Area, WCL consisting of all Civil, Structural, and Electrical Works and all other accessories and facilities required to make it complete in all respects including Power Evacuation, Connectivity approvals and Comprehensive Operation & Maintenance of plant for ten years.”

1.2 Locations and Connectivity

The site identified for installation of solar power plant is Nandan Washery area including railway track. Satellite image of the proposed sites for installation of ground mounted solar power plant is shown below. The boundary coordinates are listed in Table I.1 below:

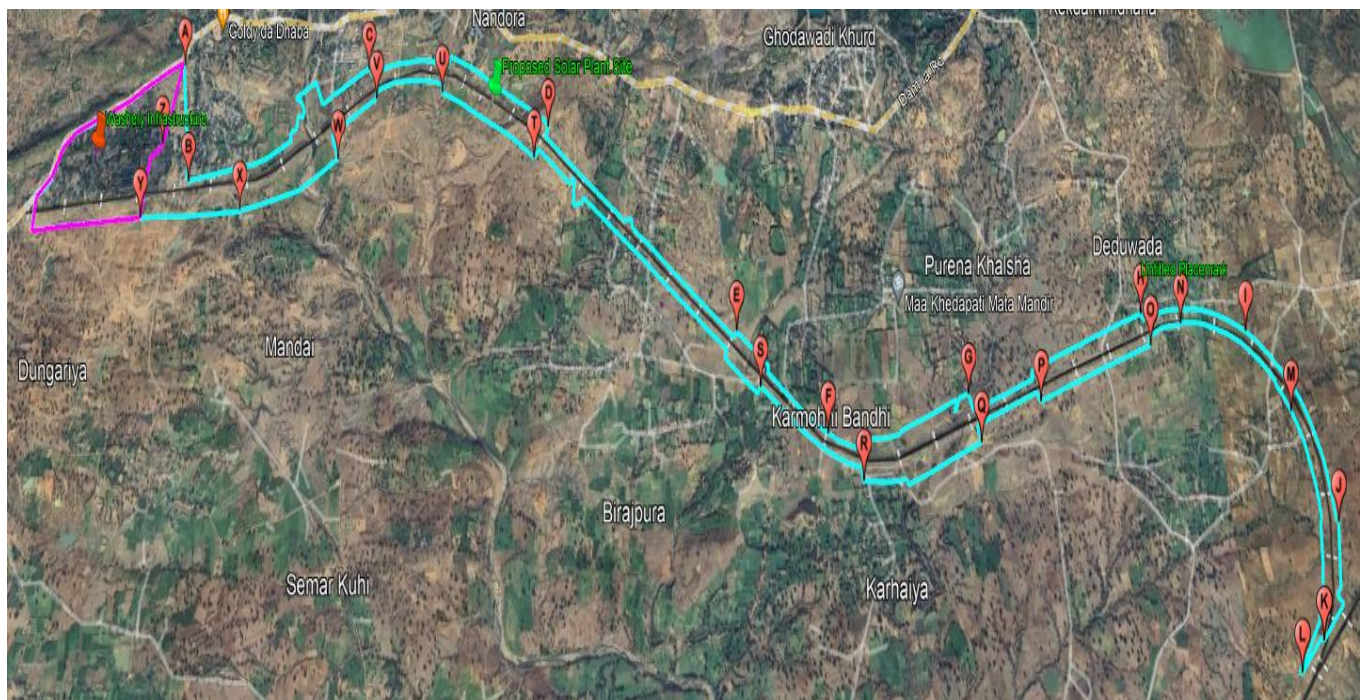


Fig – I.1: Satellite image of the proposed site

Table I-1: Coordinates for marked proposed solar site

Boundary Name	Latitude	Longitude	Boundary Name	Latitude	Longitude
A	22°11'19.74"N	78°27'23.00"E	N	22°10'35.89"N	78°31'57.26"E
B	22°10'59.45"N	78°27'27.84"E	O	22°10'32.31"N	78°31'48.62"E
C	22°11'19.43"N	78°28'15.11"E	P	22°10'23.53"N	78°31'18.32"E
D	22°11'8.64"N	78°29'6.64"E	Q	22°10'17.42"N	78°31'2.15"E
E	22°10'34.94"N	78°29'58.78"E	R	22°10'11.65"N	78°30'31.20"E
F	22°10'18.84"N	78°30'22.36"E	S	22°10'26.11"N	78°30'4.95"E
G	22°10'24.87"N	78°30'59.56"E	T	22°11'3.37"N	78°29'3.00"E
H	22°10'37.21"N	78°31'46.72"E	U	22°11'15.31"N	78°28'36.29"E
I	22°10'34.82"N	78°32'14.44"E	V	22°11'13.91"N	78°28'17.99"E
J	22°10'5.59"N	78°32'32.06"E	W	22°11'3.62"N	78°28'8.47"E
K	22° 9'48.67"N	78°32'24.14"E	X	22°10'54.61"N	78°27'42.85"E
L	22° 9'44.18"N	78°32'17.69"E	Y	22°10'53.11"N	78°27'15.99"E
M	22°10'22.15"N	78°32'23.59"E	Z	22°11'5.89"N	78°27'19.38"E

The proposed site is located in Chhindwara district of Madhya Pradesh. The site is well connected through roads (SH19) and rail. Nearest railway stations are Hirdagarh and Junnardeo Railway Station while the nearest airport is Nagpur airport.

Chhindwara has a subtropical climate bordering tropical wet and dry climate. It has a hot, dry summer (April–June) followed by monsoon rains (July–September) and a cool and relatively dry winter. Average annual rainfall is 1,125.2 mm. Temperature during winter is around 4 to 6 degrees Celsius while temperature during summer remains around 38 to 42 degrees Celsius. Humidity is generally high with a maximum of around 95 % during the rainy season.

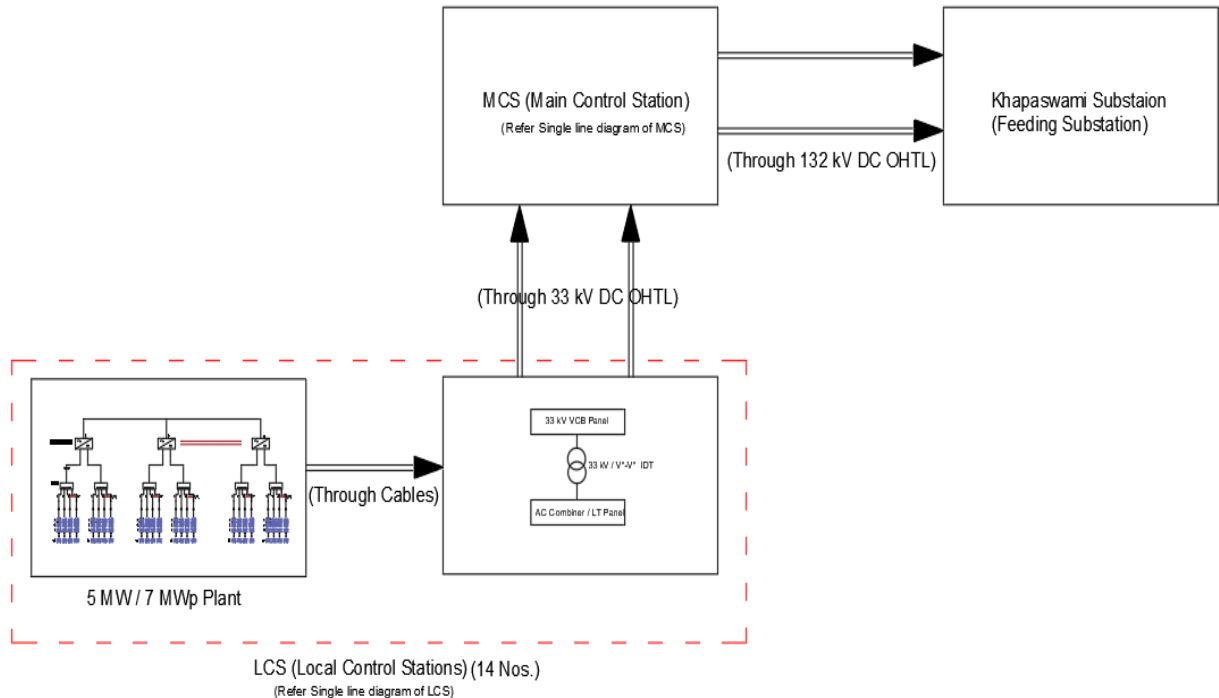
Total available land at the proposed locations is around 160 Ha, for installation of solar power plant of 70 MW with additional minimum DC overload capacity of 40%.

There are some small bushes and trees within the sites, which need to be cleared by the bidder for installation of PV Modules. Tree cutting permission, if required, shall be in the scope of WCL. However, uprooting, removal and transportation of trees and bushes shall be in the scope of Bidder. Also, there are some undulations at the site which require land preparation before installing MMS structures. Providing hindrance free land shall be in the scope of WCL.

The Bidder is advised to visit and examine the site of works (including capacity assessment) and its surroundings and satisfy himself with all the conditions and obtain for itself on its own responsibility all information that may be necessary for

preparing the Bid and entering into a Contract for the required job. The costs of visiting the site shall be borne by the Bidder.

1.3 Tentative block diagram for Plant Configuration



DISCLAIMER

Though adequate care has been taken while preparing the bidding documents, the Bidders/Applicants shall satisfy themselves that the document is complete in all respects. Intimation of any discrepancy shall be given to this office immediately. If no intimation is received from any Bidder within the prescribed time from the date of notification of NIT/ Issue of the NIT documents, it shall be considered that the NIT documents are complete in all respects has been received by the Bidder.

Employer, reserves the right to modify, amend or supplement this NIT documents including all formats and Annexures.

While this bidding documents have been prepared in good faith, neither Employer or its authorized representatives nor their employees or advisors make any representation or warranty, express or implied, or accept any responsibility or liability, whatsoever, in respect of any statements or omissions herein, or the accuracy, completeness or reliability of information, and shall incur no liability under any law, statute, rules or regulations as to the accuracy, reliability or completeness of this bidding documents, even if any loss or damage is caused by any act or omission on their part.

CHAPTER-II

SCOPE OF WORK

1.0 BRIEF SCOPE OF WORK

The scope of the proposal includes the design, engineering, procurement, supply, construction, storage at site, associated civil works, services, permits, licenses, installation, insurance at all stages, erection, testing and commissioning including power evacuation, connectivity approvals and ten (10) years Operation and Maintenance (O&M) from the date of Operational Acceptance of ground mounted 70 MW(AC) Solar Power Plant completely covering the following activities and services in respect of all the equipment & works specified and covered under the specifications.

Since, the proposed plant is for captive consumption at various load centers of WCL at Maharashtra through open access, mapping of various load centers of WCL at Maharashtra shall be in the scope of bidder.

All the required connectivity approvals for inter-state transmission of power i.e. solar generation at Madhya Pradesh and consumption at various load centers in Maharashtra including plant registration and other required statutory inspection / approvals shall be in the scope of bidder.

Construction of 132 KV double circuit transmission line (approx. 6 KM) from MCS to Feeding substation including ROW and two bays extension arrangements as approved by MPPTCL within Feeding substation shall be in the scope of bidder.

The satisfactory operation of the Solar Power Plant and its integration with the power evacuation system shall be included in the scope of work of the Contractor and shall not be limited to the following:

- a) Basic and detailed design Engineering including civil and other allied works of the plant including power evacuation system.
- b) Review and approval of engineering drawings, calculations, structural design calculations, Equipment layout, Civil structural/architectural Drawings, Performance & Guarantee Test procedure etc.
- c) Operation & Maintenance/ instruction manuals, as built drawings and other required information.
- d) Providing training of Employer's personnel.
- e) Packing and transportation from the manufacturer's works to the site including customs clearance & port clearance, port charges, (if any).
- f) Reliability and Functional guarantee tests after successful completion of trial operation.

- g) Satisfactory completion of the contract.
- h) Supply of spares.
- i) Special tools and tackles if any required for maintenance of the plant.

2.0 DESIGN AND ENGINEERING

- 2.1 The Contractor shall prepare the detailed design basis report along with relevant standards (with respective clause description) and PERT Chart. The Contractor shall submit a copy to Employer for review and approval prior to detail engineering.
- 2.2 Documents, drawings and design calculations shall be submitted to the Employer both in soft as well as hard copies (4 nos.) for review and approval. The Employer shall return, as suitable, either soft or hard copies to the Contractor with category of approval marked thereon. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.

Sl. No.	Category	Status
1.	Category-I	Approved and Approved subject to incorporation of comments.
2.	Category-II	Commented and required resubmission for approval after incorporation of comments.
3.	Category-III	Vendor drawing kept for record/ reference.
4.	Category-IV	Resubmission for record/ reference after incorporation of Comments.

- 2.3 Approval of document/drawing/vendor drawing neither relieves the vendor/ contractor of his contractual obligations and responsibilities for correctness of design, drawings, dimensions, quality & specifications of materials, weights, quantities, assembly fits, systems/ performance requirement and conformity of supplies with Technical Specifications, Indian statutory laws as may be applicable, nor does it limit the Employer/ Purchaser's rights under the contract.

Submission of basic design data, design documents, drawings and engineering information including GTP and test reports to Employer or its authorized representative for review and approval in hard copy and soft copy from time to time as per project schedule. The documents typically include, but not limited to, the following:

- a) Solar insolation data and basis for generation
- b) Detailed general technical specifications (GTP) of all the equipment.
- c) General arrangement and assembly drawings of all major equipment
- d) Schematic diagram for entire electrical system (DC, AC and auxiliary systems)

- e) GTP & G.A. drawings for all types of structures/ components, H.T switchgears & other interfacing panels.
 - f) Test reports
 - g) Design calculations and sheets
 - h) Geo technical investigation data and Topographical survey report including topographical survey data and Contour plan of the area.
 - i) GA drawings of the entire project including equipment rooms/control rooms, inverter platforms, office cum control room, roads, storm water drainage, sewage networks, security gate, fire protection system, transformer yard fencing etc.
 - j) 33 KV transmission line drawings and erection plans as per DISCOM/ STU guidelines.
 - k) Quality assurance plans for manufacturing (MQP), Standard Operating procedure (SOP) and field activities (FQP).
 - l) Fire safety & evacuation plan and disaster management plan.
 - m) Detailed risk assessment and mitigation plan.
 - n) O&M Instruction's and maintenance manuals for major equipment.
 - o) As-built drawings / documents.
- 2.4 Estimation of the plant generation based on Solar Radiation and other climatic conditions prevailing at site.
- 2.5 Design of associated civil, structural, electrical & mechanical auxiliary systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, design earthing system, indoor and outdoor lighting/ illumination etc., GTP and GA drawings for the major equipment including 33 KV transmission line, design basis & calculation sheets, and other relevant drawings and documents required for engineering of all facilities within the periphery to be provided under this contract.
- 2.6 All drawings shall be fully corrected to match with the actual "As – Built" site conditions and submitted to Employer after commissioning of the project for record purpose. All as-built drawings must include the Good for Construction deviation list.

3.0 PROCUREMENT AND SUPPLY

- 3.1 Ground Mounted Solar PV modules with 70 MW AC capacity with minimum 40 % DC overloading.
- 3.2 Module Mounting Structure (MMS) suitable for mounting PV modules for ground mounted solar plant. Minimum clearance of module (at highest tilt angle) from ground shall be 300 mm.
- 3.3 Array Junction boxes, SCBs with mounting structure as per approved design.
- 3.4 Solar and DC cables along with lugs, glands, ferrules, straight/Y-connectors, conduits, cable ties and other material as required.
- 3.5 Power Conditioning Units (String Inverter) of suitable rating.

- 3.6 AC Combiner Box / LT Switchgear panel of appropriate rating with adequate number of inputs for pooling of power from String Inverters to Inverter duty transformers.
- 3.7 Bus-ducts (as per approved design), AC Cables (LT & HT) of appropriate size and rating along with cable termination kits, ferrules / tags, conduits, cable ties and other materials required for cable laying and termination at both the ends.
- 3.8 Step-up transformers (inverter duty) in relevance with state grid code and inverter manufacturer requirements.
- 3.9 Indoor/Outdoor 33 KV Panels including Vacuum Circuit Breakers, Current Transformers, Potential Transformers, Relays and other accessories for complete protection. Outgoing feeder of the panel shall be rated as per rated capacity / design of the plant.
- 3.10 ABT meters with all necessary metering rated CTs and PTs at the plant take-off point as well as at the interconnecting substation as per Appropriate Authority / CEA Metering Regulations 2006 as amended time to time and state metering code
- 3.11 Auxiliary supply system including Auxiliary transformers of adequate rating, distribution panels, cables and related accessories for plant internal consumption.
- 3.12 Supervisory Control and Data Acquisition (SCADA) system for remote monitoring/control of plant facilities along with required communication cables.
- 3.13 Data acquisition system and communication infrastructure to transfer real time data to SLDC/RLDC as per DISCOM/STU specification.
- 3.14 Sin Wave Inverters / UPS of min. 5kVA along with 4 nos. 150AH batteries and associated luminaires, distribution boards, cables and accessories etc. for each local control stations as well as Main control station.
- 3.15 110 V DC Battery Bank, Battery Charger, Distribution Boards, Cables and associated equipment for each local control stations as well as Main control station.
- 3.16 Control Cables including end terminations and other required accessories.
- 3.17 Portable cabin/PEB buildings for Local Control Station (LCS), Security rooms and Store-rooms etc.
- 3.18 Communication cables including end terminations and other required accessories.
- 3.19 Earth strip/cables, earth electrodes, earth enhancing compound and all other associated materials for complete earthing of the plant as per the relevant standards.
- 3.20 Lightning Protection System for entire plant area.
- 3.21 HDPE pipes, cable conduits, cable trays and accessories/trenches.
- 3.22 LED luminaries with diffuser for illumination, lighting poles, distribution boxes and power supply cables along with required conduits, fittings etc.
- 3.23 Testing instruments as specified.
- 3.24 Mandatory spares as required.
- 3.25 CCTV camera system along with mounting poles, power supply cables, communication cables, network switches, conduits, fittings and monitoring station for plant surveillance for entire plant area.

- 3.26 Fire detection and protection system in building, inverter station, transformer yard and switchyard.
- 3.27 Lightning arrestors and Isolators for 33 KV and 132 KV system.
- 3.28 Weather monitoring station (min 3 nos.) shall include but not be limited to the following:
- Pyranometer / Albedometer
 - Ultrasonic Anemometer (wind speed and direction)
 - Temperature Sensor – Ambient and module surface
 - Power source to all sensors
 - Data Logger
- 3.29 Supply for equipment required for 2 x 40 MVA, 33 KV / 132 KV Main control station (MCS) as per Annexure-A.
- 3.30 33 kV Double Circuit Over Head Transmission Line including Poles / Towers, Conductors, Insulators, Cable Termination Kits and associated accessories from LCSs to MCS.
- 3.31 132 kV Double Circuit Over Head Transmission Line on Towers including Conductors, Insulators, Cable Termination Kits and associated accessories from MCS to Feeding Substation.
- 3.32 Obtaining Right of Way (RoW), for 132 KV transmission lines including all applicable documentation and compensation, if any.
- 3.33 All the electrical equipment required at feeding / integrating substation for bay extensions including any rearrangement / replacement of feeding / integrating substation equipment / material, if required, which is necessary for evacuation of power from the Plant.
- 3.34 Materials and accessories, which are required for satisfactory and trouble-free operation and maintenance of the above equipment like module cleaning system, supply of spares for all equipment, supply of tools and tackles etc.
- 3.35 All safety equipment for safe working environment.
- 3.36 Any other equipment / material not mentioned but required to complete the Solar Power Plant facilities in all respect.

4.0 INSTALLATION, TESTING AND COMMISSIONING

The scope of installation, testing and commissioning for the plant facilities shall include, but not limited, to the following.

- 4.1 Installation of PV Modules on Module Mounting Structures and interconnection of PV Modules as per system requirement.
- 4.2 Laying of solar cables through HDPE conduits underground / along cable trays from PV Modules to SCBs (if required) / PCU along with termination at both the ends.
- 4.3 Installation, Testing and Commissioning of String Monitoring Units (as per approved design).
- 4.4 Installation, Testing and Commissioning of Power Conditioning Units.

- 4.5 Laying of DC cables from SCB to string inverter along with termination at both the ends (if required).
- 4.6 Installation, Testing and Commissioning of AC combiner box, LT / HT switchgear panels.
- 4.7 Laying of LT AC cables along cable trays / trench from PCU to AC combiner box / LT switchgear panel along with termination at both the ends.
- 4.8 Laying of AC LT cables from AC Combiner Box / LT Switchgear panel to Inverter duty transformer along with termination at both the ends.
- 4.9 Installation, Testing and Commissioning of inverter-duty transformers.
- 4.10 Laying of HT AC cables along cable trays / trench from inverter-duty transformer to HT switchgear panel and to 33 KV OHTL along with termination at both the ends.
- 4.11 Installation, Testing and Commissioning of 33 KV switchboard panel / bay and associated accessories.
- 4.12 Installation, Testing and Commissioning of 33 KV double circuit OHTL from Local control stations to Main Control station.
- 4.13 Installation, Testing and Commissioning of all the equipment required for 2 x 40 MVA, 33 KV / 132 KV Main control station (MCS) as per (but not limited to) Annexure-A.
- 4.14 Installation, Testing and Commissioning of 132 KV double circuit OHTL from Main Control station to feeding substation.
- 4.15 Installation, Testing and Commissioning of all the electrical equipment required at feeding / integrating substation for two numbers bay extension including any rearrangement / replacement of feeding / integrating substation equipment / material, if required, which is necessary for evacuation of power from the Plant.
- 4.16 Installation, Testing and Commissioning of ABT meters with all necessary metering rated CTs and PTs at Plant take-off point as well as at Interconnecting Substation as per CEA Metering Regulations 2006 as amended time to time and state metering code. ABT Meters at plant take-off point shall be installed inside existing Main Control Room.
- 4.17 Installation, Testing and Commissioning of auxiliary power supply system consisting of auxiliary transformers, AC distribution boards, AC LT cables and related accessories.
- 4.18 Laying of LT Power and Control Cables along with termination at both the ends
- 4.19 Installation, Testing and Commissioning of suitable communication system for interfacing PCU, Transformer, Switchgear panel, metering, UPS, Fire alarm panel and other plant equipment with SCADA.
- 4.20 Installation, Testing and Commissioning of data acquisition system.
- 4.21 Installation, Testing and Commissioning of Uninterrupted Power Supply (UPS) / Inverter set distribution boards, cables and related accessories for each LCS and MCS.
- 4.22 Earthing and lightning protection system of PV Modules, Module Mounting Structures, PCU, switchgear panels and all other electrical equipment.
- 4.23 Installation of indoor & outdoor illumination system including all required accessories and laying of power supply cables.

- 4.24 Installation, Testing and Commissioning of Weather Monitoring Station along with laying of required power supply and communication cables.
- 4.25 Installation of CCTV cameras on strategic locations including all required accessories, laying of power/communication cables and installation of monitoring station and other associated equipment.
- 4.26 Installation of fire detection and fire protection system for buildings, transformer yard, sub-station.
- 4.27 Installation, Testing and Commissioning of module cleaning system including water treatment plants.
- 4.28 Pre-commissioning checks and tests for all equipment.
- 4.29 Synchronization and Commissioning of plant as per DISCOM / TRANSCO requirements.
- 4.30 Any other works related to installation, testing and commissioning not mentioned but required to complete the Solar Power Plant facilities in all respect.

5.0 CIVIL WORK

- 5.1 Conducting geotechnical investigation and topographical survey of the plant area. The land is covered with bushes and trees. Cleaning of such trees and bushes shall be under the scope of Contractor/Bidder.
- 5.2 General clearing of plant site, 33 KV transmission line corridor, 132 KV transmission line corridor by cutting of any vegetation & shrubs including disposal of waste material.
- 5.3 Earthwork for site levelling & grading including dozing and rolling off the ground as required to make it levelled surface and well compacted for construction of control rooms and switch yard etc.
- 5.4 Construction of internal roads all along 33 KV OHTL. The plant shall be connected with nearby existing roads.
- 5.5 Construction of approach roads to the site for transportation of material / equipment etc. and access roads.
- 5.6 Construction of storm water drainage and sewage network.
- 5.7 Construction of chain link fence with gates for entire plant area. Chain line fence for plant area may be done in patches as per the site condition ensuring safety of the plant.
- 5.8 Construction of foundation for Module Mounting Structures (MMS) and erection of MMS.
- 5.9 Foundation and erection of portable cabin/PEB (as control rooms at LCS) along with requisite furniture, air-conditioning and other equipment / material as per the specifications.
- 5.10 Foundation and erection of portable cabin/PEB (storage container) of area sufficient enough for storing spare PV Modules, cable drums etc. for local control stations (LCS).
- 5.11 Foundation and erection of Security rooms (portable cabin/PEB) for local control stations (LCS).

- 5.12 Toilet facility (portable cabin/PEB) shall be provided for plant area.
- 5.13 Civil structural works, foundation and erection of equipment for 2 x 40 MVA, 33 KV / 132 KV Main Control Station along with requisite furniture, air-conditioning and other equipment / material as per the specifications.
- 5.14 Foundation and construction of continuous raft/ mat foundation for inverter-duty transformer.
- 5.15 Construction of foundation and / or mounting structure for String Combiner Box, AC Combiner Box / LT Switchgear panel, Inverter, Auxiliary Transformer, 33 kV Switchgear panel, Metering panel and other electrical equipment.
- 5.16 Construction of foundation and / or mounting structure for lightning mast, lighting poles, CCTV poles, weather monitoring station and other equipment.
- 5.17 Construction of underground/over ground tanks, water treatment plants and plumbing network for drinking water and cleaning of PV Modules.
- 5.18 Suitable arrangement of water to cater to day-to-day requirement of drinking water and permanent water supply for module cleaning and other needs of SPV power plant during entire O&M period.
- 5.19 Construction of fence for transformer yard and switchyard.
- 5.20 Construction of foundation for 33 KV double circuit OHTL from LCS to MCS.
- 5.21 Construction of foundation for 132 KV double circuit OHTL from MCS to Feeding Substation.
- 5.22 Civil structural works, foundation and erection of equipment for bays extensions at Feeding substation as per DISCOM / TRANSCO requirement.
- 5.23 Any other civil works no mentioned but required to complete the solar power plant facilities in all respect.
- 5.24 All approvals, equipment, items and works, which are not otherwise specifically mentioned in this document but are required for successful completion of the work in all aspects, including construction, commissioning, Comprehensive O&M of Solar PV Power Plant and guaranteed performance are deemed to be included in the scope of the contractor.

6.0 STATUTORY APPROVAL

- 6.1 Obtaining statutory approvals / clearances / compliances on behalf of the Employer from various Government Departments, not limited to, the following:
 - Pollution control board clearance, if required
 - Mining Department, if required
 - Forest Department, if required
 - All other approvals as and when necessary for setting up of a solar power plant, power evacuation, railways, power line crossing, panchayat, NHAI etc. as per the suggested guidelines.
- 6.2 All statutory approvals / permissions and/or No Objection Certificates (NoC) etc. from DISCOM / TRANSCO for obtaining connectivity at the substation as per Project Particulars provided above.

- 6.3 The Contractor shall be responsible for obtaining approval from the Madhya Pradesh, Maharashtra State DISCOM / TRANSCO and CTU concerning metering, including NET Metering/Net Billing/Open Access on the behalf of WCL. This responsibility is exclusively borne by the Contractor.
- 6.4 All other statutory approvals and permissions and their respective compliances, not mentioned specifically but are required to carry out hassle free Construction and O&M of the plant.
- 6.5 Adequate and seamless insurance coverage during EPC and O&M period to mitigate all risks related to construction and O&M of the plant to indemnify the Employer.
- 6.6 The Contractor shall comply with the provision of all relevant acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Mines Act 1952, Employees State Insurance Act 1948, Contract Labour (Regulations & Abolishment) Act 1970, Electricity Act 2003, Grid Code, Metering Code, MNRE guidelines or any modification thereof or any other law relating whereto and rules made there under or amended from time to time.

7.0 OPERATION AND MAINTENANCE

- 7.1 Total Operation & Maintenance of the SPV Plant shall be with the Contractor, after operational acceptance of the plant till culmination of the O&M period and shall include deployment of engineering personnel, technicians and security personnel.
- 7.2 The EPC Contractor shall also maintain the 33 KV DC OHTL and 132 KV DC OHTL during O&M period of 10 years at the cost of EPC Contractor. Safety, security of the said transmission line up to 10 years O&M period will be the sole responsibility of the EPC Contractor.
- 7.3 To provide a detailed training plan for all O&M procedures to Employer's nominated staff, which shall have prior approval from the Employer.
- 7.4 Employ and coordinate the training of contractors' personnel who will be qualified and experienced to operate and monitor the facility and to coordinate operations of the facility with the grid system.
- 7.5 To maintain accurate and up-to-date operating logs, records and monthly Operation & Maintenance reports at the facility. Contractor shall keep the measured daily data at regular intervals and provide the same to Employer in electronic form, compatible in CSV format. The right to use the data shall remain with the Employer.
- 7.6 Procurement of spare parts, overhaul parts, tools & tackles, equipment, consumables, etc. required for smooth operation and maintenance of the plant as per prudent/standard utility practices, OEM recommendations and warranty clauses for the entire O&M period.
- 7.7 The Contractor shall establish forecasting tools for submitting schedule and comply with applicable Forecasting, Scheduling and Deviation Settlement

Regulations. The scope under this Clause shall also include establishing and maintaining forecasting tools and appointment of QCA/Aggregator. Percentage (%) Error (Deviation) shall be calculated as per the said regulations and DSM Charges in case of deviation beyond the permissible limits shall be borne by the Contractor. (if required)

- 7.8 Breakdown maintenance, Preventive maintenance to maximize the availability of the solar power plant.
- 7.9 Maintaining the log book data and energy output of each inverter and transformer.
- 7.10 Cleaning of the plant including array yard, trenches and washing of module regularly.
- 7.11 Bidder is required to maintain the spare during the O&M contract period of the solar power plant so that to maximize availability and generation of the plant.
- 7.12 Procurement of spare parts, overhaul parts, tools & tackles, equipment, consumables, etc. required for smooth operation and maintenance of the entire plant as per prudent/ standard utility practices, OEM recommendations and warranty clauses for the entire O&M period.
- 7.13 Replacement of spares shall be as per the OEM recommendations. Equipment/ spare parts/updation of software being phased out or not being supported by OEM's is also included in bidder's scope.
- 7.14 To carry out periodic overhauls or maintenance required as per the recommendations of the original equipment manufacturer (OEM) and to furnish all such periodic maintenance schedules at the time of plant commissioning/ start of O&M contract.
- 7.15 Deployment of Plant in Charge, adequate number of technical and non-technical staff during the O&M period.
- 7.16 To upkeep all administrative offices, roads, tool room, stores room, equipment in clean, green and workable conditions.
- 7.17 The contractor shall provide all amenities at his own expense to his workmen as per applicable laws and rules.
- 7.18 The contractor shall ensure that all safety measures are taken at the site to avoid accidents to his employees associated in the project. The Contractor shall immediately report the accidents, if any, to the Engineer in charge and all the concerned authorities as per prevailing laws of the state.
- 7.19 Handover the system to maintain an inventory of spare parts, tools, equipment, consumables and supplies for the facility's operation along-with required details of recommended spares list with all associated information regarding replacement records, supplier details, tentative cost, storage details, specifications on the basis of replacement frequency and mean time between failures and mean time to restore at the culmination of penultimate year under O&M period.
- 7.20 The Contractor shall comply with the provision of all relevant Acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Maturity Benefit Act 1961, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Employees State Insurance

- Act 1948, Contract Labour (Regulations & Abolishment) Act 1970 or any modification thereof and rules made there under from time to time.
- 7.21 Contractor shall be responsible to carry out all test and work as per statutory requirement.
- 7.22 Operation part consists of deputing necessary manpower necessary to operate the Solar Photovoltaic Power Plant at the full capacity. Operation procedures such as preparation to starting, running, routine operations with safety precautions, monitoring etc., shall be carried out as per the manufacturer's instructions to have trouble free operation of the complete system.
- 7.23 Daily work of the operation and maintenance in the Hybrid Solar Photovoltaic Power Plant involves periodic cleaning of Modules as and when required, logging the voltage, current, power factor, power and energy output of the Plant at different levels. The operator shall also note down time/ failures, interruption in supply and tripping of different relays, reason for such tripping, duration of such interruption etc. The operator shall record monthly energy output, down time, etc.
- 7.24 Earth resistance of Plant as well as individual earth pit is to be measured and recorded every month. If the earth resistance is high (compared to standards) suitable action is to be taken to bring down the same.
- 7.25 A maintenance record is to be maintained by the operator/ O&M-in-charge to record the regular maintenance work carried out as well as any breakdown maintenance along with the reasons for the breakdowns and steps taken to attend the breakdown, duration of the breakdown etc.
- 7.26 The Preventive Maintenance Schedules will be drawn such that some of the jobs other than breakdown, which may require comparatively long stoppage of the Power Plant, shall be carried out preferably during the non-sunny days or evenings. Prior information shall be provided to the Employer for such preventive maintenance prior to start.
- 7.27 The Contractor will attend to any breakdown jobs immediately for repair/ replacement/adjustments and complete at the earliest working round the clock. During breakdowns (not attributable to normal wear and tear) in O&M period, the Contractor shall immediately report the accidents, if any, to the Employer showing the circumstances under which it happened and the extent of damage and/or injury caused.
- 7.28 The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
- 7.29 If negligence / mal operation of the contractor's operator results in failure of equipment, such equipment should be repaired/replaced by the contractor free of cost.
- 7.30 The contractor shall be responsible for all the required activities for the successful running, committed energy generation & maintenance of the Solar Photovoltaic Power Plant covering:
- Deputation of qualified and experienced engineers and technicians at the facility.

- Deputation of Security personnel for the complete security of plant.
- Successful running of Solar Power Plant for committed energy generation.
- Co-ordination with STU/SLDC/other statutory organizations as per the requirement on behalf of Employer for Joint Metering Report (JMR), furnishing generations schedules as per requirement, revising schedules as necessary and complying with grid requirements. (if required)
- Monitoring, controlling, troubleshooting maintaining of logs & records, registers.
- Furnishing generation data monthly to Employer/Owner by 1st week of every month for the previous month.
- Periodic cleaning of solar modules as approved by the Employer and water quality as per the recommendations of OEM.
- Replacement of Modules, Invertors/PCU's and other equipment as and when required during the O&M period without additional cost to Employer.

8.0 SECURITY SERVICE

- 8.1 The contractor has to arrange proper security system including deputation of security personnel at his own cost for the check vigil for the Solar Power Plants for the complete scope of works including comprehensive O&M period.
- 8.2 The security staff may be organized to work on suitable shift system; proper checking & recording of all incoming & outgoing materials vehicles shall be maintained. Any occurrence of unlawful activities shall be informed to Employer immediately. A monthly report shall be sent to Employer on the security aspects.
- 8.3 Any other activities required for completion of project, but not specified in the above shall be in the scope of contractor. The Contractor must provide the BOM of the plant as per the design during the time of submission of design basis report. The detailed technical specifications of major equipment to be followed strictly and are described in the technical specification section.

CHAPTER-III

SYSTEM DESCRIPTION

1.0 SYSTEM DESCRIPTION AND GENERAL ARRANGEMENT

2.0 PV Plant Layout

The electrical design of the plant can be split into the DC and AC systems with DC system comprising of array(s) of PV modules, Inverters, Solar & DC cabling (module, string and main cable), DC connectors (plugs and sockets), Junction boxes/combiners, Disconnects/switches, protection devices, earthing. The AC system includes AC cabling, switchgear, transformers, substation, earthing and lightning protection etc. To achieve cumulative plant capacity, required nos. Mono-PERC, Half-Cut, PV modules of identical type (min. 545 Wp) shall be installed. The proposed solar power plants shall be designed on 1500 V DC system. Since the total output current of all the strings shall be very high, these strings shall be divided into several sub groups and connected to Array Junction boxes/ string monitoring boxes (SMB)/ DC junction boxes etc. and/ or these units will be connected to the inverter input.

For the proposed solar power plant, string inverters of suitable capacity shall be used. However, inverter rating of string inverters shall be as per standard industry practices. The DC power generated from the DC field shall be converted into AC three phase power by using string inverters and further stepped up to 33 KV using inverter duty transformers (IDT). Power at 33kV from IDTs / LCS shall be pooled through 33kV overhead lines, in proposed pooling substation / Main control station (MCS) (2X40MVA, 33/132kV substation) which shall be installed at a suitable location in the proposed Nandan washery site.

The Khapaswami Substation/feeding substation is operating at a voltage level of 132 kilovolts (kV) and plays a pivotal role in the overall power transmission and distribution network within the region. The installed capacity of Khapaswami Substation is 103MVA (40MVA +63MVA), 132/33kV. The power generated by the proposed ground mounted solar power plant will be injected at the Khapaswami Substation, which is operated by the MPEB (electricity utility) at a voltage level of 132 kilovolts (kV). This substation is about 6 kilometers away from the proposed pooling substation. Necessary power evacuation arrangement at Khapaswami Substation/feeding substation shall be in the scope of bidder.

3.0 Local control stations – LCS

For control, monitoring and power evacuation of generated power, several (min 14 nos.) Local control stations –LCS shall be constructed. Location of these LCS shall be decided during project execution period. These LCS shall consist of local control room (LCR), Store room, security room, and will house IDT, AC combiner

box, HT switchboard panel and other required equipment. All the rooms in LCS shall be pre-engineered building type (PEB) or portable cabin. Package/ split AC of suitable capacity shall be provided as per heat load requirement in the local control room. Suitable ventilation system shall be provided for other rooms. Necessary firefighting arrangements with fire-detection and alarm system shall also be provided in LCS. A single line diagram for LCS is shown in drawing no. 1. Tentative layout of the LCS is shown in drawing no. 2.

4.0 Inverter Duty Transformer (IDT)

A dual LV winding inverter transformer (outdoor type, $V^* - V^* / 33$ kV) of suitable capacity shall be suitably installed at each LCS to step up the voltage to 33 kV level. LV voltage (V^*) of the IDT shall be as per Inverter output voltage. The interconnection between inverter / AC combiner box / LT Switchboard panel to inverter transformers shall be through single core, copper cable or bus-duct of suitable rating and required runs. The transformers shall conform to IS: 2026/1180 and IEC 60076. The transformers shall be oil type. HV side of these transformers shall be connected to the 33 kV switchboard installed in the LCS.

5.0 Pooling Substation / Main control station – MCS

For pooling of power at 33 KV from LCS, a pooling substation i.e. Main control station (MCS) (2X40MVA, 33/132kV substation) shall be constructed. Approx. area for MCS shall be 100 meters x 100 meters. Main Control Station shall consist of a Main control room (MCR) of minimum plinth area 520 Sq. Mtrs. MCR building shall contain supervisor room, SCADA room, Inverter/UPS & battery-bank room and tool room. It shall also house monitoring station of CCTV, distribution boards etc. Package/ split AC of suitable capacity shall be provided as per heat load requirement in SCADA room and supervisor room. Suitable ventilation system shall be provided for other rooms. Necessary firefighting arrangements with fire-detection and alarm system shall also be provided in MCS. Tentative layout / General arrangement of the MCS is shown in drawing no. 3. A single line diagram for MCS is shown in drawing no. 4

5.1 Power Transformer

Two numbers of Power Transformers shall be provided at pooling substation i.e. MCS. The transformers will be of capacity 40 MVA, 33/132 kV, oil immersed, double wound, core type with on load tap changing (OLTC) device and all necessary protective elements. The Transformers will be provided with protections for through faults and internal faults through over load (O/L), earth fault (E/F), restricted earth fault (REF), differential protection, Buchholz relay protection, winding temperature, oil temperature rise protection, explosion / pressure relief device etc. The transformers shall conform to IS: 2026/1180 and IEC 60076.

5.2 **Circuit Breaker (CB)**

Required number of Vacuum Circuit Breakers/SF6 breakers as shown in the single line diagram in drawing no. 4 shall be provided. All the Circuit Breakers on 33 kV and 132 kV sides will be of outdoor type with indoor control and relay panels with SCADA enabled. All the Circuit Breakers will be operated remotely, however, facility for local electrical operation will also be provided.

The outdoor Circuit Breakers, both on 33 kV and 132 kV sides will be controlled remotely from the control panels located in the control room of the substation. The control panels will meet the requirement of control, protection, metering, signaling, SCADA compatible and annunciation of circuit breakers and transformers. All the relay panels for various protections on 33 kV and 132 kV side will also be located in the respective control panels.

All the auxiliary circuits of the protective system will be operated by 110 V DC supplied from storage Battery / Rectifier.

5.3 **Current Transformer (CT), Potential Transformers (PT) and Isolator**

Outdoor type Current Transformers (CT) of required quantity and rating will be provided in the switchyard of 33 kV and 132kV system for protection and metering. The CT's will be provided for restricted earth fault protection, over current and earth fault protection, differential protection, bus bar protection, distance protection and for metering. Remotely operated Isolators (3 pole) shall be provided on 33 kV and 132kV side. Required numbers of potential transformers, current transformers and isolators shall be provided as shown in the single line diagram no. 3.

5.4 **Control and relay panel for 132 KV SF6 CBs and 33 KV VCBs**

The outdoor Circuit Breakers both on 132 kV and 33 kV side will be controlled remotely from the control panels located in the control room of the substation. The control panels will meet the requirements of control, protection, metering, signaling and annunciation needs of Circuit Breakers and Transformers. All the relay panels for various protections on 132 kV and 33 kV side will also be located in the respective control panels. Various relays for different protection schemes will be judiciously selected so that their reliability, effectiveness and quality are highest order and are suitable for continuous satisfactory performance over the years. Relays of latest and improved design and proven quality and reliability will be preferred. Arrangement for remote tripping by protective relays will be provided. Automatic indication of operating switches will also be provided.

5.5 **MCS / Substation earthing**

The main object of an earthing system in a substation is to provide under and around the substation a surface which shall be at a uniform potential and near zero or absolute earth potential as possible. The primary requirements of substation earthing are:

- i) It shall stabilize circuit potentials with respect to ground and limit the overall potential rise.
- ii) It shall protect life and property from over voltage.
- iii) It shall provide low impedance path to fault currents to ensure prompt and consistent operation of protective devices during ground faults.
- iv) The impedance of ground shall not exceed 1 ohm.
- v) The step and touch potentials shall be within safe limits.
- vi) It shall keep the maximum voltage gradient along the surface inside and around the substation within safe limits during ground faults.

The earthing system meeting the above requirements comprises an earthing mat buried horizontally at a depth of minimum 0.6 meter below the surface of the ground. All the non-current carrying parts of the electrical equipment in substation are connected to the earth mat. The earthing mat shall be connected to the following in a substation:

- i) The neutral point of each system/transformer through its own independent earth. Each of these earth points shall be interconnected with the station earthing mat by two different diagonally opposite connectors to avoid common mode failure.
- ii) Equipment framework and non-current carrying parts.
- iii) All extraneous metallic framework not associated with equipment.
- iv) The earth point of lightning arresters, PTs, CTs and the lightning down conductors in the substation through their permanent independent earth electrode.
- v) Substation fence.

Earthing of the complete 132kV/33kV substation will be done strictly in accordance with the latest revision IS 3043 and Central Electricity Authority Regulation-2010, IEEE standards & Electricity Act-2003(current). Safe electrode system may be adopted for better resistance value and also for maintenance free operation.

Adequate earthing system shall be provided for safety of operating personnel as well as for proper system operation and performance of the protection device. The earthing system shall be designed to have impedance to ground as low as possible and shall not exceed 1 ohm and the step and touch potentials shall be within safe limits. The outdoor switchyard shall have earthing mat made of 40 mm dia. MS rod and earth pits as required. Type of earth conductors for different uses are as tabulated below.

Equipment	Earth conductor buried in earth	Earth conductor above ground level & in built up trenches
a) Main earth grid	40mm dia MS Rod	65 x 8 mm GI flat

Equipment	Earth conductor buried in earth	Earth conductor above ground level & in built up trenches
b) All H.T. Equipment	Not applicable	50 x 6 mm GI flat
c) 415 V/230 V Switch boards	Not applicable	50 x 6 mm GI flat
d) Columns, structure, cable trays, bus duct enclosures, steel tubular poles & Towers	Not applicable	25 x 8 mm GI flat
e) Gantries and other non-current carrying metal parts	Not applicable	25X6 mm GI flat
f) LT motors 31kW to 125 kW 1kW to 30 kW	Not applicable	25X8 mm GI flat 25X6 mm GI flat

The grid should have minimum earth resistance value within the specified limit i. e. below 1 ohm. Earth pits shall be constructed with earth electrodes and chemical earthing compound.

Earth pits shall be covered with top cover of cast iron. Earth pits/ Earthing electrodes will be provided around the substation outdoor yard which will be interconnected by suitable size Galvanized iron flats/ strips laid in the ground. Test link and Watering arrangement shall also be provided with earth pit. The fencing and structural members in the outdoor yard will be connected to this earth grid.

Earthing of lightning arrestor/lightning mast shielding to their respective earth pit shall be done through insulated cable of suitable size.

The metal bodies of all the outdoor switchyard equipment shall be connected to the earth grid by GI strip at two places. The neutral of transformers shall be earthed through separate earth pits. The substation fencing and the lighting masts shall also be earthed separately through separate earth electrodes. The metal bodies of all the indoor equipment shall also be earthed by GI flats at two places.

There shall be provision for easily disconnecting the earthing electrode temporarily for measurement of earth pit resistance purpose. Metallic sheath, screens/shields and armour of all cables shall be earthed at both the ends at the equipment where the cables are terminated. Suitable earthing clips shall be provided as required.

Required number of earth pits will be provided around the substation building and will be inter connected with the help of suitable size galvanized Iron strips / flats

buried below the ground at required depth. The control cubicles and other equipment will be connected to this earth grid.

Required number of earth electrodes will be provided and connected to overhead earth wire (shield wire) provided for direct lightning stroke shielding protection through suitable size of insulated conductor.

Suitable arrangement for watering the earth pits shall also be provided if conventional earth pits are provided.

The Bidder shall conduct the soil conductivity tests before taking up the design. The detailed calculations for selection of number of earth pits, detailed earthing scheme shall be furnished after the placement of order for approval by the customer before taking up the construction.

5.6 **MCS / Substation Lightning protection system**

Metal Oxide Lightning arrester of station class shall be provided on the structures of 132kV incoming lines, primary side of the 132/33 kV Transformers and 33kV outgoing feeders for protection against traveling waves due to lightning. The 132kV lightning arresters shall be provided with surge monitor/ counter.

All the 132kV and 33kV structures will be extended by 2m high over the conductors. At the top of these structures, horizontal shield wires will be drawn for protection against direct lightning strokes. The shield wires will be connected to earth by separate earth pits. In addition three 15 m high lightning masts is to be erected in such a way that the entire substation area is protected against lightning. Separate earth pit will be provided for each lightning mast.

The lightning protection system will be as per relevant Indian Standards and IE rules.

5.7 **MCS / Substation Firefighting system**

Suitable firefighting system (consisting of hydrant points, portable fire extinguishers, sand buckets etc.) to quench electric fires in the outdoor switch yard, diesel gen. shed, transformer oil filter/purification shed, oil storage shed, pump room and the substation building will be provided as per the IER rules. Fire/ smoke detectors and alarm system will be provided to warn the people working at the substation. Each control panel (132kV & 33kV) shall be provided with individual fire extinguisher with sensor inside the panel. The Tariff advisory committee and National Building codes will also be considered for designing the firefighting system. Along with these CO2 fire extinguisher and chemical powder type (both portable and trolley mounted) are to be provided.

Individual Nitrogen injection system for firefighting shall be provided with both the power transformers.

5.8 **Ventilation, Air conditioning and other facilities for MCS / Substation**

The control room, engineer's room and office room of the substation (132/33kV Substation) shall be airconditioned by the help of adequate number of 2 T capacity split type air conditioners with 5 star rating (inverter AC) along with servo stabilizer.

BLDC Ceiling fans of adequate size shall also be provided in the substation control room, engineer's room, office room and store room. Exhaust fans of adequate size shall be provided in battery room and toilets.

A water cooler with water purifier shall be provided in substation.

Substation shall be having a bore hole with submersible pump and necessary water storage and distribution facility for drinking and industrial facility.

5.9 **Protection System**

The transformer protection shall include following;

- (i) High speed biased numerical differential protection (relay having 2nd harmonic restraint and 5th harmonic bypass) in 132 kV side.
- (ii) Numerical over fluxing protection in 132 kV side
- (iii) Numerical non-directional IDMT relay on both sides
- (iv) Protection for over load and back up numerical over current and earth fault (O/C and E/F) protection
- (v) Trip circuit supervision relay on both sides
- (vi) DC auxiliary 110 V supply voltage monitoring relay to be installed at both sides of transformers and feeders.
- (vii) Gas pressure type and winding and oil temp. protection to give alarm and tripping

The 132kV and 33kV strung bus will be protected with high speed differential bus bar protection scheme along with local breaker back up protections.

The incomer 33kV transmission line feeders will be protected for O/L, E/F and distance protection.

All the auxiliary circuits of the protective system will be operated by 110 V DC supplied from storage Battery / Rectifier.

5.10 **Instrumentation and Metering**

Digital microprocessor based power meter shall be provided on 132kV, 33kV side of this substation for measurement, monitoring and management of different electrical parameters. The different parameters to be displayed in regular intervals are as shown below:

- i) Values of current (RMS), Voltage (RMS), frequency.
- ii) Current and Voltage demand parameters

- iii) Power Factor
- iv) Average power values
- v) Power demand parameters
- vi) Total Energy
- vii) Minimum / maximum log
- viii) Real time current, voltage and frequency
- ix) Real time power values
- x) Phase rotation
- xi) Counters
- xii) Remote Relay control
- xiii) Self-diagnostic tests

All the meters shall be of preferred standard size and of required accuracy class. They shall be flashed in the front panel of respective control panels.

Fault annunciation with visual and audible alarm shall be provided for different types of tripping of Circuit Breakers, auxiliary power supply (AC/ DC), air pressure, SF6 gas pressure fall, winding and oil temperature rise etc. Facility for acceptance of audible alarm shall also be provided.

Lamp indicators and semaphore indications with mimic diagrams shall also be provided for various Circuit breakers and Isolators.

Lamp indications (Green, Red, and Yellow) for power supply (AC/DC) and other equipment shall also be provided. Condition Monitoring & Self Diagnostic Facilities as required will also be provided.

Any other meters and indications other than the above mentioned if necessary for safety and effective operation of the substation shall also be provided. All the sign board, Danger Plates, Safety Rules display chart etc. as per statutory rules shall be provided at the suitable locations.

5.11 Interlocking arrangement

Various interlocking systems will be provided:

- To prevent simultaneous supply to a bus bar from two sources
- To prevent of an Isolator operation when its associated circuit breaker is ON
- For suitable interlocking between Circuit Breakers and Isolators to facilitate maintenance of the equipment.
- For electrical interlocks for switching operation and other necessary functions in order to ensure correctness and safety.
- All possible combinations of interlocking shall be made to avoid parallel operation of transformers and all other bus sections

- For suitable mechanical / Electrical interlocks to ensure the safety of equipment, operating personnel and to prevent un-authorized/ inadvertent operation of the equipment.

6.0 Auxiliary supply

Dry type auxiliary transformers shall be provided in all the LCSs and pooling substation (MCS) to cater the lighting and other auxiliary loads of the plant. Min. capacity and voltage rating of this transformer will be 63 kVA, 33/0.415 kV.

This transformer will receive power from 33 kV switchboard panel installed in the substation. Secondary of this transformer will be connected to a 415 V distribution board panel. This distribution board will be used to cater power requirement of lighting and other miscellaneous loads of the plant.

7.0 Battery and battery charging set

To meet DC power requirement of the plant a separate DC system shall be provided in each LCS and MCS. This will consist of 110 V battery and float & float cum boost charger to be installed in the plant control building. The battery & charger shall cater to all the DC loads of the plant which mainly comprises of DC emergency lighting load, control supply for the switchgears etc.

The battery shall be of storage type Lead Acid type. The Battery shall be high discharge performance type. The plates shall be designed for maximum durability during all service conditions including high rate of discharge & rapid fluctuation of load.

Battery charger will be float & float cum boost charger of suitable capacity for quick boost and trickle charging as well as supplying the DC loads. The battery chargers will be of silicon controlled rectifier type completely automatic and self-regulating type. The float charger will be capable of charging the battery and at the same time supply the continuous DC load. The boost charger will be capable of charging the fully discharged battery to full charge.

A DC Distribution board shall be provided for providing DC supply for following purpose:

- Closing and tripping coils of circuit breakers
- Emergency lighting, control board indications
- Indicating lamps
- Holding circuits for relays and contactors
- Signalling and protective circuits
- Interlocking

The capacity of battery shall be adequate to supply momentary current required for the operation of switchgear, the continuous load of indicating lamps, holding circuit for relays and contactors, emergency lighting load, etc. AC Supply to Battery charger shall be fed from AC Distribution Board through cable. Control circuit shall be fed from DC distribution board through cables.

8.0 Lightning and Over Voltage Protection for PV plant

The PV Power plants shall be provided with Lightning and Over Voltage protection connected to proper earth mats. The main aim of the protection is to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components. The source of over voltage can be lightning or other atmospheric disturbance.

Lightning protection system shall be provided to protect the solar array, inverter platform and control room using ESE-type Lightning arrestors complying with relevant Indian and International standard.

The complete lightning protection system will comprise the following key components:

- ESE type Lightning Air Terminal
- Mounting support and mounting accessories
- Down conductor
- Lightning Event Counter
- Dedicated earthing system

9.0 Earthing System for PV plant

Each Array structure of the Solar PV area shall be grounded properly. The array structures are to be connected to chemical earth pits as two points as per Indian/International standards. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. The earth conductor shall run through appropriate pipes partly buried and partly on the surface of the control room building. The complete earthing system shall be mechanically & electrically connected to provide independent return to earth.

All electrical outdoor equipment structures will be grounded through the proper grounding conductor. All Lightning Arrester shall be connected to the main grid through chemical earth pits as per Indian/International standards.

10.0 Supervisory Control and Data Acquisition (SCADA) System

The PV power plants shall be monitored through the SCADA system. This will enable monitoring the status of inverters / CBs/ ACDBs / Transformers to gather information on energy generation. Periodic reports of the plant's performance will be provided by the monitoring system. A suitable display system can also be installed suitably in the plant to access live data on the performance of the solar system. Remote data access will be provided through secured gateway connectivity. The status of all breakers shall also be monitored.

11.0 Automatic Weather Station (AWS)

An Automatic Weather Station (AWS) is required in order to measure climatic parameters and global solar radiation periodically. The realistic climatic parameters are required for performance testing of the proposed solar PV power plant. Ambient temperature of 55 Deg. C and relative humidity of 95% shall be considered for equipment design. One no. of AWS has been envisaged at each solar PV power plant in order to carry out the Performance Guarantee test of the project.

The Automatic Weather Station (AWS) shall be with the following features:

- Measurement of Global & Horizontal Irradiance
- Measurement of Wind Speed, Wind Direction, Ambient Temperature and Relative Humidity
- Measurement of Cell Temperature
- Facility for Data Logging
- Supports TCP/IP, DHCP configurations
- Supports serial (RS-232/485, MODBUS) and analog (0-1V, 0-5V, 4-20mA) output
- Modular and easily customized
- In-Built Memory for storing data for at least 12 months' period.
- Graphical Display Software

12.0 Fire Fighting for PV plant

Proposed plant shall be equipped with suitable fire protection & firefighting systems for protection of entire equipment switchyard & control room as per CEIG requirements.

The firefighting system for the proposed power plant for fire protection shall be consisting of:

- a) Sand buckets
- b) Portable fire extinguishers
- c) Microprocessor based fire alarm panel.

Two nos. each of portable (4.5/5 kg CO₂) and trolley mounted fire extinguishers (20 kg dry powder type) shall be provided along with sand buckets and stands near each inverter transformers and in pooling substation. NIFPS system shall be provide for power transformers in the pooling substation.

Additionally, suitable number of portable fire extinguishers of 4.5 / 5 kg (CO₂) and 10 kg (Dry powder type) capacity shall be provided in the control room building. Fire buckets with sand shall also be provided at strategic locations for emergency. Automatic Fire detection & Fire alarm system along with required sensors/equipment shall also be provided in the control room buildings.

Fire detection alarm system shall include (but not limited to) the following items:

- Fire Alarm control Panel
- Multi Sensor smoke detector
- Heat Detectors
- Hooter cum strobe
- Manual call Point
- Hooter
- Fault isolation modules
- Control Modules
- Cables from Sensors to Fire panels.
- Digital output from the fire detection system shall be integrated with SCADA
- Network Control Module
- Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA

13.0 Illumination System

A comprehensive illumination system shall be provided in the entire project. Each building shall be provided with adequate light fittings, 6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room, etc. All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel. The substation shall be illuminated by suitable numbers of LED light fittings. All the lighting circuits shall be controlled through lighting distribution boards located in control room building.

14.0 CCTV System

CCTV Cameras system and all other accessories required for its proper operation shall be installed to have complete coverage of following areas for 24 hours.

- Main entry: Covering all the entry/exit
- Along the Plant Perimeter: Covering complete perimeter of Plant Area to capture all possible intrusion.
- Control Rooms: Covering Entry/Exit and Equipment Rooms.
- Switchyards.

15.0 Water supply system

The plants shall be provided with proper water supply system for the purpose of sanitation, drinking and modules cleaning. A pumping station along with piping network shall be provided for the site. The provision of necessary storage tanks shall be kept to meet the total water requirement of the plant. To achieve required quality of water for module cleaning, water treatment plant shall be provided.

16.0 Miscellaneous

5 KVA (min.) inverter set / UPS complete with 4 nos. 150 AH batteries and other necessary arrangement shall be provided in LCS as well as in pooling substation. Miscellaneous items like furniture, air conditioners, ceiling fans and exhaust fans of adequate sizes shall be provided in the plant control building.

17.0 Civil Works

Necessary civil works of the project have to be carried out based on the existing conditions of the sites. The sub soil conditions at sites will be taken care during design as well as during construction. The natural drainage conditions are to be maintained to the maximum extent so as to avoid flooding of site during rainy seasons and minimize the cost of land grading & levelling operations. Necessary quality controls have to be maintained at site during construction. Site may require surface dressing and filling at some patches to maintain the level. Main gate complex, security post, roads, water supply arrangement etc. have been provided in the report as per requirement.

The broad civil scope of work under this package shall include Civil, Structural and Architectural Works related to but not limited to the following areas, System, Structures / Substructures, Buildings and Facilities:

A. Design & Construction of Permanent Facilities

Sl. No.	Facility	Quantity
1.	Module Mounting structure	As required
2.	Local Control Station	Min. 14 Nos.
3.	Main Control Station	1 no.
4.	Shed / Platform for Power Transformer, VCB, ACDB, Station Transformer	As required
5.	Cable Trenches / Trestle including any Cable Tray supporting facility	As required
6.	Toilet	As required

7.	All Equipment Supporting Foundation and Structures	As per Detailed Engineering & Geotech Investigation.
8.	Sewage disposal system such as Septic Tank & soak pit for all toilets	As per actual
9.	Approach Roads and Access roads	To be provided as per requirement.
10.	Pump house, Water treatment plant and water supply system for plant cleaning & drinking water	As required
11.	Drainage system.	As required
12.	Chain Link Fencing (Diamond type)	To be constructed along the periphery of the plot (in Patches)
13.	Fencing of Yards (Transformer, metering, switchyard, etc.)	To be provided for each Transformer & Metering
14.	Security Post	Min. 8 Nos.

Any other misc. requirement necessary for completion of commissioning & operation in line with Bidder's technical proposal / detailed Engineering.

CHAPTER-IV

TECHNICAL SPECIFICATION OF MAJOR ITEMS

The specifications mentioned for all the equipment which include Solar modules, PCU, combiner boxes, DC cables, module mounting structures, transformer, CT, PT, LT/ HT cables, MCS equipment, interfacing panels, switch gears & other associated equipment etc., to complete the power generation and evacuation to the respective Substation, in the bidding documents are for the reference only. It is subject to revise/ alter as per the design/ planning/ good engineering practices etc., to be carried out by the selected bidder, to the satisfaction of the Employer or its authorized representatives. It is advised that the bidders must satisfy himself with the prevailing site conditions before design/ plan. The design must be optimized as per the site conditions and directed to achieve the maximum output from the installed capacity at all times. Moreover, the components not separately mentioned, but are required to complete the plant for operation is also included in the scope of bidder and shall be vetted by the Employer or its authorised representatives.

All equipment and installation shall confirm to the following rules/acts/regulations amended up to the date:

1. The Indian Electricity Act
2. The Indian Electricity Rules
3. CEA Regulations
4. MNRE Guideline
5. Safety rules, acts and regulations

Broad technical specification of following electrical equipment have been provided in the section:

Electrical System

1. Photovoltaic Modules
2. String Monitoring Unit / SCB
3. Solar and DC Cables
4. Power Conditioning Unit
5. Inverter Transformer and Auxiliary Transformer
6. 33 KV HT Switchgear
7. AC Cable
8. Auxiliary Supply
9. AC Combiner box
10. LT Switchgear
11. Uninterrupted Power Supply (UPS)
12. Battery and Battery Charger
13. Earthing (Except for MCS)

14. Lightning Protection System (Except for MCS)
15. Communication Cables
16. SCADA
17. Illumination
18. Weather Monitoring System
19. CCTV Camera
20. Fire Alarm System
21. Testing Instruments
22. 120 KV Surge Type Lighting Arrestor
23. 132 KV isolator and earth switch
24. 132 KV Current Transformer
25. 132 KV Potential Transformer
26. 132 KV Outdoor Type SF6 Circuit Breaker with Indoor Remote-Control Panel
27. 132/33 KV, 40 MVA Power Transformer
28. 30 KV Surge Type Lighting Arrestor
29. 33 KV Off Load Isolator and Earth Switch
30. 33 KV Outdoor Structure Mounted Vacuum Circuit Breaker with Indoor Remote-Control Panel
31. 33 KV Current Transformer
32. 33 KV Potential Transformer
33. Earthing & Lightning Protection System for MCS / Pooling Substation

Note: Pre- dispatch Inspection will be carried out for following items:

1. Photovoltaic Modules
2. Power Conditioning Unit
3. HT and LT Switchgears
4. Inverter Duty Transformer
5. Cables (Solar, DC, AC cable)
6. MMS structure

The Contractor shall give not less than 15 (Fifteen) day notice in writing for carrying out the inspection, Domestic or Overseas). The cost of pre-dispatch inspection (Exclusive of Employer/ Owners representative's TA/DA) shall be borne by Contractor. Such pre-dispatch inspection(s) at the manufacturer's facility shall be carried out in the presence of the Employer/Owner or their authorized representatives.

However, in case re-inspection is necessitated on account of non-acceptance of item(s) due to failure on Factory Acceptance Test(s), the cost of associated travel and accommodation for the revisit shall be borne by the Contractor. A minimum of 07 (Days) notice shall be given by the Contractor for witnessing such inspection at the works\

The Contractor shall provide assistance, instruments, labour and materials as are normally required for examining, measuring and testing any workmanship as may be selected and required by CMPDI.

1.0 Photovoltaic Modules**1.1 Standards and Codes**

Photovoltaic Modules shall comply with the specified edition of the following standards and codes.

Standard	Description
IEC 61215-1:2016 Ed.1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements
IEC 61215-1-1:2016 Ed.1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules
IEC 61730-1:2016 Ed.2	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
IEC 61730-2:2016 Ed.2	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
IEC 61701:2011 Ed.2	Salt mist corrosion testing of photovoltaic (PV) modules (Applicable for coastal and marine environment)
IEC 62716:2013 Ed.1	Photovoltaic (PV) modules - Ammonia corrosion testing (if applicable)
IEC TS 62804-1:2015 Ed.1	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon (under conditions of 85°C/85% RH for minimum 192 hours)
As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, PV Modules used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards. Further, PV Modules should have been included in the ALMM list as per MNRE Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration) Order, 2019.	

1.2 PV cells in a crystalline silicon module shall be protected by encapsulation between front glass and back sheet/back glass. The glass shall be made of high transmissivity and front surface shall give high encapsulation

The technical details of Solar PV Modules shall be as given below:

Sl. No.	Description	Details
1	Cell type	Mono Crystalline Silicon, Half Cut
2	Peak Power rating of Module at STC	Shall not be less than 545 Wp
3	Rated power at STC	No negative tolerance is allowed
4	Temperature co-efficient of power	Not less than -0.43%/°C

5	Module efficiency	≥ 20.0 %
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1.3 Component Specifications

- (i) For PV modules with back sheet, toughened low iron glass with minimum thickness of 3.2 mm for mono-crystalline modules.
- (ii) In case of glass-glass modules, with minimum of 2 mm glass thickness on each side. It shall be laminated using a laminator with symmetrical structure, i.e. heating plates on both sides.
- (iii) The glass used shall have transmittance of above 90%.

- 1.4 The back sheet used in the PV modules shall be of three-layered structure durable for humid – hot conditions with properties of moisture barrier, elongation retention and UV resistance. The back sheet shall have the following properties.

Parameter	Value
Material thickness	≥ 300 microns
Water vapour transmission rate	< 2 g/m ² /day
Partial discharge test voltage	≥ 1000 V / 1500 V
Elongation at break	$> 100\%$
Adhesion strength with encapsulant	> 40 N/cm
Interlayer adhesion strength	> 4 N/cm

The Employer reserves the right to conduct Pressure Cooker (PC) test/ Highly Accelerated Stress Test (HAST) to confirm the durability of the back sheet in accelerated conditions.

Pressure Cooker Test shall be carried out under following conditions:

121 °C /100 %RH and 2 ATM pressure for 48 hours. The apparatus shall be such that specimen is not dipped in water but exposed to vapor (steam) while maintaining aforementioned conditions. Necessary sensors for measurement of temperature, pressure and RH shall be installed for verification.

For acceptance:

1. There shall be no delamination or microcracks observed in the back sheet.
2. The back sheet shall retain 30% of the initial value (as per approved GTP) of the Elongation at Break.

- 1.5 The encapsulant used for the PV modules should be polyolefin based, UV resistant and PID resistant in nature. No yellowing of the encapsulant with prolonged exposure shall occur. The encapsulant shall have the following properties.

Parameter	Value
Gel content	> 75%
Transmittance	>90%
Volume resistivity	> $1 \times 10^{14} \Omega \cdot \text{cm}$
Peeling strength with glass	> 60 N/cm

- 1.6** The sealant used for edge sealing of PV modules shall have excellent moisture ingress protection with good electrical insulation (Break down voltage >15 kV/mm) and with good adhesion strength. Edge tapes for sealing are not allowed.
- 1.7** The module frame shall be made of anodized Aluminium, which shall be electrically & chemically compatible with the structural material used for mounting the modules. It is required to have provision for earthing to connect it to the earthing grid. The anodization thickness shall not be less than 15 micron.
- 1.8** The material used for junction box shall be UV resistant to avoid degradation during module life. The degree of protection of the junction box shall be at least IP67. Minimum three number of bypass diodes and two number of IEC 62852/EN 50521 certified MC4 compatible connectors with appropriate length of IEC 62930/EN 50618 certified 4 sq.mm copper cable shall be provided. The cable length shall be in accordance with the PV Module wiring strategy and adequate to ensure that the cable bending radius standard is not exceeded.
- 1.9** Each PV Module shall be provided a RFID tag / bar code which is embedded inside the module lamination and must be able to withstand harsh environmental conditions. The RFID data base shall contain the following information. RFID / bar code scanner and database of all the modules containing the following information shall also be provided.
- I. Name of the manufacturer of PV Module
 - II. Name of the Manufacturer of Solar cells
 - III. Type of cell: Mono
 - IV. Month and year of the manufacture (separately for solar cells and module)
 - V. Country of origin (separately for solar cells and module)
 - VI. I-V curve for the module
 - VII. Peak Wattage, I_m , V_m and FF for the module
 - VIII. Unique Serial No. and Model No. of the module.
 - IX. Date and year of obtaining IEC PV module qualification certificate
 - X. Name of the test lab issuing IEC certificate
 - XI. Other relevant information on traceability of solar cells and modules as per ISO 9000 series.

- 1.10** PV modules must be warranted with linear degradation rate of power output except for first year (maximum 3% including LID) and shall guaranteed 90% at the end of 10 years and 80% of the initial rated power output at the end of 25 years from the completion of trial run. The modules shall be warranted, against all material/ manufacturing defects and workmanship for minimum of 10 years from the date of supply.
- 1.11** The bidder shall provide the sample solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current.
- 1.12** SPV module shall perform satisfactorily with ambient temperatures between -10°C & +60°C.
- 1.13** The minimum design clearance (at the highest tilt angle) between the lower edge of the modules and the developed ground level shall be 400 mm. A tolerance of +/- 50mm shall be allowed as per site conditions
- 1.14** All the modules in the PV plant should be arranged in a way so as to minimize the mismatch losses.
- 1.15** Each module should have two suitably sized stranded UV resistant cables and terminated with DC plug-in connector directly. The positive (+) terminal has a male connector while the negative (-) terminal has a female connector. Any different design offered shall be reviewed during detailed engineering. The connectors used for interconnecting the modules and connectors used for connecting the strings and/or to the String combiner Box, i.e. field connectors shall be of same make for better compatibility (refer Connectors chapter elsewhere for detailed Specification of Field Connectors). In case, 1500 V modules are used, the connecting cable shall be as per the relevant standard.
- 1.16** The bidder has to submit, along with the data sheet of the module, a detailed Bill of Material (BoM) elaborating on the properties, such as, thickness, material composition etc. of the major components of the module which shall be same as per the type tested.
- 1.17** The cells used for module making shall be free from all defects like edge chipping, breakages, printing defects, discoloration of top surface etc. Only Class A solar cell shall be used. The modules shall be uniformly laminated without any lamination defects.
- 1.18 Transportation, Handling, Storage and Installation**
- i Transportation, handling, storage and installation of modules shall be in accordance with the manufacturer manual so as not to breach warranty conditions. The Standard Operating Procedure (SOP) for the same shall be shared by the Contractor prior to dispatch.
 - ii It is required to construct a temporary platform (graded) while keeping the modules at least above the highest flood level. If the contractor scheduled/ planned to mount the modules immediately after the receipt at site, then the module shall be kept in common storage area with proper arrangement.

- iii The modules shall be stacked as per the manufacturer's recommendation only and shall be covered with tarpaulin sheet in case the PV Modules are required to be stored at site for more than one month. In any case, the temporary platform for keeping the modules shall be treated with anti-termite treatment.

1.19 Name Plate

All individual modules shall be provided with Name Plate label at the back of module which shall provide the information given below for identification. They shall be clearly visible and shall not be hidden by equipment wiring. Type of labels and fixing of labels shall be such that they are not likely to peel off/ fall off during the life of the panel.

- i Manufacturer's Name
- ii Model Number, Serial Number
- iii Overall Dimensions (W x L x D)
- iv Weight (kg)
- v Maximum Power (P_{MAX}), Voltage (V_{MP}), Current (I_{MP})
- vi Short Circuit Current (I_{SC}), Open Circuit Voltage (V_{OC})
- vii Main System Voltage
- viii Relevant standards, Certification lab. Name
- ix Warnings, if any

2.0 String Monitoring Unit / SCB

2.1 Standards and Codes

Standard/Code	Description
IEC 60529	Enclosure Ingress Protection
IEC 62262	Enclosure Impact Protection
IEC 60269	Fuse
IEC 61643-31 or EN 50539-11	Surge Protection Device
IEC 62852 or EN 50521	Solar cable connector
IEC 60695-2-11	Fire hazard testing

2.2 Construction

- i. SMU enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP65 and mechanical impact resistance shall be at least IK08.
- ii. Not more than two strings can be connected in parallel to a single input of SMU. One spare input terminal along with connector shall be provided for each SMU.

- iii. Every SMU input shall be provided with fuses on both positive and negative side. In case of negative grounded system, fuse at positive side only is acceptable. The rating of the fuses shall be selected such that it protects the modules from reverse current overload. The fuses shall be 'gPV' type conforming to IEC 60269-6.
 - iv. DC switch disconnecter of suitable rating shall be provided at SMU output to disconnect both positive and negative side simultaneously.
 - v. Type-II surge protective device (SPD) conforming to IEC 61643-31 / EN 50539-11 shall be connected between positive/negative bus and earth.
 - vi. Resistance Temperature Detector (RTD) type or semiconductor type temperature sensor shall be provided to monitor the cabinet temperature.
 - vii. MC4 connector conforming to IEC 62852 or EN 50521 shall be provided at each SMU input. Cable gland (double compression metallic) of suitable size for DC cables shall be provided at the SMU output.
 - viii. UV resistant printed cable ferrules for solar cables & communication cables and punched/ embossed aluminium tags for DC cables shall be provided at cable termination points for identification.
 - ix. Suitable communication interface shall be provided to communicate the data to SCADA. The following parameters shall be measured/ monitored and made available at SCADA.
 - String current
 - Bus voltage
 - Output current
 - Cabinet temperature
 - DC disconnecter switch ON/OFF status
 - SPD operating status
- 2.3** The SMU unit shall be warranted against all material/manufacturing defects and workmanship for minimum of 10 (ten) years from the date of supply.
- 2.4** Routine tests and acceptance tests for the assembled unit shall be as per the Quality Assurance Plan (QAP) approved by the Employer.
- 3.0 Solar and DC Cable**
- 3.1** Solar and DC Cables in a solar PV plant used in the following areas:
- i Interconnecting SPV modules (Solar Cable).
 - ii From SPV Modules up to String Combiner Box (SCB) (Solar Cable) and / or to the Inverter.
 - iii From SCB up to the Inverter (DC Cable) (applicable as per plant design).

3.2 Standards and Codes

Cable	From	To	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SMU/SCB	Copper/ XLPO	1.8 kV DC	IEC 62930/ EN 50618/
DC Cable	SMU / SCB	PCU	Copper / XLPE	1.5 kV DC	IS 7098

* Cable used for module interconnection shall also be referred as solar cable.

3.3 Solar cable outer sheath shall be flame retardant, UV resistant and black in colour. Solar cable with positive polarity should have marking of red line on black outer sheath.

3.4 DC cables shall be single core, armoured, Flame Retardant Low smoke (FRLS), PVC outer sheath conforming to IS 7098.

3.5 In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.

- i Cable size and voltage grade
- ii Word 'FRNC/ FRLS' (as applicable) at every metre
- iii Sequential marking of length of the cable in metres at every metre

3.6 Cables shall be sized based on the following considerations:

- i Rated current of module
- ii The average voltage drop in the cables (Modules to Inverter) shall be limited to 1.5 % of the rated voltage. The Contractor shall provide voltage drop calculations in excel sheet.
- iii Short circuit withstand capability.
- iv De-rating factors according to laying pattern

3.7 The cables (Solar and DC) shall be warranted against all material/ manufacturing defects and workmanship for minimum of 10 (ten) year from the date of supply.

3.8 Type test, routine test and acceptance tests requirements shall be as per IEC 62930/EN 50618 for solar cables and IS 7098 for DC cables.

3.9 Installation

- i Cable installation shall be as per IS 1255.
- ii Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.
- iii Solar cables shall be provided with UV resistant printed ferrules and DC cables shall be provided with punched/ embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.
- iv Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

- v Solar cables, wherever exposed to direct sunlight and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits. The size of the conduit or pipe shall be selected on the basis of 40% fill criteria.
- vi Solar cables shall be aesthetically tied to Module Mounting Structure using UV resistant cable-ties suitable for water – based applications.
- vii A.C and D.C cables shall be kept in separate trenches. The horizontal and vertical clearances between power and communication cable shall not be less than 300mm.
- viii Cable Sealing System

Modular multi-diameter cable sealing system consisting of frames, blocks and accessories shall be installed where the underground and over ground cables enter or leave LCR/MCR/BESS enclosures. Cable sealing system shall consist of multi- diameter type peel-able blocks of different sizes to suit the various cables. It should be simple, easy and quick to assemble & re-assemble the cable sealing system. Solid blocks shall not be used on frame. Frames & stay-plate material shall be of galvanized steel and for compression, single piece wedge with galvanized steel bolts shall be used. 30% spare blocks on the frame shall be provided for expansion in future. Cable sealing system should have been tested for fire/ water /smoke tightness.

4.0 Power Conditioning Unit

4.1 Standards and Codes

Power Conditioning Unit (PCU) shall comply with the specified edition of the following standards and codes.

Standard	Description
IEC 61683 Ed. 1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 62109-1 Ed. 1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
IEC 62109-2 Ed. 1	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
IEC 61000-6-2 Ed. 2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed. 2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

IEC 62116 Ed. 2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 and 2019 Amendment(or latest amendment)	
As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, Inverters used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards.	

4.2 Technical Parameter

Parameter	Specification
Rated AC power	As per design
Maximum input voltage	1500 V
Rated AC output voltage	As per design
Tolerance on rated AC output voltage	+/-10%
Rated frequency	50 Hz
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.9 lag to 0.9 lead
Efficiency	Minimum 98%
Maximum loss in Sleep Mode	0.05% of rated AC power
Total Harmonic Distortion	Less than 3% at 100% load
Degree of protection	Central Inverter – IP 21 (Indoor)/IP 54 (Outdoor), String Inverter – IP 65

- 4.3** The rated/ nameplate AC capacity of the PCU shall be AC power output of the PCU at 50°C.
- 4.4** Maximum power point tracker (MPPT) shall be integrated in the PCU to maximize energy drawn from the Solar PV array. The MPPT voltage window shall be sufficient enough to accommodate the output voltage of the PV array at extreme temperatures prevailing at site.
- 4.5** The PCU output shall always follow the grid in terms of voltage and frequency. The operating voltage and frequency range of the PCU shall be sufficient enough to accommodate the allowable grid voltage and frequency variations.

4.6 Construction

- i Power Conditioning Unit (PCU) shall consist of an electronic three phase inverter along with associated control, protection, filtering, measurement and data logging devices.
- ii Every DC input terminal of PCU shall be provided with fuse/MCB/MCCB of appropriate rating. One spare DC input terminal shall be provided for each PCU.
- iii Type-II surge protective device (SPD) conforming to IEC 61643-31 / EN 50539-11 shall be connected between positive/ negative bus and earth.
- iv In case external auxiliary power supply is required, UPS shall be used to meet auxiliary power requirement of PCU. It shall have a backup storage capacity of 2 hours.
- v Circuit Breaker and fuse of appropriate voltage and current rating shall be provided at the output to isolate the PCU from grid in case of faults or otherwise.
- vi The PCU shall be tropicalized and the design shall be compatible with conditions prevailing at site. Suitable number of exhaust fan with proper ducting shall be provided for cooling keeping in mind the extreme climatic condition of the site as per the recommendations of OEM to achieve desired performance and life expectancy.
- vii All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through protective conductor of appropriate size. DC negative terminal shall be grounded. In case DC negative grounding is not possible, appropriate anti-PID device shall be provided.
- viii Dedicated communication interface shall be provided to monitor the PCU from SCADA.
- ix PCU front panel shall be provided with LCD/ LED to display all the relevant parameters related to PCU operation and fault conditions. It shall include, but not limited to, the following parameters.
 - DC input power
 - DC input voltage
 - DC input current (for each terminal)
 - AC output power
 - AC output voltage (all the 3 phases and line)
 - AC output current (all the 3 phases and line)
 - Frequency
 - Power Factor

In case of outdoor PCU, PCU without LCD display with provision for data access over Bluetooth shall be acceptable.

- x String inverter, if installed in open, shall be placed inside a canopy shed with at least 15 cm in all directions. Alternatively, the Contractor may install the inverter on the column post of the Module Mounting Structure, below the

modules. In such case, the canopy is not required, and the column and foundation shall be designed accordingly.

4.7 Operating Mode

Operating modes of PCU shall include, but not limited to, the following modes. These operating modes and conditions for transition are indicative only. The Contractor shall provide the detailed flow chart indicating the various operating modes and conditions for transition during detailed engineering.

Standby Mode

The PCU shall continuously monitor the input DC voltage and remain on Standby Mode until it reaches the pre-set value.

MPPT Mode

When the input DC voltage is above the pre-set value and AC grid connection conditions are fulfilled, the PCU shall enter into MPPT mode.

Sleep Mode

When the AC output power/DC input voltage decreases below the pre-set value for pre-set time delay, the PCU shall switch into Sleep Mode.

4.8 Protection Features

The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices.

The PCU shall provide protection against the following type of faults, among others.

- i DC/AC over current
- ii DC/AC over voltage
- iii DC reverse polarity
- iv DC earth fault
- v AC under voltage
- vi AC under frequency/over frequency
- vii Islanding
- viii Over temperature
- ix Lightning surges

4.9 Grid Support Function

i Active power regulation

The PCU shall be able to limit the active power exported to the grid based on the set point provided through PCU front control panel. The PCU shall also be able to automatically the limit the active power after an increase in

grid frequency above a pre-set value. The ramp rate shall be adjustable during operation and start-up after fault. The applicability of the requirement shall be as per CEA regulation and Erection, Testing, Commissioning, Associated Transmission System and compliance.

ii **Reactive power control**

The PCU shall be able to inject /absorb reactive power to/ from the grid based on the set point provided through PCU front control panel. The same shall be performed automatically with adjustable ramp rate based on dynamic changes in grid voltage or reactive power reference.

iii **Voltage Ride Through**

The PCU shall remain connected to the grid during temporary dip or rise in grid voltage as per the LVRT and HVRT requirements of CEA Technical Standards for Connectivity to the Grid Regulations. The PCU shall also be able to inject reactive power during the period of voltage dip.

4.10 The complete Power Conditioning Unit shall be warranted against all material/manufacturing defects and workmanship for minimum of 10 (ten) years from the date of supply.

4.11 Tests

i **Type Tests**

The type test certificates as per the standards mentioned above should be from any of the ILAC/IECEE member signatory accredited Test Centres. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted. It is the responsibility of the Contractor to substantiate the compliance for CEA Regulations using test reports.

ii **Routine Tests**

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

5.0 Inverter Transformer and Auxiliary Transformer

5.1 Standards and Codes

Inverter transformer and auxiliary transformer, wherever applicable, shall comply with the latest edition of the following standards and codes including amendments.

Standard	Description
IS 1180, IS 2026, IEC 60076	Specification of Power Transformers
IS 11171, IEC 60076	Dry-Type Power Transformers

IS 2099, IEC 60137	Bushings for alternate voltage above 1000 V
IS 335, IEC 60296	Insulating oil
IS 3639	Fittings and Accessories for Power Transformers
IS 12063	Degree of protection provided by enclosures
CBIP publication no. 295	
Indian Electricity rules and other statutory regulations	

5.2 Technical Requirement

Parameters	Inverter Transformer	Auxiliary Transformer
VA Rating	As per system design requirement	
Voltage Ratio	33 kV / Inverter output voltage	As per system design
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)	Continuous application (Outdoor/Indoor)
Winding	As per system design requirement	2
Frequency	50 Hz	50Hz
Nos. of Phase	3	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement	Dyn11
Cooling	ONAN	ONAN/ AN
Tap Changer	OCTC, No. of steps shall be as per system requirement	
Impedance at 75°C	As per Inverter Manufacturer requirement	As per system requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)		
Top Oil	50°C	As per IS/IEC
Winding	55°C	As per IS/IEC
SC withstand time (thermal)	2 second	2 second
Short Circuit Apparent power	As per system requirement	
Termination	As per system requirement	

Bushing rating, Insulation class (Winding & bushing)	36 kV – porcelain bushings 1.1 kV – epoxy bushings	As per the system requirement
Noise level	As per NEMA TR-1	
Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7	
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% 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 140% for at least five seconds. Bidder shall furnish over fluxing characteristic up to 150%	
Air Clearance	As per CBIP	

5.3 Construction

- i The transformer shall be provided with conventional single compartment conservator with prismatic toughened glass oil gauge. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. Inverter transformers shall be provided with Magnetic Oil Gauge (MOG) with low oil level alarm contact.
- ii It is the responsibility of the Contractor to ensure that the inverter transformer comply with all the requirements of inverter provided by the inverter manufacturer.
- iii Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.
- iv The transformer shall be suitable for continuous operation with a frequency variation of $\pm 2.5\%$ from nominal frequency of 50 Hz without exceeding the specified temperature rise.
- v Inverter Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from tank through shield bushing and the same shall be brought down to the bottom of the tank using copper flat and support insulator for independent grounding.

- vi Neutral bushing of Inverter duty transformer shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker "For testing purpose only. Do not earth". Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.
- vii Inverter transformer shall have 150 mm dial type Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI) with alarm and trip contacts. All indicators shall have accuracy of 1.5%. For inverter transformers, WTI shall be provided for all the windings.
- viii The 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.
- ix Marshalling 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 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.
- x Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided.
- xi Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.
- xii Filter valve at top the tank and drain cum sampling valve at bottom of the tank shall be provided.
- xiii All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.
- xiv LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.
- xv Air release plug, bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.
- xvi Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
- xvii The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformers are deemed to be included in the contract without extra charges.

- xviii Fire-protection for inverter transformer shall be provided in accordance with relevant CEA regulations as amended time to time.

5.4 Dry Type Auxiliary Transformer

- i Transformer shall be cast resin encapsulated dry type transformer, made of cold rolled grain-oriented silicon steel laminations of M4 grade or better. Winding conductor shall be electrolytic grade Copper and insulation shall be Class F or better.
- ii The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23 suitable for indoor installation. The enclosure shall be provided with suitable hardware and accessories required for satisfactory operation of the transformer per the relevant standard.

- 5.5** The transformers shall be warranted for minimum of 10 (ten) years against all material/ manufacturing defects and workmanship.

5.6 Testing and Inspection

Type Tests and Special Tests

The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on a similar transformer by NABL accredited laboratory.

Type Tests

- i Lightning impulse (Full & Chopped Wave) test on windings as per IEC 60076-3 / IS 2026-3.
- ii Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076-2 / IS 2026-2

Special Tests

- i Measurement of zero-sequence impedance as per IEC 60076-1/ IS 2026-1.
- ii Measurement of harmonics of no-load current as per IEC 60076-1/IS 2026-1.
- iii Measurement of acoustic noise level as per NEMA TR-1
- iv Short-circuit withstand test as per IEC 60076-5 / IS 2026-5

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

Type and Special tests are not required for auxiliary transformers of rating including 100 kVA and below. However, auxiliary transformer shall have minimum 3-star BEE rating as per BIS guidelines.

5.7 Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IEC 60076 / IS 2026 unless specified otherwise.

- i Measurement of winding resistance at each tap

- ii Measurement of voltage ratio between HV and LV windings at each tap
- iii Check of vector group
- iv Measurement of no-load loss and no-load current
- v Measurement of short-circuit impedance and load loss
- vi Magnetic balance test as per CBIP manual publication no. 295
- vii Separate source voltage withstand test
- viii Induced over voltage withstand test
- ix Measurement of insulation resistance
- x Marshalling box functional test
- xi IR Measurement on wiring of marshalling box
- xii Breakdown voltage test on transformer oil as per IS 335
- xiii Oil leakage test on completely assembled transformer along with radiators

6.0 33 kV HT Switchgear

6.1 Standards and Codes

All equipment provided under HT switchgear shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IS/IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and up to and Including 52 kV
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV

IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

6.2 Technical Requirement

Parameter	Specification
System Parameters	
Highest system voltage	36 kV
Rated system voltage	33 kV
Rated frequency	50 Hz
Number of phases	3
Power frequency withstand voltage	70 kV (r.m.s.)
Lightning impulse withstand voltage	170 kV (peak)
System fault current	As per system requirement
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C2
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2s for metering at outgoing feeder), 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class F

Voltage Transformer	
Accuracy class	0.2 for metering, 3P for protection
Rated VA burden	As per requirement
Insulation class	Class F

6.3 Switchgear Panel

- i The switchgear panel shall be free standing, floor mounted, single front, single tier fully compartmentalized, metal enclosed construction. Each panel shall have separate compartments for circuit breaker, bus bars, cable termination and auxiliary circuit.
- ii The circuit breakers shall be mounted on horizontally withdrawable trucks with locking facility in SERVICE and TEST positions.
- iii The panel enclosure shall be constructed with CRCA steel/Aluzinc sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.
- iv All surfaces shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. The minimum dry film thickness (DFT) shall be 100 microns.
- v The circuit breaker and auxiliary circuit compartments provided on the front side shall have separate concealed hinged doors. Cable and bus bar compartments provided on the rear side shall have separate bolted covers. All doors and covers shall be provided with neoprene/synthetic rubber gaskets to prevent entry of vermin and dust.
- vi Pressure relief device shall be provided in each high voltage compartment of a panel to safely vent the gases in the event of internal arc. Seal-off bushing arrangement shall be provided between the breaker compartment and bus bar/cable compartments to prevent transfer of arc from one compartment to other.
- vii Automatic safety shutters shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to TEST position.
- viii Degree of protection shall not be less than IP 5X for auxiliary circuit compartment. However, for remaining compartments it shall not be less than IP 4X. For outdoor panels, degree of protection shall not be less than IP 55.
- ix Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.
 - The breaker shall be operated only if it is in SERVICE or TEST position.
 - Movement of the breaker truck between SERVICE and TEST positions shall be possible only if the breaker is OFF.
 - It shall be possible to open the door only when the breaker is in TEST position.
- x Panel shall be provided with local bus-bar protection.

- xi Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.
- xii 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.
- xiii Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.
- xiv Gapless, metal-oxide surge arrestors shall be provided between line and earth in cable compartment of the switchgear panel.
- xv Suitable lifting hooks shall be provided for each panel.

6.4 Circuit Breakers

- i Circuit breakers shall be of vacuum type. It shall comprise of three separate identical single pole units operated through the common shaft and shall be fully interchangeable both electrically and mechanically.
- ii The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.
- iii The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.
- iv The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating mechanism.
- v The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.
- vi Mechanical indicators shall be provided to indicate OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided. These indicators and counter shall be visible from the panel front door without opening it.

6.5 Relays

- i All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.
- ii The relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.
- iii All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO).
- iv All numerical relays shall have minimum four no. of current inputs, three for phase current and one for earth current, suitable for CT secondary current of 1A. The current inputs shall be compatible with both residual connected CT and Core Balance CT (CBCT). In addition, numerical relay in main outgoing feeder shall have three no. of voltage inputs for Under Voltage/Over Voltage protection.
- v All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.
- vi Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.
- vii The numerical relay shall have the following protection functions with at least two independent protection setting groups. The protection functions shall be selectable from any of the IEC characteristic curves.
 - Definite time (DT) phase over current protection
 - Inverse Definite Minimum Time (IDMT) phase over current protection
 - Definite time (DT) earth fault current protection
 - Inverse Definite Minimum Time (IDMT) earth fault current protection
 - Under Voltage protection
 - Over Voltage protection
- viii Transformer feeder protection relay shall have provision for the following protection functions.
 - Buchholz alarm & trip
 - Oil Temperature Indicator (OTI) alarm & trip
 - Winding Temperature Indicator (WTI) alarm & trip
 - Pressure Relief Valve (PRV) trip Magnetic Oil Gauge (MOG) alarm
- ix All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.
- x The numerical relay shall be able to record faults and events in non-volatile memory.
 - Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.
 - Event record – At least 200 events with date and time stamp.
- xi The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay

- shall also be able to provide circuit breaker monitoring, CT and VT supervision.
- xii The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.
 - xiii The numerical relay shall have RS-232/RS-485/RJ-45/USB ports on front side for local communication with PC and on rear side for remote communication to SCADA system.
 - xiv The numerical relay shall have feature for time synchronization through the SCADA System / networking.
 - xv The numerical relay shall be provided with backlit alphanumeric LCD to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

6.6 Instrument Transformer

- i Instrument transformers shall be completely encapsulated cast resin type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchgear is operating at its rated load and the outside ambient temperature is 50°C.
- ii Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.
- iii Voltage transformers shall be single phase units. Bus voltage transformers shall be housed in a separate panel on withdrawable truck.
- iv HRC fuses of suitable rating shall be provided on primary side of voltage transformers. For secondary side, four pole Miniature Circuit Breakers (MCB) shall be provided with its supervision facility.

6.7 Earthing

- i An earth bus made of copper shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar.
- ii The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.
- iii All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with Owner's Earth conductor.
- iv Positive earthing of the breaker truck and frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.
- v All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

- vi Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.
- vii Separate earthing trucks shall be provided for earthing of busbars and incoming/outgoing feeders. The trucks shall have voltage transformer to indicate presence of voltage prior to earthing. An audible alarm shall also be provided in case of voltage on the earthing terminal. Integral earth switches may also be considered instead of earthing trucks. The earthing truck/switch shall have short circuit withstand capability equal to that of the associated switchgear panel.
- viii The interlocks shall be provided to ensure the following.
 - It is not possible to rack-in the earthing truck/close the earthing switch when the breaker truck is in SERVICE position.
 - It is not possible to rack-in the breaker truck into SERVICE position when earthing truck is connected/earthing switch is in closed position.

6.8 Bus Bar

- i Bus bar shall be made of copper or aluminium with uniform cross section throughout their length. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit current.
- ii All bus bars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.
- iii Bus bars shall be provided with heat shrinkable sleeves of suitable insulation class throughout their length with proper colour coding. All bus bar joints and taps shall be shrouded.
- iv Bus bar support insulators shall be made of non-hygroscopic, arc and track resistant, high strength material suitable to withstand stresses due to over voltage and short circuit current.
- v The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

6.9 Measuring Instruments

- i All the measuring instruments shall be digital, flush mounting type with communication facility.
- ii All feeders except main outgoing feeder shall be provided with digital Multi-Function Meter (MFM). Tri Vector Meter (TVM) shall be provided for the main outgoing feeder (in the HT Panel). Accuracy class of MFM shall be 0.2 and that of TVM shall be 0.2S.
- iii Measuring instruments shall have provision to display the following parameters.
 - Line and phase voltages

- Line and phase currents
- Active power, Reactive power, Apparent power
- Frequency
- Power factor
- Total Harmonic Distortion (THD)

6.10 Wiring and Terminal blocks

- i All internal wiring shall be done with 650 V grade, 1.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 2.5 sq.mm copper wire shall be used.
- ii Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.
- iii Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.
- iv The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.
- v All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 650 V, 10 A and made of non- inflammable material.
- vi CT and VT secondary circuits shall be terminated on stud type, non-disconnecting terminal blocks.
- vii At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

6.11 The HT panel unit shall be warranted for minimum of 5(five) years against all material/ manufacturing defects and workmanship.

6.12 The switchgear panel shall be of type tested design. The following type test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

Test	Standard	Relevant IEC Clause
Switchgear Panel		
Dielectric tests		
Power frequency voltage test	IEC 62271-200	6.2.6.1
Lightning impulse voltage test	IEC 62271-200	6.2.6.2
Dielectric tests on auxiliary and control circuits	IEC 62271-200	6.2.10
Measurement of the resistance of the main	IEC 62271-200	6.4.1

circuit		
Temperature-rise tests	IEC 62271-200	6.5
Short-time withstand current and peak withstand current tests	IEC 62271-200	6.6
Verification of the IP coding	IEC 62271-200	6.7.1
Verification of making and breaking capacities	IEC 62271-200	6.101
Mechanical operation test	IEC 62271-200	6.102
Internal arc test	IEC 62271-200	6.106
Circuit Breaker		
Mechanical operation test at ambient air temperature (M2 Class)	IEC 62271-100	6.101.2
Basic short-circuit test-duties	IEC 62271-100	6.106
Relays		
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional requirements	Relevant parts of IEC 60255-100 series	
Current Transformers		
Temperature-rise test	IEC 61869-2	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-2	7.2.3
Tests for accuracy	IEC 61869-2	7.2.6
Short-time current tests	IEC 61869-2	7.2.201
Voltage Transformer		
Temperature-rise test	IEC 61869-3	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-3	7.2.3
Test for accuracy	IEC 61869-3	7.2.6

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

6.13 Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

7.0 AC Cable

7.1 Standards and Codes

All AC Cables shall conform to the following standards and codes.

IS 7098	Crosslinked polyethylene insulated PVC sheathed cables, Part 1: For working voltage up to and including 1100 V
IS 7098	Crosslinked Polyethylene Insulated Thermoplastics Sheathed Cables Part 2: for Working Voltages from 3.3 kV up to and Including 33 kV

7.2 All AC cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.

7.3 Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. However, cable joints may be allowed if the route length is more than maximum available drum length subject to Employer's approval.

7.4 In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.

- Cable size and voltage grade
- Word 'FRLS' at every metre
- Sequential marking of length of the cable in metres at every metre

7.5 Cables shall be sized based on the following considerations:

- Rated current the equipment.
- Total power loss in LT cable (from inverter-to-inverter transformer) shall be limited to minimum value. For HT cables (from inverter transformer to plant take-off point), total power loss shall be limited to minimum. The Contactor shall provide power loss calculations sheet.
- Short circuit withstand capability as per design for 1s.
- De-rating factors according to laying pattern

7.6 All cables shall be warranted for minimum of 10 (ten) year against all material/manufacturing defects and workmanship.

7.7 Type routine and acceptance tests requirements shall be as per relevant standards for all cable sizes.

7.8 Installation

- Cable installation shall be as per IS 1255.
- Cables within transformer yard and switchyard shall be laid through RCC cable trench with supports.

- Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.
- All AC cables shall be provided with punched/embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

8.0 Auxiliary Supply System

- 8.1 Scheme for Auxiliary supply system shall be submitted by contractor during detailed engineering for the approval by Employer.
- 8.2 It shall mainly comprise of auxiliary transformer, AC distribution board(s) (ACDB), Battery & battery charger system, emergency lighting network, Uninterrupted power supply (UPS), distribution cables and metering & protective devices.
- 8.3 Auxiliary system shall be provided with two independent sources for reliable auxiliary power supply.
- 8.4 Following consideration shall be taken into account while sizing the auxiliary transformer:
- 20% future load margin
 - 20% design margin
 - Total connected load at 0.8 power factor

9.0 AC Combiner Box

9.1 Standards and Codes

Standard/Code	Description
IEC 60529	Enclosure ingress protection
IEC 62262	Enclosure impact protection
IEC 61643	Surge protection
IEC 60269	Fuse
IEC 60947-2	Circuit Breaker

9.2 Construction

- Enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP 65 and mechanical impact resistance shall be at least IK07.
- Bus bar shall be made of copper and of sufficient cross section to carry maximum operating current without exceeding the allowable temperature rise. The Contractor shall submit bus bar sizing calculation during detailed engineering.

- iii Fuse/MCB/MCCB of suitable rating conforming to relevant IEC standards shall be provided at each input of the combiner box.
- iv Moulded Case Circuit Breaker (MCCB) of suitable rating conforming to IEC 60947-2 shall be provided at the output of combiner box for protection and isolation.
- v Type-II surge protection device (SPD) conforming to IEC 61643 shall be connected between all the three phases and Earth.
- vi Double compression metallic cable gland of suitable size shall be provided for both input and output cables.

9.3 AC Combiner Box unit shall be warranted for minimum of 10 (Ten) year from the date of supply against all material/ manufacturing defects and workmanship.

9.4 Approval

- i Documents/Drawings
 - Guaranteed Technical Particular (GTP) Datasheet
 - Bill of Materials along with the datasheet of each component
 - General Arrangement (GA) drawing
 - Bus bar sizing calculation
 - Quality Assurance Plan (QAP)
- ii Test Certificates/Reports
 - Test certificates of fuse/MCB/MCCB and SPD
 - Enclosure ingress protection and impact protection test certificates

9.5 Routine tests and acceptance tests for the assembled unit shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

10.0 LT Switchgear

10.1 Standards and Codes

All equipment provided under LT switchgear shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IS/IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers

IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor- starters
IEC 60947-5-1	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 62052-11	Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 11: Metering equipment
IS 694	Polyvinyl chloride insulated unsheathed-and sheathed cables/ cords with rigid and flexible conductor for rated voltages - up to and including 450/750V
IEC 61869	Instrument Transformers
IS 3043	Code of practice for earthing
IEC 60255	Measuring relays and protection equipment - Part 1: Common requirements

10.2 Technical Parameters

System Details	
Rated system voltage	415 V \pm 10%, 3 Phase, 50Hz, 4 wire, Neutral Solidly Earthed
Digital Multifunctional Meter (MFM)	
Accuracy class	0.5 class for main distribution board at main control room and 0.5 class for DB at inverter room(s)
Communication with SCADA	RS485 communication with Modbus RTU
Current transformer (CT)	
Type	Cast Resin Bar Primary
Voltage class and frequency	650V, 50Hz
CT Secondary Current	1 or 5 A
Class of insulation	Class F
Accuracy class & burden	
a) For Protection	5P20, 5VA PS Class for REF and core balance CT (CBCT)
b) For Metering	Class 0.5, 5VA (min)
Minimum primary earth fault current to be detected by CBCT	1 A

Instrument Security Factor for metering CT	5
Voltage transformer (VT)	
Type	Cast Resin
Accuracy class	0.5
Rated Voltage factor	1.1 continuous, 1.5 for 30 seconds
Class of insulation	E or better
Moulded case circuit breaker (MCCB)	
Rated voltage	415 V
Release	Thermal-Magnetic/Microprocessor
Rated current	As per system requirement
Poles	4 poles
Rated insulation level	690 V
Rated ultimate and service short circuit breaking Capacity	As per system requirement
Rated Making capacity (as per system requirement)	2.1 X Short circuit breaking Capacity
Utilization category	A

10.3 Constructional Details

- i The panel shall be metal enclosed, free standing, floor mounted, modular type with compartmentalized construction having degree of protection of IP 24 (Indoor) and IP54 (outdoor) as per IS/IEC 60529. All doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust.
- ii All switches, push buttons etc. shall be operated front and shall be flush/semi-flush mounted.
- iii The panel shall be fabricated from 2 mm CRCA sheet steel for frame & load bearing surfaces. Partitions may be fabricated from 1.6 mm CRCA if no components are mounted on them.
- iv Cable entries shall be from bottom. The opening of cable entry shall be covered by 3mm thick gland plates with proper sealing to avoid water and rodent entry.
- v Earthing bus bar of suitable cross section shall be provided throughout the length of panel.
- vi The panel shall be duly wired with suitable size of 1.1kV, PVC insulated cable and terminals shall be brought out for cable connections. 10% spare terminals subjected to minimum one of each rating shall be provided on each distribution switchgear. All wire shall have ferrules as per wiring diagram.
- vii The panel shall be painted with 2 coats of primer after pre-treatment and 2 coats of Polyurethane / epoxy paint with shade as decided by the Owner.
- viii The panel shall be of dead front construction suitable for front operated and back maintained functioning.

- ix 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.
- x Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.
- xi Suitable lifting hooks shall be provided for each panel.
- xii Each switchgear panel shall be provided with thermostatically controlled space heaters to prevent condensation within the enclosure. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.
- xiii Earth leakage relay with Core balance CTs (CBCT) shall be provided on main incoming feeders having phase CT ratio more than 50/1A. CBCT's shall be circular window type with window size based on the overall diameter of the cables, to be finalized during detailed engineering.

10.4 Distribution panels (ACDB and DCDB) shall be warranted for minimum of 10 (Ten) year against all material/ manufacturing defects and workmanship.

10.5 Routine test and acceptance tests requirements shall be as per relevant standards for all cable sizes.

11.0 Uninterrupted Power Supply

11.1 Standards and Codes

Standard/Code	Description
IEC 62040-1	Uninterruptible power systems (UPS) - Part 1: General and safety requirements for UPS
IEC 62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC 62040-3	Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements

11.2 General Requirements

The Uninterrupted Power Supply (UPS) system shall be designed to supply power to following loads (but not limited to).

- Data logger / SCADA
- Fire Detection/ Alarm Panel
- HMI of SCADA
- Emergency Lighting
- Inverter's Auxiliary supply (if applicable)
- HT panel auxiliary
- CCTV

Sizing of UPS shall be done considering the above-mentioned load at power factor of 0.8 lagging inclusive of 10% design margin at 50 °C.

11.3 System Description

- i The UPS shall automatically provide continuous, regulated AC power to critical loads under normal and abnormal conditions, including loss of input AC power. The UPS system shall consist of the following major equipment.
 - UPS Module
 - a) Insulated Gate Bipolar Transistor (IGBT) Converter
 - b) Insulated Gate Bipolar Transistor (IGBT) Inverter
 - c) Digital Signal Processor (DSP) using Pulse Width Modulation (PWM) for Direct Digital Control (DDC) of all UPS control and monitoring functions
 - d) Static bypass switch
- ii Battery system for 2 hours
- iii Battery protective and disconnect device
- iv Maintenance bypass switch
- v LCD display panel and LED indications
- vi Integrated UPS Communications Protocols capable of communicating with SCADA system

11.4 The UPS shall meet the following minimum specifications.

Parameter	Specification
Topology	Online double conversion UPS
Input	
Voltage	230 V \pm 10% AC
Frequency	50 \pm 5 Hz
Power factor	0.95
Output	
Voltage	230V \pm 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Sealed, Maintenance-Free (AGM) battery
Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED Indicators	Load on Inverter, Battery operation, Load on Bypass, Overload, LCD Fault, UPS Fault
	Closing contacts for each of the following conditions: <ul style="list-style-type: none"> • Unit on Battery • Low Battery

Electrical contacts	<ul style="list-style-type: none"> • Summary Alarm • UPS On • Input Fail
Local Display	LCD/ LED
SCADA communications	RS-232 or RS-485 Interface Port
Overall efficiency	>90%
Electrical Protection	Input/ output under voltage, over temperature, overload, Short circuit, battery low trip

11.5 The UPS shall be forced air cooled by internally mounted fans. The fans shall be redundant in nature to ensure maximum reliability. The fans shall be easily replaceable without the use of special tools.

11.6 Contractor shall provide the Operation & Maintenance Manual and mandatory spare parts list along with the equipment.

11.7 Tests

- i Routine tests and acceptance tests on final product shall be done as per QAP approved by the Employer.
- ii On completion of installation and commissioning of the equipment on site tests shall be carried out with the max. available load, which does not exceed the rated continuous load. An on-site test procedure shall be submitted by contractor include a check of controls and indicators after installation of the equipment.

12.0 Battery and Battery Charger

12.1 Standards and Codes

Standard/Code	Description
IEC 60896-22:2004	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements
IEC 60896-21:2004	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IS 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates)
IS 8320	General requirements and methods of tests for lead acid storage batteries.
IS 15549	Stationary Regulated Lead Acid Batteries

12.2 110 V DC system (Battery, Battery Charger & DCDB) in accordance with this specification and standards stated herein, shall comprise of the following.

- i Sealed Maintenance Free (VRLA) Battery complete with racks & accessories.
- ii One No. Float charger.
- iii One No. Float cum Boost charger.
- iv DC Distribution Board (DCDB)

12.3 Battery

- i Battery shall be used to supply the following loads with back up of two hours in case of complete power failure:
 - Trip and closing coil of HT circuit breaker
 - Spring charging motors for HT circuit breaker
 - Annunciator and Indication circuit of HT panel
 - Auxiliary supply to protection relays
- ii The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.25 & depth of discharge of 80%.
- iii The design of the battery bank and sizing calculation along with the data sheet for the battery and battery charger shall be submitted for approval.
- iv Battery voltage – 220V or 110V DC

12.4 Charger

- i The Float Charger shall be used to supply normal DC loads and float charging current of charged battery. The Float cum Boost charger shall be designed to supply boost charging current requirement of the associated battery as well as to supply normal DC load. After full discharge of battery bank, the Float Cum boost charger shall be capable of charging the battery to its full capacity in 8 hours duration while supplying normal DC load.
- ii The float charger shall have both auto and manual voltage regulation arrangements with provision of selector switch.
- iii Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage and current to 2% and 5% respectively.
- iv Digital Outputs shall be configured for connection to the SCADA to monitor the outputs like charger output current, output voltage, float/boost mode, etc.
- v The charging equipment shall be housed in a free standing, floor mounted compartmentalized panels. Panel shall have provision for bottom cable entry with removable undrilled cable gland plate of 3.0 mm thickness.
- vi The panel shall be of CRCA sheet steel construction having thickness of at least 2.0 mm. Degree of protection provided by the enclosure to the internals of charger shall be IP-42.
- vii The instruments, switches and indicating lamps shall be flush mounted on the front panel.

12.5 DC distribution board (DCDB)

- i DCDB shall be an integral part of a battery charger.
- ii Doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust. Also, door shall be provided with lock and key arrangement to prevent unauthorized access to the board.
- iii DCDB shall have adequate number of outgoing feeders with double pole, DC MCBs.
- iv At least 20% feeders shall be provided as spare.

12.6 Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

13.0 Earthing (Except for MCS / Pooling substation)**13.1 Standards and Codes**

Earthing system shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, earthing system shall comply with the following standards and codes.

Standard/Code	Description
IS 3043	Code of Practice for Earthing
IEC 62561-2	Requirements for conductors and earth electrodes
IEC 62561-7	Requirements for earthing enhancing compounds
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
Indian Electricity Rules	

13.2 General Requirements

- i Earthing system shall be designed based on system fault current and soil resistivity value obtained from geo-technical investigation report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.
- ii The earth electrode shall be made of high tensile low carbon steel rod, molecularly bonded by high conductivity copper on outer surface with coating thickness not less than 250 micron as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS 3043.
- iii Earth conductors shall be made of copper bonded steel or galvanized steel of sufficient cross section to carry the fault current and withstand corrosion.

- iv Earth conductors buried in ground shall be laid minimum 600 mm below ground level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures.
- v Earth electrodes shall not be situated within 1.5m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be two times the driven depth of the electrode.
- vi Transformer yard and switchyard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.
- vii All welded connections shall be made by electric arc welding. For rust protection, the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound.

13.3 Earthing of PV array field

- i All PV Modules, Module Mounting Structures (MMS) and String Monitoring Unit (SMU) structures in the PV array field shall be bonded to the earthing system by two distinct connections.
- ii Each PV Module frame shall be earthed using copper wire of sufficient cross section. The copper wire shall be connected to the earth hole provided in the module frame using suitable arrangement in line with the manufacturer recommendation. The earthing arrangement shall use stainless washers to prevent galvanic corrosion between aluminium frame and copper wire. In order to achieve effective earthing, serrated washers shall be employed to penetrate the anodization layer of the module frame.
- iii Continuous copper earthing wire shall be run to connect a group of modules and both ends of the loop shall be bolted to the DC earth grid using bimetallic lugs and stainless-steel fasteners. The copper earthing wire shall be routed in such a way to avoid physical contact with the module aluminium frame.
- iv The connection between MMS and DC earth grid shall be bolted or welded. Portion of the MMS which undergoes welding at site shall be coated with two coats of cold galvanising and anti-corrosion paint afterwards.
- v Earth electrodes of the DC earth grid shall be uniformly distributed throughout the PV array field so that optimum earth resistance is offered to leakage current flowing from any module frame or MMS.
- vi SMU equipment earthing point shall be connected to the DC earth grid using flexible copper cable of sufficient cross section as recommended by the manufacturer. The connection with the DC earth grid shall be done using suitable bimetallic lugs and stainless-steel fasteners.

13.4 PCU Earthing

DC negative bus bar of the PCU shall be earthed to avoid Potential Induced Degradation (PID). DC negative bus bar and PCU equipment earth shall be bonded to the PCU earth bus and connected to earth electrodes through flexible

copper cable of sufficient cross section as mentioned by the manufacturer. In case negative earthing provision is not available, suitable anti-PID device shall be provided. The interconnection of PCU earth electrodes with DC earth grid shall be as per PCU manufacturer recommendation.

13.5 Transformer Earthing

- i Inverter transformer neutral shall be floating, not to be earthed. However, recommendation of inverter manufacturer shall also be taken into account.
- ii Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.
- iii Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.
- iv Neutral and body of the auxiliary transformer shall be earthed.

13.6 Inverter Room and Control Room Earthing

- i Metallic enclosure of all electrical equipment inside the inverter room and main control room shall be connected to the earth grid by two separate and distinct connections.
- ii Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.
- iii SCADA and other related electronic devices shall be earthed separately using minimum two no. of earth electrodes.

13.7 Switchyard Earthing

The metallic frame work of all switchyard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.

Switchyard shall be shielded against direct lightning stroke by provision of overhead shield wire or earth wire or spikes(masts) or a combination there of as per CEA regulations 2010 (Technical standards)- 42(2)(C).

- 13.8** Type test reports for earthing electrode, earth enhancing compound and its associated accessories shall be submitted during detailed engineering for approval.

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. The earth plate shall be provided to facilitate its identification and for carrying out periodical inspection.

14.0 Lightning Protection System (Except for MCS / Pooling substation)

- 14.1** Lightning Protection System (LPS) for entire plant against direct lightning strokes shall be provided as per IEC 62305:2010 or NFC 17-102:2011.

- 14.2** Protection level for the entire plant shall be Level-I.
- 14.3** LPS as per IEC 62305
Location of air terminals shall be designed as per rolling sphere method.
- 14.4** LPS as per NFC 17-102
Lightning Protection System shall consist of following accessories.
- i Early Streamer Emission (ESE) air terminal.
 - ii Highly insulated poly-plastic adaptor to fix the ESE air terminal with the FRP mast.
 - iii Fiberglass Reinforced Plastic (FRP) mast.
 - iv Coupler to connect FRP mast with GI mast.
 - v GI tubular pole supported on RCC pedestal and foundation structure through Base plate & Anchor bolt assembly.
 - vi Down-conductor: PVC insulated flexible copper cable of suitable size complying with EN 50164-2 or equivalent standard. It shall be routed along the mast with suitable fixings and connectors.
 - vii Test joint with each down conductor.
 - viii Lightning event counter complying with EN 50164-6 or equivalent standard. It shall be fixed at suitable height in series with the down conductor.
 - ix Earth termination system in accordance with NFC 17-102. Earth electrodes shall comply with the EN 50164-2 or equivalent standard. Earth enhancing compounds complying with EN 50164-7 or equivalent standard, may be used where soil resistivity is higher and making it impossible to achieve system resistance within specified limit.
- 14.5** Accessories listed above are indicative only and any other fittings or accessories, which are usual or necessary for satisfactory operation of the lightning protection shall be provided by the Contractor without extra charges.
- 14.6** Necessary foundation/anchoring for holding the lightning mast in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.
- 14.7** The product shall be warranted for minimum of 10 (ten) years against all material/ manufacturing defects and workmanship.
- 14.8** Type test reports as per IEC 62305:2010 or NFC 17-102:2011 shall be submitted during detailed engineering for approval.

15.0 Communication Cable

15.1 Optical Fibre Cable

- i Optic Fibre cable shall be galvanized corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor/ indoor application so as to prevent any physical damage.

- ii The cable shall have multiple single-mode or multimode fibres on as required basis so as to avoid the usage of any repeaters.
- iii The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
- iv The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling.
- v All testing of the optic fibre cable being supplied shall be as per the relevant IEC, EIA and other international standards.
- vi The Contractor shall ensure that minimum 100% cores are kept as spare in all types of optical fibre cables.
- vii Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.
- viii Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standard.

15.2 Communication Cable (Modbus)

- i Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 Sq.mm. Cable shall be flame retardant according to IEC 60332-1-2.
- ii Cable shall be tested for Peak working voltage of not less than 300 V and shall be suitable for serial interfaces (RS 422 and RS 485).
- iii Communication cable shall be laid through underground with suitable HDPE ducts.

16.0 SCADA

16.1 General Requirements

- i The Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire solar plant and its auxiliary systems.
- ii The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall etc. needed for the completeness.
- iii SCADA System shall have the provision to perform the following features and/or functions:
 - Web enabled Operator Dashboards: Showing key information on Generation, Performance and Current Status of various equipment in Single Line Diagram (SLD) format with capability to monitor PV array string level parameters.

- Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.
- Fault and System Diagnostics with time stamped event logging.
- Support for O&M Activities: The interface shall allow integration with Surveillance System(s), Module Cleaning System and various other O&M support systems to provide a Data Analysis and Decision Support System for smooth and efficient Plant Operations.
- AI based Distributed Analytics for Predictive Maintenance, trend analysis and Alerts.
- Generate, store and retrieve user configurable Sequence of Event (SOE) Reports.
- Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.
- Transfer of plant data reliably, to an Owner designated server or Cloud on any kind of remote network including low bandwidth and wireless links such as 2G/3G/VSAT

(Note: Telecom Lease line connection, if required for transferring data from Plant over internet shall be taken by Contractor in the name of Employer for O&M period)

- iv The Control system shall be designed to operate in non-air-conditioned area. However, the Contractor shall provide a Package/ Split AC of suitable capacity decided by heat load requirement in SCADA room at Main Control Room.

16.2 Architecture

- i The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database.
- ii Data acquisition shall be distributed across MCR and LCRs while plant level data aggregation shall be done in both local and remote server (as specified by Owner).
- iii Analog and Digital IO modules shall have integrated processor for distributed IO processing and control.
- iv Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.
- v Plant SCADA Server shall have Industrial Grade server hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.

- vi Plant data for monitoring and control operations should be accessible without dependence on external network.
- vii A virtual/cloud server running SCADA & Monitoring Software shall be configured in parallel with Plant Server to enable easy access to plant data from outside the plant without having to login to plant server. Effectively, the plant data shall be replicated in both places i.e. between systems at the Plant Server and Remote Server to provide data redundancy for complete plant data.
Note: Configuration of Cloud server and procurement of associated subscription services shall be in the scope of the EPC Contractor.
- viii Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant or remote server. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software and Plant Data shall be installed/stored on local and remote servers only with user access control for protecting the software and data assets from accidental deletion or corruption.
- ix Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 50 Mbps or higher bandwidth. In case no broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided. SCADA system shall be capable of sending all plant data in real time to the Remote Server.
- x GPS based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with antenna, receiver, cabinet and internal interconnection cables. All SCADA controllers, servers, OWS and communicating equipment shall be synchronized to the GPS clock.

16.3 Industrial IoT Controllers & Data Acquisition

The Plant SCADA and Monitoring System may use one or more IIoT Controllers at each Inverter Control Room and MCR for the purpose of data acquisition and data forwarding to the Local and Remote SCADA Servers. The IIoT Controllers shall meet the following minimum requirements:

- i The IIoT Controllers shall be distributed in nature and work independently of other IIoT Controllers or any central controller in the system.
- ii Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet,/IEC 61850 etc.)
- iii Shall have local storage for a minimum of 2 weeks (in case of network failure).
- iv Provide web-based interface to configure the controller for various equipment in the field.
- v IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT/BESS & Transformer panels through distributed DI/AI modules.

- vi Controls: Shall be capable of Controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.
- vii Data Communication with Servers: Shall send the data collected, from all the equipment at Inverter Control Room and/or Main Control Room, to the Monitoring & Control Server.
- viii Controllers shall be capable of sending data over Internet connections USB data cards.
- ix Shall not require a static public IP address, at the plant for the purpose of remote access.

16.4 Functionalities

- i The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC& AC Equipment including inverters, string combiner boxes, weather station, MFM, Transformer, BESS, Switchgear (LT & HT Panels) and Plant EMS Controller at regular intervals not greater than one minute.
- ii The SCADA system shall monitor Instantaneous and cumulative environment parameters from weather sensors or data loggers as well as BESS parameters at same interval as electrical parameters and provide PR, CUF, State of Charge (SoC) etc. on the fly.
- iii The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on status change of hardwired DI shall also be provided.
- iv The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds. The list of such parameters shall be finalised in consultation with the Owner.
- v The SCADA system shall enable integration with other sub-systems at the plant for supporting O&M activities. The list shall include but not limited to:
 - Surveillance Cameras,
 - Module Cleaning System – For monitoring of water usage and efficacy of cleaning process.
- vi The SCADA system shall have user-friendly browser-based User Interface for secure access from anywhere, for minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of total plant generation, day's export, irradiance, Inverter Control Room level generation and performance indicators like PR and CUF.
- vii Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.
- viii The system shall have Configurable Analysis page for self-configured as well as on demand Analytics charts.
- ix The SCADA system shall be extensible to include maintenance of O&M schedules and related activities for plant equipment as per the O&M Manual.

- x Connectivity shall be provided to Owner's Data Monitoring Centre. Data collected by Plant SCADA shall be replicated in real-time, using industry standard interfaces such as Web Services, OPC-UA, data files, as required – with Owner's Central Monitoring System. The data recording intervals for different parameters from different devices in the solar plant shall be considered when creating schedules to "push" the data from Plant SCADA to Owner's Data Monitoring Centre.
- xi Mobile User Interface: summary of plant performance and issues should be accessible in a mobile Native UI or browser UI.
- xii Data Communication to SLDC: SCADA system shall provide required interface to integrate with 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 and it shall be the responsibility of the Contractor to determine the same.
- xiii Power Plant Control: SCADA system shall provide required interface to the local SCADA operator to set various power control modes (active/reactive power/frequency/PF) through the inverters over industry standard communication protocols like Modbus over TCP/IP.
- xiv Forecasting and Scheduling: SCADA shall provide day ahead and week ahead forecasting and scheduling for power generation at the plant as per SLDC/Utility stipulations.
- xv Predictive Maintenance: SCADA system shall have in-built or pluggable frameworks to support AI based Predictive Maintenance for all key equipment including inverters, transformers and switchgear at the plant.
- xvi All programming functionalities shall be password protected to avoid unauthorized modification.
- xvii The Contractor shall provide software locks and passwords to Employer for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

16.5 Earthing

- i Two isolated electronic earth pits near to SCADA panel at every Inverter and Control Room with < 1 Ohm resistance shall be provided. One earth pit shall be used for protective/body earth and the other to be used for Signal Earth.
- ii Apart from providing separate earth pits, manufacturer specified earthing recommendations shall be followed for all communicating equipment connected to SCADA. This includes but is not limited to SMBs, Inverters, WMS and Switchgear panels.

16.6 Communication Cable Laying

- i All RS485, IO and CAT6 cables shall be laid in separate conduits with a minimum separation of 1.5ft from AC/DC power cables all along.

- ii Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure minimum 1.5 ft separation between power and communication cables all along the trench.
- iii IO Cables between switch gear panels and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.
- iv RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

16.7 Control Cabinets / Panels / Desks at Main Control Room

- i The cabinets shall be IP-22 protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.
- ii The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications.

16.8 Software Licence

The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project and shall not be hardware/ machine-specific.

16.9 Hardware at Main Control Room

- i The Hardware as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.
- ii The Local Monitoring & Control Server and the Operating Work station, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories:

Plant Server	
Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 8 X 2TB SATA hard discs in RAID 5 configuration, 4 Nos. of 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.

Operating System	Operating System and Database shall be of enterprise scale (RedHat Linux or equivalent Linux OS or Windows OS, Oracle/MySQL or equivalent DB), with required AMC for 5 years.
Accessories	<ol style="list-style-type: none"> 1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3. Pointing Device: Mouse 4. Intelligent UPS (on line): Minimum 2 hour battery backup.
Operator Workstation	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 500GB hard disk, 32" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	<ol style="list-style-type: none"> 1. Screen Display Unit: Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer. 3. UPS of required capacity with 2 hour battery backup.

iii The Hardware as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

16.10 FAT (Factory Acceptance Test) procedure shall be submitted by bidder for approval. SCADA shall communicate with all third devices which are part of solar plant and same shall be demonstrated during the FAT.

17.0 Illumination

17.1 Standards and Codes

LED luminaires shall be tested at independent laboratory as per the following test standards.

Standard/Code	Description
LM79-08	Electrical and Photometric Measurements of Solid-State Lighting Products
LM 80-15	Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

17.2 General specification

- i This specification covers design, supply and installation of uniformly Illumination system along the peripheral & internal roads, main control room & inverter rooms, switchyard and other facilities including entry points/gate(s) inside the plant area.
- ii The Contractor shall furnish Guaranteed Technical Particulars of the LED luminaires, from renowned brands available in the market for approval of Employer.
- iii Lighting system shall work on the auxiliary supply and same shall be incorporated in auxiliary loads. The Contractor shall provide minimum 20% of total lighting points as emergency lighting points, fed from UPS DB or DCDB as per scheme adopted by the Contractor. Indoor and outdoor emergency lights shall be provided at each inverter room, main control room, security room and main gate.

17.3 Lighting Levels

- i The average LUX level of 10 lux is to be maintained in switchyard. However, a lux level of 20 lux ((10+10) additional switchable on requirement only) is to be maintained in switchyard on transformer.
- ii The lighting system for outdoor and indoor areas of solar power plant shall be designed in such a way that uniform illumination is achieved. Average LUX level to be maintained in different areas shall be as under:

Area	LUX
Control Room and equipment rooms	300
Office	300
Battery & other rooms	200
Internal Roads	20
Transformer yard/Switchyard	50
Metering point	50

- iii The lighting level shall take into account appropriate light output ratio of luminaires, coefficient of utilization maintenance factor (of 0.7 or less) to take into account deterioration with time and dust deposition and illuminance uniformity [Uo] shall be min 0.3.
- iv Plant boundary/ Peripheral area shall be illuminated with chain-link/Boundary wall post mounted LED floodlights for area lighting as per following specifications:

Input Voltage	AC 220-240V
Frequency	50Hz~60Hz
LED power Consumption	50 W

LED luminous efficiency	85 Lm /W
Led Luminous Flux	4500 lm
lamp's Efficiency	> 88 %
Color Temperature	Cool White
Color Rendering Index	> 75
Light Distribution	Symmetric / circular spot
Light Design	LED+ Reflector
LED Junction Temperature	≤80°C
Working Temperature	-40°C ~ 55°C
IP Grade	IP65
Mechanical Strength	IK08
Working Life-span	30000 Hrs
Certification	CE& ROHS
Warranty	3 Years Product Replacement

17.4 LED Luminaire for Outdoor Applications (Other than Peripheral Area)

- i LED luminaires shall meet the following parameters.

Parameter	Specified Value
Input voltage	170 - 260 V
Input Frequency	50 Hz +/-1 Hz
Power Factor	0.90 (Minimum)
Luminaire efficacy	> 90 lumens per watt
Beam Angle	Minimum 120°
Total Harmonic Distortion	< 10 %
Working Humidity	10% - 90% RH (Preferably Hermetically sealed unit)
Degree of Protection	Minimum IP 65 (for Outdoor fixtures)
Luminaire Casing	Powder coated metal / Aluminium.
Colour Temperature	5700 K (cool day light)
Colour Rendering Index	> 65
Moisture protection in case of casing damage	IP 65 (driver unit shall preferably be totally encapsulated)

- ii The LED luminaire (outdoor) housing, heat sink, pole mounting bracket, individual LED reflectors and front heat resistant tempered glass should be provided.
- iii The LED luminaire (outdoor) housing should be made of non-corrosive, high-pressure, die-cast aluminium and the housing should be power coated grey, so as to ensure good weatherability. Each individual LED source should be provided with an asymmetrical distribution high reflectance aluminized reflector, which should ensure that the light distribution of the luminaire is suitable for road lighting applications (wide beam distribution) and should ensure high pole to pole spacing.
- iv The luminaire should be provided with in-built power unit and electronic driver.
- v The luminaire should be suitable for standard street light poles and should be suitable for side entry and bottom entry (post top).
- vi GI Lighting pole of suitable diameter capable of withstanding system and wind load, shall be provided with average Zn coating thickness of 80micron. The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.
- vii All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.
- viii Lighting panels shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, etc. shall be earthed by means of separate earth continuity conductor. Cable armour shall be connected to earthing system at both the ends. Proper earthing of street light poles shall be ensured.
- ix Junction box for lighting shall be made of fire-retardant material. The degree of protection shall be IP55 for outdoor JB.
- x Lighting cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.

17.5 LED Luminaire/Lamps for Indoor Applications

LED luminaire/lamps shall have minimum 3-star BEE rating. All indoor LED luminaire/lamps shall be supplied with proper diffuser to avoid direct visibility of LED and suitable heat sink for longer life.

- 17.6** All luminaires shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (two) years from the date of supply.

18.0 Weather Monitoring System

The Contractor shall provide the following measuring instruments with all necessary software and hardware required to integrate with SCADA

18.1 Pyranometer

The Contractor shall provide minimum 2 (two) number of Class-A pyranometers (ISO 9060:2018 classification) along with necessary accessories for measuring

incident solar radiation at horizontal and inclined plane of array (POA). Specification of the pyranometer / albedometer shall be as follows:

Parameter	Specification
Spectral Response (50% points)	0.31 to 2.8 micron
Operating temperature range	0°C to +80°C
Ingress Protection	IP 67
Resolution	Minimum +/- 1W/m ²
Output	Analog output: 4 – 20 mA Serial output: RS 485

Each instrument shall be supplied with necessary cables. Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with the equipment. The signal cable length shall not exceed 20m. The Contractor shall provide instrument manual in hard and soft form.

18.2 Temperature Sensor

The Contractor shall provide minimum 3 (three) temperature sensors (1 (one) for ambient temperature measurement with shielding case and 2 (two) for module temperature measurement). The temperature sensor shall be Resistance Temperature Detector (RTD)/ Semiconductor type with measurement range of 0°C to 80°C. The instrument shall have valid calibration certificate.

18.3 Anemometer

Contractor shall provide minimum one no. ultrasonic wind sensor (no moving parts) for wind speed and direction monitoring.

Parameter	Specification
Velocity range with accuracy limit	0-60 m/s with +/-2% accuracy @12 m/s; Resolution: 0.01 m/s
Wind direction range with accuracy limit	0 to 360° (No dead band) with +/-2° accuracy @12 m/s; Resolution: 1°
Mounting Bracket	Anodized Aluminium bracket to reduce corrosion, all mounting bolts of SS
Protection Class	IP 66
Output	RS 485

18.4 Data logger and Data Acquisition System

Data logger for the weather monitoring station should have the following features: Provision for analog, digital and counter type inputs for interfacing with various type of sensors

i Analog Input

- Adequate nos. for all analog sensors with redundancy

- Provision for operation in different current and voltage ranges as per connected sensors.
- Accuracy of +/-0.1% of FS
- ii Digital Inputs
 - Adequate no. of Digital inputs and outputs for the application
- iii Provision for RS232 and RS485 serial outputs.
- iv Built-in battery backup.
- v Connectivity and Data transmission:
 - RS485 MODBUS interface for data collection and storage on SCADA
 - Communication protocol should support fast data transmission rates, enable operation in different frequency bands and have an encryption-based data security layer for secure data transmission.
- vi Display Settings: Graphic LCD screen which should be easily accessible and should display relevant details like all sensor values, battery strength, network strength etc.
- vii Provision of Time synchronization with the SCADA GPS Synchronisation clock.
- viii Data Storage: Provision for at least 2 MB internal Flash Memory and at least 8 GB Micro SD card (expandable)
- ix Protection level: IP65

19.0 CCTV Camera

19.1 CCTV Cameras along with monitoring stations (sufficient numbers) and all other accessories required for its proper operation must be installed to have complete coverage of following areas for 24 hours.

- i Main entry: Covering all the entry/exit
- ii Along the Plant Perimeter: Covering complete perimeter of Plant Area to capture all possible intrusion.
- iii Control Rooms: Covering Entry/Exit and Equipment Rooms.
- iv Switchyard.

19.2 The CCTV system shall be designed as a standalone IP based network architecture. System shall use video signals from different cameras at defined locations, process the video signals for viewing on monitors at control room and simultaneously record all video streams using latest compression techniques.

19.3 Camera shall be colour, suitable for day and night surveillance (even under complete darkness) and network compatible.

19.4 It shall be possible to control all cameras i.e., PTZ auto/ manual focus, selection of pre- sets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitor for live video.

19.5 Monitoring stations of the CCTV Network shall be installed in Main Control Room.

19.6 The system shall support video analytics in respect of the following:

- i Video motion detection.
- ii Object tracking.
- iii Object classification.
- iv Camera server shall be provided with sufficient storage space to storage recordings of all cameras at HD mode for a period of 15 days. All recordings shall have camera ID, location, date and time of recording.

20.0 Fire Alarm System

20.1 Standards and Codes

Standard/Code	Description
IS 2189	Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System Code of Practice
IS 2171	Portable Fire Extinguishers, Dry Powder (Cartridge Type)
IS 8149	Functional requirements for twin CO ₂ fire extinguishers (trolley mounted)
IS 2546	Galvanized mild steel fire bucket
National Building code 2016	

20.2 Contractor shall ensure the compliance of fire detection and alarm system as per relevant standards and regulations. The installation shall meet all applicable statutory requirements and safety regulations of state/central fire department/body or any other competent authority in terms of fire protection.

20.3 Firefighting system for the proposed power plant for fire protection shall be consisting of but not limited to:

- i Sand buckets.
- ii Portable fire extinguishers (CO₂ and dry powder type).
- iii Microprocessor based fire alarm panel.
- iv Multi sensor smoke detectors.
- v Hooter cum strobe.
- vi Manual call points.
- vii Cables from sensor to fire Panel.

20.4 Minimum two numbers of fire extinguishers (CO₂ and Foam type each, of capacity 9 kg having BIS certification marking as per IS: 2171) shall be provided at every building/ enclosure, transformer yard and switchyard. However, contractor must comply with existing building code for fire protection and relevant IS codes.

- 20.5** Four numbers of stand with four sand buckets on each stand shall be provided in the Transformer Yard. Sand buckets inside the building shall be provided at strategic locations as decided during detailed engineering.
- 20.6** Digital output from the fire detection system shall be integrated with SCADA.
- 20.7** Contractor shall submit the plan for fire and smoke detection system for the Employer's approval.

21.0 Instruments

Contractor shall provide the following set of instruments for on-site testing.

21.1 Earth resistance tester

Parameter	Specification
Display	Backlit LCD or LED display
Range	Earth Resistance: up to 2000 Ω Earth Voltage: 200 V
Accuracy	$\pm (2\% + 5)$
Safety Ratings	IP 56
Accessories	
Earth Ground Stakes – 4 Nos.	
Cable reels – 3 Nos.	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories	

21.2 Array tester

Parameter	Specification
Display	Backlit LCD or LED display
Functionality	All electrical tests required by IEC 62446- 1:2016
Memory	Up to 200 records & USB downloadable to Computer
Accessories	
A set of two, 4mm fused leads for extra protection during installation tests	
Leads which enable the array tester to connect directly to PV arrays	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories	

21.3 Insulation tester

Parameter	Specification
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Display	Backlit LCD or LED display
Insulation Test Range	0.1 MΩ to 10 GΩ
Test Voltage	250V, 500V, 1000V, 5000V
Test Voltage accuracy	+20% on positive side only no negative variation is allowed
Accessories	
Heavy duty Test Leads with Alligator Clips – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories	

21.4 Digital Multimeter

Parameter	Specification
Voltage Range	1500 V DC / 1000 V AC (True RMS)
Display	4 ½ digits, Backlit LCD or LED
Measuring Category	1000 V CAT-III as per IEC 61010-1
Additional Functions	Resistance, Temperature, Continuity, Diode, Capacitance, Frequency, Duty cycle measurement
Accessories	
Temperature Probe – 1	
Test Leads with Alligator Clips – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories.	

21.5 Clamp meter

Parameter	Specification
Current Range	400 A DC / 1000 A AC (True RMS)
Display	4 digits, Backlit LCD or LED
Measuring Category	1000 V CAT-III as per IEC 61010-1
Additional Functions	Active, Reactive, Apparent Power, Power Factor and THD
Accessories	
Test Leads – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories.	

21.6 Infra-red thermal imaging camera

Parameter	Specification
Spectral response	8 μm to 14 μm (LW)
Temperature-sensitivity and calibration range	-20 °C to +120 °C
Atmospheric air temperature	-10 °C to +40 °C
Thermal sensitivity	NETD \leq 0.1 K at 30 °C
Geometric resolution	640 x 480 pixels
Photo camera resolution	Approx. 30 times of IR camera resolution
Absolute error of measurement	$< \pm 2$ K
Adjustable parameters	Emissivity, ambient temperature
Adjustable functions	Focus, temperature level and span
Measurement functions	Measuring spot, measuring area with average and maximum temperature
Calibration	The measuring system (Camera, lens, aperture and filter): The camera has to be traceably calibrated at least every two years. The calibration has to be documented. If the camera is not compliant, it has to be readjusted by the manufacturer.
Documentation	Storing of the infrared picture with the radiometric data

21.7 Digital LED lux meter

Parameter	Specification
Range	0 – 1000 lux
Accuracy	$\pm (2\% + 5)$
Resolution	1 lux
Display	3½ digits, Backlit LCD/LED
Accessories	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories.	

- 21.8** All testing equipment shall possess valid calibration certificate issued from approved NABL labs.
- 21.9** Instruments of superior rating is allowed after seeking consent of the Employer.
- 21.10** Maintenance, calibration, up keeping, repair & replacement of these tools will be in the scope of the Contractor under the O&M Contract.
- 21.11** It is Contractor's responsibility to arrange for tools, tackles, logistics, test kits, manpower, experts etc. required for trouble free operation of Plant.

22.0 Specification for 120 KV Surge Type Lightning Arrestors

22.1 Scope

This specification covers requirements for 120 kV Surge Type Lightning Arrestors at site and suitable for outdoor application.

The 120 kV Surge Type Lightning Arrestors shall comply with the latest revision of IS 15086 (Part 4): 2017 /IEC 60099 Part-4 except where modified or extended by the provision of this specification and with the relevant parts of standards mentioned in clause 2.4.3.1.2.

Any material and component not specifically stated in this specification but necessary for trouble free operation of the equipment and accessories specified herein shall deemed to be included.

22.2 Other Relevant Standards

The other relevant Indian standards are as under:

IS 15086 (Part 4): 2017 /IEC60099 Part-4	:	Metal Oxide Surge type lightning Arrestors without gaps for AC Systems
IEC 60099 Part-5, 2018		Selection and application recommendations
IS: 15086 Part-5,2020		Application guide for nonlinear resistor type surge arrestors.
IEC 60270	:	Partial Discharge Measurement.
IS 2071 (Part 1) : 2016/ IEC 60060-1 : 2010	:	Methods of HV Testing
IS 5350 (Part 1): 1970 Reaffirmed In: 2019	:	Dimensions for outdoor porcelain post insulators.

22.3 Design Criteria

The 120 kV Surge Type Lightning Arrestors shall be suitable for 132000V ($\pm 10\%$), 3-phase, 50 Hz ($\pm 3\%$) power supply. The nominal discharge current carrying capacity has been specified in **Annexure-I** at the rated voltage and frequency.

22.4 Constructional Features

These surge arrestors shall be of Heavy Duty, Station Class and Gapless metal oxide (Zinc Oxide) type.

The arrestors shall be composed of units of non-linear resistors made of Zinc oxide. The Arrestors supplied shall be suitable for heavily polluted atmosphere.

A leakage current monitor with surge counter shall be provided with each surge arrester.

22.5 PERFORMANCE

Electrical Features

The lightning arrester shall ensure:

- a) Continuous operation at rated voltage (120 kV & 50 Hz) while carrying out effectively and without damage the automatic extinction of the follow up current.
- b) Continuous operation within variation for voltage between $\pm 10\%$, and frequency variation between $\pm 3\%$ and combined voltage and frequency variation of 10%.
- c) The arrestors shall divert any switching surge in excess of basic insulation level at the relevant nominal system voltage and cut off follow-up current of power frequency.

ANNEXURE -I

Technical Parameters for 30 KV Surge Type Lightning Arrestors

1.	Nominal system voltage	:	132 kV
2.	Highest system voltage	:	145 kV
3.	Rated Voltage	:	120 kV
4.	Nominal discharge current	:	10 kA
5.	System	:	3 Phase, 50 C/S,
6.	Type	:	outdoor installation, single phase, single column construction, station-class, heavy duty.
7.	Location	:	Outdoor as per the drawing
8.	Mounting	:	Self-supporting, mounting on pedestal
9.	Other requirements	:	i) Grounding terminal ii) Post insulator conforming to IS 5350: Part 3 : 1971 (Reaffirmed Year : 2019)
10.	Line terminals	:	Each terminal should be suitable to accept ACSR bus and it should be suitable for Horizontal Takeoff.
11.	Standards to conform	:	IS 15086 (Part 4): 2017 /IEC 60099 Part-4

23.0 Specification for 132 KV Disconnecting Switch Isolator and Earthing Switch

23.1 Scope

This specification covers requirements for 132 kV, Isolator and Earthing Switch suitable for outdoor application.

The 132 kV, Isolator and earthing switch shall comply with the latest revision of IS: 9921 except where modified or extended by the provision of this specification and with the relevant parts of standards mentioned in clause 2.4.3.2.2.

The isolators which are required to have earthing switches will also be combined in one unit. Interlock shall be provided between the isolator and the earthing switch to ensure proper operation and safety.

Any material and component not specifically stated in this specification but necessary for trouble free operation of the equipment and accessories specified herein shall be deemed to be included.

23.2 Other Relevant Standards

The other relevant Indian standards are as under:

IS/IEC 62271-102:2003 Reaffirmed In: 2018	:	High-Voltage Switchgear and Control gear Part 102 Alternating Current Disconnectors And Earthing Switches
IS 9921: Part 1: 1981 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 V - Part I : General and Definitions
IS 9921: Part 2 1982 (Reaffirmed Year: 2012)		Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 V: Part 2 Rating
IS 9921: Part 3: 1982 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1000 V - Part III: Design and Construction
IS 9921: Part 4: 1985 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (isolators) and Earthing Switches for Voltages Above 1000 V - Part 4: Type Tests and Routine Tests
IS 9921: Part 5: 1985 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 v - Part 5: Information to be Given with Tenders, Enquiries and Orders

IS 3043: 2018	:	Code of practices for earthing.
IS 11353: 1985 (Reaffirmed Year: 2017)	:	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS 5350: Part 3: 1971 (Reaffirmed Year: 2019)	:	Dimensions of Indoor and Outdoor Porcelain Post Insulators and Post Insulator Units for Systems with Nominal Voltages Greater Than 1000 V - Part III: Outdoor Pedestal Post Insulators
IS/IEC 60168: 2000	:	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass for Systems with Nominal Voltages Greater than 1 000 V
IS 13134: 1992 Reaffirmed In: 2018	:	Guide for selection of Insulators in respect of pollution conditions.
IS:2486	:	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 volts.
IS/IEC 60137: 2017	:	Insulated Bushings for Alternating Voltages above 1000 V
IEC 61109:2008	:	Insulators for overhead lines - Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V - Definitions, test methods and acceptance criteria

23.3 System Details

The rotating units shall be supported by thrust/taper roller bearings. All moving parts shall be fitted with non-ferrous bushes. The operating mechanism shall comprise of suitable bars and GI pipes of adequate length brought down a pole to a handle provided with galvanized guides. The same shall have arrangement for padlocking as OFF and ON position of the switch.

23.4 Design Features

The design of isolators shall be in accordance with the latest practice. However following points shall be taken into consideration.

Electrical Features

- a) The 132 kV, Off Load Isolator and Earthing Switch shall be suitable for 132000V, 3-phase, 50 Hz power supply.

- b) The isolator shall be designed for an operating temperature of 70⁰C.
- c) All similar components shall be interchangeable and shall be of same type and rating for easy maintenance and low spare inventory.
- d) Continuous operation at rated current at specified ambient conditions.
- e) Continuous operation within variation for voltage between $\pm 10\%$ and frequency variation between $\pm 3\%$ and combined voltage and frequency variation of 10%.
- f) The rated current carrying capacity, breaking and making capacity of the Isolator has been specified in **Annexure-II**
- g) The isolator, when earthing switches are used, shall have arrangement for fixing the same. The earthing switch shall have independent manual drive with mechanical interlock to prevent mal-operation.

Interlocking

The main switch and main switch with earth switch are required to be interlocked with associated switch gear and protection schemes through auxiliary contacts. Mechanical interlocking shall be provided between main switch and earth switch. Electrical interlocking shall be suitable for 110V DC supply. It shall be possible to lock isolator when in de-energised condition. It shall also be possible to engage the crank for operation by energising the device through a push button, only when all interlocking contacts are through.

Mechanical Features

The isolator should be fitted with Arching horns to interrupt light load and magnetizing current on transformer.

The Isolator shall be designed to withstand severe weather conditions and should be capable of withstanding electro-dynamic stresses due to short circuit.

23.5 Constructional Features

Switch Blades

The blade shall be made of hard drawn electrolytic copper strips liberal section to give extra strength and thermal capacity. All copper parts should be silver plated and ferrous parts metallized to give smooth finish.

Main Bearing

The main bearing ball thrust or taper roller bearing supporting the main rotating insulator operating shaft shall be adjustable in the field if necessary. The insulator shall be bolted to the top of the sheet steel base of fabricated construction. All working parts shall be made of non-rusting steel or specially treated to resist corrosion and the hole shall be brass bushed.

23.6 Operating Mechanism

Motorised operating as well as manual operating mechanism shall be provided

for 132 kV isolators. The motorized operation shall be both by local panel as well as remote panel.

The main switch shall be completely closed or opened with about 20 revolutions of cranking. Manual operating mechanism gang operated through a lever /handle on operating shaft shall be provided for earth switch.

The operating mechanism shall provide quick, simple and effective operation. The design shall be such that one person shall be able to operate the isolator without undue effort. The earth switch shall close or open by rotation of lever through 90 degrees. The operating mechanism shall be suitable to hold the main switch or earth switch in closed or opened position and shall not change due to gravity, wind, short circuit, vibration, seismic acceleration, shock, accidental touching etc

23.7 Fittings and Spares

All standard fittings shall be provided

ANNEXURE -II

Technical Parameters for 132 KV, Off Load Isolator With Earthing Switch

1.	Nominal system voltage	:	132 kV
2.	Highest system voltage	:	145 kV
3.	Rated Current	:	As per requirement
4.	Rated Voltage & Frequency	:	132 kV, 50 Hz
5.	No. of Phases	:	3
6.	Rated short time current	:	31.5 kA (rms) for 3 seconds
7.	Rated Current of earthing switch	:	As per requirement
8.	Rated Insulation Level		
8.1	One minute power frequency withstand voltage	:	275 kV rms
8.2	Lightning impulse withstand voltage	:	650 kV peak
9.	Type of interlock between Isolating and earthing switch	:	Integral Mechanical
10.	Operating mechanism	:	Motorized as well as manually operated, the motorized operation shall be both by local panel as well as remote panel.
11.	Mounting	:	Structure mounted
12.	Type	:	OFF-LOAD, three phase, Horizontal mounted, manually operated, double break with centre post rotating type

			with or without earth switch
13.	No. of phases per set	:	Three
14.	Contacts	:	Contact shall be designed to withstand rated current without over-heating. The switch shall have self-aligning hard drawn electrolytic copper contact.
15.	Reference standard	:	IS:9921
16.	Application	:	Outdoor
17.	Earthing switch	:	As Required
18.	Supporting insulator	:	The supporting insulator shall be 3 nos. of post type brown glazed porcelain insulator per phase and tested in accordance with IS/IEC 60168 : 2000
19.	Accessories	:	Base channel of hot dipped galvanized iron
		:	Operating down rod with complete mechanism
		:	Operating handle, mounting base, pad lock system
		:	Square rod of phase gang operation
		:	Post insulators conforming to IS 5350 : Part 3 : 1971 (Reaffirmed Year : 2019)
		:	Earth Switch

24.0 Specification for 132 KV Current Transformers

24.1 The specification covers design, manufacture, assembly, testing at manufacturer's works, packing and delivery of outdoor Instrument Transformers for protection and metering services in 132/33 kV substation. All 132 kV instrument transformers shall be out door type, single phase, oil immersed , self-cooled and shall be supplied with first filling of insulating oil. The current transformer shall confirm to IS 2705 (Part 1): 1992 Reaffirmed In: 2017 and also to the following technical parameters:

24.2 Other Relevant Standards

The other relevant Indian standards are as under:

IS 2705 (Part 1): 1992 Reaffirmed In : 2017	:	Current transformers - Specification: Part 1 general requirements (Second Revision)
IS 4201: 1983 Reaffirmed in: 2016	:	Application guide for current transformer (First Revision)
IEC 61869-2:2012	:	Instrument transformers - Part 2: Additional requirements for current transformers

ANNEXURE-III

24.3 Technical Parameters

1	Nominal system voltage	:	132 kV rms
2	Highest system voltage	:	145 kV rms.
3	Frequency	:	50 Hz
4	No. of phases	:	3
5	Application	:	Outdoor
6	Ratio	:	As per requirement
7	Mounting	:	Shall be suitable for mounting on structures.
8	Type	:	outdoor type, single phase, oil immersed, self-cooled, live tank, hermetically sealed
9	Cores	:	5
10	Class of accuracy	:	
	a) Core-I	:	0.5
	b) Core-II	:	10P
	c) Core-III	:	PS

	d)		
11	Purpose :		
	a) Core-I	:	Metering
	b) Core-II	:	Protection
	c) Core-II	:	Protection
12	Rated burden :		
	a)Core –I	:	As required
	b) Core-II	:	As required
	c) Core-II	:	As required
13	Rated insulation level :		
	a) One minute power frequency with stand voltage	:	275 KV (RMS)
	b) Impulse withstand test voltage with standard full wave	:	650 kV (Peak)
14	Short time current rating for 3 seconds	:	31.5 KA

24.4 List of Fitting and Accessories

The supply of the current transformers shall be complete with the following accessories:

- 1 Primary terminals
- 2 Nitrogen filling valve with cap.
- 3 Oil level indicator
- 4 Secondary terminals
- 5 Secondary terminal box
- 6 Lifting lugs
- 7 Cable Gland
- 8 Primary reconnection links
- 9 Oil filling plug
- 10 Oil drain plug
- 11 Earthing terminals
- 12 Abnormal pressure release device
- 13 Rating and diagram plate

25.0 Specification for 132 KV Potential Transformer

25.1 The specification covers design, manufacture assembly, testing at manufacturer's works, packing and delivery of outdoor Instrument Transformers for protection and metering services in 132/33 kV substation. All 132 kV instrument transformers shall be out door type, single phase, oil immersed, self-cooled and shall be supplied with first filling of insulating oil. The potential transformers shall conform to IEC 61869-1:2007 and also to the following technical parameters:

25.2 Other Relevant Standards

The other relevant Indian standards are as under:

IEC 61869-1:2007	:	<u>Instrument transformers - Part 1: General requirements</u>
<u>IEC 61869-3:2011</u>	∴	<u>Instrument transformers - Part 3: Additional requirements for inductive voltage transformers</u>
IS 4146: 1983 Reaffirmed In: 2016	:	Application guide for voltage transformers (First Revision)

ANNEXURE-IV

25.3 Technical Parameters:

1	Nominal system voltage	:	132 kV rms
2	Highest system voltage	:	145 kV rms.
3	Frequency	:	50 Hz
4	No. of phases	:	3
5	Application	:	Outdoor
6	Mounting	:	Pedestal
7	Transformation ratio	:	
	a) Core-I	:	132/√3 KV / 110/√3 V
	b) Core-II	:	
8	Class of accuracy	:	
	a) Core-I	:	1
	b) Core-II	:	3 P
9	Purpose :	:	
	a) Core-I	:	Metering
	b) Core-II	:	Protection
10	Rated burden :	:	

	a)Core –I	:	As required
	b) Core-II	:	As required
11	Rated insulation level :		
a)	Impulse withstand test voltage with standard full wave	:	650 kV (Peak)
b)	One minute power frequency with stand voltage	:	275 kV (rms)
12	Short time current rating for 3 seconds	:	31.5 KA

25.4 List of Fitting and Accessories

The supply of the Potential Transformers shall be complete with the following accessories:

- 1 HT terminals
- 2 Nitrogen filling valve with cap.
- 3 Oil level indicator
- 4 Secondary terminal box with HV neutral terminal
- 5 Lifting lugs
- 6 Oil filling plug
- 7 Earthing terminals
- 8 Earthing terminal box.
- 9 Oil drain plug
- 10 Abnormal pressure release device
- 11 Rating and diagram plate

26.0 132 KV Outdoor Type SF6 Circuit Breaker with Indoor Remote-Control Panel

26.1 Scope

This specification covers design, manufacture, assembly, testing before supply, inspection, packing, delivery, at site of outdoor type SF6 circuit breakers of rated insulation class of 132 kV. The circuit breakers shall be of the following types and shall be complete with all the accessories and auxiliary equipment required for their satisfactory operation in 132 kV /33 kV substation.

The circuit breaker shall comply with the latest revision of **IEC 62271-100:2021** except where modified or extended by the provision of this specification and with the relevant parts of standards mentioned in clause **2.4.3.3.2**.

Any material and component not specifically stated in this specification but necessary for trouble free operation of the equipment and accessories specified herein shall be deemed to be included.

26.2 Other Relevant Standards

The other relevant Indian standards are as under:

IEC 62271-100:2021	:	<u>High-voltage switchgear and control gear - Part 100: Alternating-current circuit-breakers</u>
IEC 60273:1990	:	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 5561: 2018	:	Specification for electric power connectors
IS 2629: 1985 Reaffirmed In: 2016	:	Recommended practice for hot- dip galvanizing and steel
IS 2633: 1986 Reaffirmed In: 2016	:	Method for testing uniformity of coating on zinc coated articles
IS 9135: 1979 Reaffirmed In: 2017	:	Guide for testing of circuit breakers with respect to out-of- phase switching
IS 3043: 2018	:	Code of practices for earthing.
IS 11353: 1985 (Reaffirmed	:	Guide for Uniform System of Marking and Identification of Conductors and

Year: 2017)/ IS 5578 : 1984 Reaffirmed In : 2016		Apparatus Terminals
IEC 60947-5-1:2016	:	<u>Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices</u>
IS 8603 : 2008 Reaffirmed In : 2019	:	Dimensions for porcelain transformer bushings for use in heavily polluted atmospheres 12/17.5 kV, 24 kV and 36 kV (First Revision)
IS 2705 (Part 1): 1992 Reaffirmed In : 2017	:	Current transformers - Specification: Part 1 general requirements (Second Revision)
IS: 10118	:	Code of practice for selection, installation and maintenance of Switchgear and Control gear.
IS: 4794	:	Push Button Switches
IS 12021: 2015	:	Specification of Control transformers for switchgear and control gear for voltages not exceeding 1000 V A.C.
IS/IEC 60137: 2017	:	Insulated Bushings for Alternating Voltages above 1 000 V
IEC 60168:1994, AMD2:2000	:	<u>Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V</u>
IEC 60529:1989, AMD 2000	:	<u>Degrees of protection provided by enclosures (IP Code)</u>
IEC 60270	:	<u>Partial Discharge Measurement</u>
IEC 60060	:	<u>High Voltage Test Technique</u>

26.3 Service Conditions

Ambient air temperature : Maximum 50⁰C.
 Altitude : Upto 1000 M above MSL.
 Relative Humidity : Approximately 97 %.

Pollution degree : Heavily polluted with coal dust.

26.4 Design Criteria

The Circuit Breaker shall be suitable for a power supply of 132000V ($\pm 10\%$), 3-phase, 50 Hz ($\pm 3\%$) with a combined variation of voltage & frequency up to $\pm 10\%$.

All similar components shall be interchangeable and shall be of same type and rating for easy maintenance and low spare inventory.

The current carrying capacity shall be continuous and the breaking and making capacity of the circuit breaker shall be as specified in **Annexure-V**

26.5 Construction

The unit shall consist of outdoor circuit breaker with interrupter units and operating mechanism box and indoor control panel for remote operation.

Interrupter Unit with Operating Mechanism Box

- i. The interrupter units together with the HV connections shall be enclosed in a sealed housing (preferably of porcelain) conforming to IP-65 protection **IEC 62271-100:2021**. Three such assemblies suitably separated for adequate phase clearances shall be mounted on a base-frame with a common operating shaft. This assembly along with the operating mechanism is intended to locate line terminals at a safe height above the ground.
- ii. All the control actuating devices shall be installed in the operating mechanism box.
- iii. The breaker shall be provided with alarm and lockout for low gas pressure.
- iv. The interrupter contacts shall be silver plated copper or copper chromium.
- v. ON/OFF push buttons shall be provided in the operating mechanism.
- vi. The breaker shall be equipped with motorised spring charge and closing mechanism along-with manual charging facility. The motor provided in the mechanism box shall be 230 V AC. The closing shall be electrical as well as manual.

Operation of the breaker from control panel

- i. The breaker shall be electrically operated from a remote control panel.
- ii. The necessary circuitry for ON/OFF/TRIP indication, spring charged or free indication and operation counter shall be provided in the control panel.
- iii. Terminal blocks for control cables shall also be provided in the control panel for interfacing with interlocks, if any.

Tripping Mechanism

- i. Breakers shall be provided with C.T. operated I.D.M.T. and instantaneous relay.
- ii. The tripping mechanism shall be trip free. The trip circuit shall be operated by 110 V D.C. control power.

Duty Cycle

The duty cycle is O - .3 sec - CO - 3 min - CO.

26.6 Performance

The design of the circuit breaker and accessories shall be in accordance with the latest standard practice and shall be such as to facilitate inspection, cleaning, repairs and maintenance and shall ensure safety operations under situation of sudden variations of loads and voltages.

Electrical Features

The breaker shall ensure

- a) Continuous current carrying capacity at specified ambient conditions.
- b) Operation within variation of voltage and frequency as mentioned earlier.
- c) The insulation levels conforming to the values given in relevant code.

Mechanical Features

The breaker shall be able to withstand the thermal and electromagnetic stress arising out of fault level of 31.5 kA (rms) for 3 second.

26.7 Protections and Interlocks

- i. All circuit breakers shall have programmable numeric type relays having suitable range. The following protections shall be provided for circuit breakers controlling different type of feeders.

Sl. No.	Type of Feeder	Protection to be provided
1	Incomer	Overload, short circuit and earth fault & CBCT operated earth leakage relay.
2	Transformer control	Overload, short circuit and earth fault and auxiliary relays for Buchholz, Differential protection, Oil and Winding temperature protections.
3	Bus coupler	Directional protection.
4	Outgoing	Overload, short circuit and earth fault.

- ii. Sufficient number of NO + NC auxiliary contacts shall be provided for the protections and interlock.

- iii. Necessary mechanical and electrical interlocking shall be provided among associated breakers and isolators for safe operation of the system.
- iv. While the breaker is in Off position, there shall be provision for earthing the current carrying parts of the Circuit breaker along with interlock arrangement for preventing accidental switching-on of the breaker.

26.8 Special Requirements of SF6 Gas Breaker

- i) SF6 breaker shall be so designed that upon loss of pressure the gap between open contacts shall be adequate to withstand at least the rated voltage at atmospheric pressure of gas.
- ii) The Contractor shall clearly bring out in his offer the precautions to be taken in the use of SF6 breaker
- iii) Following features shall be provided for monitoring of SF6 gas in the breaker:
 - a) SF6 gas density meter with two potential free contacts of suitable rating. One of these contacts shall be used for annunciation of low density. The other contact shall be used to ensure breaker lockout in the event of low SF6 gas density. The Contractor shall furnish a chart showing relation between pressure and density of SF6 gas, as well as settings for alarm and lockout.
 - b) Suitable pressure gauges shall be provided for SF6 gas, pneumatic air, as applicable. Gauge dials shall be clearly visible with naked eye to an observer standing on ground
 - c) Adequate number of pressure switches shall be provided for monitoring pressure of SF6 gas. The pressure switches shall be provided with sufficient number of potential free NO/NC contacts for use in control, protection and alarm circuits.
- iv) Closing coil shall operate correctly at all values of voltage between 85% and 110% at the rated control voltage and trip coil shall operate correctly at all values of voltage between 70% and 110% of the rated control voltage as specified elsewhere
- v) The Contractor shall furnish along with the offer, detailed Schematic drawings showing all types of control, protection, monitoring schemes to be employed by him. The Contractor shall be required to modify the schemes, if necessary, after discussions with the Employer.

26.9 Remote Control Panel

- i. The panel shall conform to relevant code.

- ii. The panel shall be indoor type having cubicle construction with relays, indication, mimic and metering facilities. The unit shall be fabricated with steel of minimum thickness of 2 mm for load bearing sections and 1.6 mm for non-load bearing sections respectively. The unit shall be located indoor with control wiring termination for remote control of the breaker from the indoor sub-station.
- iii. The control panel shall be freestanding type with bottom cable entry. The enclosure shall be dust and vermin proof with no access to ingress of moisture with IP 52 protection and two coats of primer and final paints, danger notice, body earthing and locks.
- iv. The panel shall be suitable for ready installation on embedded MS channels flushed with the floor or for direct installation on a leveled floor through grouting holes.
- v. All protective relays provided for the circuit breaker shall be housed in the indoor control panel.
- vi. For remote control the following features shall be provided:
 - a) 2-Way remote selector switch having three positions - Local / Neutral / Remote
 - b) 2-Way breaker control switch having three positions - On/Neutral/Off.
- vii. Indications shall be as under:
 - a) ON/OFF/TRIP with reset button.
 - b) Spring charged or free
 - c) Interlock operated
- viii. Mimic displays shall be provided on the panel as under:
 - a) Trip on overload
 - b) Trip on earth fault
 - c) Trip on short circuit
- ix. Digital microprocessor based power meter with adequate memory shall be provided for measurement, monitoring and management of different electrical parameters as follows.
 - a) Voltage.
 - b) Line current
 - c) Active power
 - d) Reactive Power
 - e) Apparent Power
 - f) Power factor
 - g) Frequency
 - h) Total Energy
 - i) kW & kVA demand

- x. Installation of outdoor Circuit Breaker unit, indoor control panel and interfacing between control panel and outdoor Circuit Breaker unit shall be in the scope of the bidder.
- xi. Proposed PT connected with bus bar in the substation shall be used for the purpose of metering and protection.

26.10 Name Plate

The name plates of the circuit breaker and its operating device shall have suitable marking as under:

Manufacturer

Type designation and serial number

Rated voltage

Rated frequency

Rated normal current

Short circuit withstand capacity

Rated short circuit breaking current

Rated making current.

Rated supply voltage of closing and opening devices

Operating duty

Supply voltage of indication and mimic.

Weights

Rated operating sequence

Year of manufacture

ANNEXURE -V

Technical Particular of 132000 V SF6 Circuit Breaker

1.	Installation	:	Outdoor Structure mounted
2.	Number of Poles	:	3
3.	Rated Voltage	:	132000 V ($\pm 10\%$)
	Highest System Voltage (RMS)		145000V
4.	Rated current (A)	:	As per requirement
5.	Type	:	SF6 gas filled
6.	Frequency	:	50 Hz
7.	Symmetrical breaking capacity	:	7201 MVA
8.	Short time current for 3 Sec.	:	31.5 kA (rms minimum)
9.	One minute power frequency withstand voltage	:	275 kV rms
10.	Lightning impulse withstand voltage	:	650 kV peak
	Type of operation		Individually three single poles

			operated single gang operated pole/three (mechanically poles coupled) simultaneous operation
11.	Operating duty Cycle		O-.3s-CO-3min-CO-
12.	Operating Mechanism	:	Operating mechanism shall be spring charge stored energy type. Operation control shall be electrical from remote as well as local. It shall be trip free along with ON / OFF / TRIP Indication.
13.	Manual/Electrically operated	:	Manual and Electrical
14.	Tripping arrangement	:	110 V DC shunt trip mechanism.
15.	Meters to be provided on the panel	:	Digital Power Meter.
16.	Protections to be provided	:	i) Short circuit ii) Overload iii) Earth Fault iv) Under voltage
17.	Indications on Control panel	:	ON, OFF, TRIP, LOCKOUT, CONTROL SUPPLY, SPRING CHARGED.
18.	Terminal arrangement		
a)	Incoming	:	ACSR conductor
b)	Outgoing	:	ACSR conductor
18.	Control Supply	:	110 V DC
19.	Auxiliary power supply	:	230V AC
20.	Control wiring	:	1.5 mm ² (minimum), 660 V, PVC, Copper conductor.
21	Drive motor operating voltage range		80% to 110% of nominal LT voltage

27.0 132/33 KV, 40 MVA Power Transformer**27.1 Scope**

This specification covers the requirements outdoor type winding 132/33 kV, 20 MVA (ONAN) power transformers, protected by primary SF6 circuit breaker and fitted with gas & oil relay, earth leakage relays, alarm, temperature indicator, tap changer, marshalling box, Nitrogen injection fire prevention system (NIFPS). The exact voltage ratio and kVA rating of the transformer has been specified in Annexure-VI.

The transformers shall comply with the latest revisions of IS: 2026 and IEC: 60076 except where modified or extended by the provisions of this specification and with the relevant parts of standards mentioned in para 2.4.3.6.2.

27.2 Other Relevant Standards

The other relevant standards applicable are as under:

IS 2026 (Part 1) : 2011 Reaffirmed In : 2021		Power transformers: Part 1 general (Second Revision)
IS 2026 (Part 2) : 2010 Reaffirmed In : 2020		Power transformers: Part 2 temperature - Rise (First Revision)
IS 2026 (Part 3) : 2018/ IEC 60076-3:2013		Power transformers: Part 3 insulation levels, dielectric tests and external clearances in air (Fourth Revision)
IS 2026 (Part 4) : 1977/ IEC 60086-3:2000 Reaffirmed In : 2021		Specification for power transformers: Part 4 terminal markings, tappings and connections (First Revision)
IS 2026 (Part 5) : 2011 Reaffirmed In : 2016		Power transformers: Part 5 ability to with stand short circuit (First Revision)
IS 2026 (Part 6) : 2017/ IEC 60076-6 : 2007		Power transformers: Part 6 reactors
IS 2026 (Part 7) : 2009/ IEC 60076-7 : 2005 Reaffirmed In : 2019		Power transformers: Part 7 loading guide for oil - Immersed power transformers
IS 2026 (Part 8) : 2009/ IEC 60076-8 : 1997 Reaffirmed In : 2019		Power transformers: Part 8 application guide
IS 2026 (Part 10) : 2009/ IEC 60076-10 : 2001 Reaffirmed In : 2019		Power transformers: Part 10 determination of sound levels
IS: 10028	:	Code of practice for selection, installation and maintenance of transformers.
IS 1866 : 2017/ IEC 60422 : 2013	:	Mineral insulating oils in electrical equipment supervision and maintenance guidance (Fourth Revision)
IS 3639: 1966 Reaffirmed In: 2021	:	Specification for fittings and accessories for power transformers
IS 8603 : 2008 Reaffirmed In : 2019	:	Dimensions for porcelain transformer bushings for use in heavily polluted atmospheres 12/17.5 kV, 24 kV and 36 kV (First Revision)
IS 335 : 2018	:	New insulating oils - Specification (Fifth Revision)
IS 3637 : 1966 Reaffirmed In : 2016	:	Specification for gas - Operated relays

IS 3638 : 1966 Reaffirmed In : 2016	:	Application guide for gas - Operated relays
IS 2165 (Part 1) : 1977 Reaffirmed In : 2016	:	Insulation co - Ordination: Part 1 phase to earth insulation co - Ordination, principles and rules (Second Revision)
IS 2071 (Part 1) : 2016 IEC 60060-1 : 2010	:	<u>High - Voltage test techniques: Part 1 general definitions and test requirements (Third Revision)</u>
IS 2705 (Part 1): 1992 Reaffirmed In : 2017	:	Current transformers - Specification: Part 1 general requirements (Second Revision)
IS 1248	:	Direct acting indicating analogue electrical measuring instruments.
IS : 3043	:	Code of practice for earthing.
IS 7404 (Part 1) : 1991 Reaffirmed In : 2015	:	Paper covered copper conductors - Specification: Part 1 round conductors (First Revision)
IS 1271 : 2012 / IEC 60085 : 2007 Reaffirmed In : 2017	:	Electrical insulation - Thermal evaluation and designation (Second Revision)
IS 1554 (Part 1) : 1988 Reaffirmed In : 2020	:	PVC insulated (heavy duty) electric cables – 1100V.
IS 6272: 1987 Reaffirmed In : 2014	:	Industrial cooling fans
IS 104 : 2017	:	Specification for ready mixed paint, brushing, zinc chrome, priming (Third Revision)
IS 2932 : 2013 Reaffirmed In : 2018	:	Enamel, synthetic, exterior: (a) Undercoating (b) Finishing - Specification (Fourth Revision)- Final paints for steel surfaces.
IS 5: 2007 Reaffirmed In : 2017	:	Colours for ready mixed paints and enamels (Sixth Revision)
CBIP	:	Specification for power and distribution transformer (Section D) (Pub no.97)
IEC 60137:2017 RLV Redline version	:	Insulated bushings for alternating voltages above 1000 V

IEC 60947-1:2020	Low-voltage switchgear and controlgear - Part 1: General rules
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27.3 Design Features

The design of the transformers and accessories shall be in accordance with the latest standard practice and shall be such as to facilitate inspection, cleaning, repairs, maintenance and operation and shall ensure safety operations under situation of sudden variations of loads and voltages as may be required under local operating conditions.

Electrical Features

The electrical features shall ensure the following:

- a) Continuous operation at rated kVA provided service conditions do not exceed the values already given.
- b) Continuous operation at rated kVA within ± 10 percent variation (combined) of voltage and frequency.
- c) Continuous operation at rated kVA at each of the tap voltages
- d) Over loading of units as indicated in IS 2026 (Part 7): 2009/ IEC 60076-7 : 2005
Reaffirmed In : 2019.
- e) Temperature rise limited to the following values:

Cooling	Oil	Winding
ONAN	45 ⁰ C	55 ⁰ C
ONAF	45 ⁰ C	55 ⁰ C (For 12500 kVA only)

- f) The insulation levels shall be uniform and conform to the following values:

Nominal system	Highest system	Rated lightning impulse withstand voltage.	Power frequency voltage 1 minute
kV rms	kV rms	kV peak	kV rms
132	145	650	245
33	36	170	70

Mechanical Features

- a) The transformer shall be able to withstand the electro-dynamic stress due to terminal short circuit of the LV side assuming the HV side fed from an infinite bus. All leads, windings in cores shall be properly supported, clamped and tightened after vacuum drying to ensure the short circuit

withstand ratings. The short circuit withstand duration shall be minimum of 2 sec.

- b) The transformer shall be so designed as to minimize any undue noise and vibration.

27.4 Constructional Details

27.4.1 Core

- a) The transformer core shall be made as per relevant IS. Lifting eyes and lugs shall be provided on the limbs and coils assembly. Preferably no bolt shall be used in the cores. Clamping shall be done externally to the limb.
- b) Cores and windings shall be capable of withstanding shocks during transport, installation & service and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

27.4.2 Tanks

- a) Tanks shall be of welded construction and fabricated from boiler steel plates of adequate thickness.
- b) Tanks stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.
- c) The tanks shall be designed to withstand:
 - i) Mechanical shocks during transportation
 - ii) Vacuum filling of oil
 - iii) Short circuit force
- d) Suitable guides shall be provided in the tank for positioning the core and coil assembly.
- e) The tank shall be suitable for movement in both directions during shipment. Each tank shall be provided with
 - i) Lifting lugs suitable for lifting the complete transformer
 - ii) A minimum of four jacking pads to be raised or lowered using hydraulic or screw jacks.

27.4.3 Tank Cover

- a) At least two adequately sized inspection covers one at each end of the tank shall be provided for easy access to bushings and earth connection. The inspection covers shall have suitable lifting arrangement.
- b) The tank covers shall be fitted with thermometer pockets (in the position of maximum oil temperature) for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank.

- c) Bushings, inspection covers, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.
- d) All bolted connections shall be fitted with weather proof hot oil resistant neoprene gasket in between for complete oil tightness. If gasket is compressible metallic stop shall be provided to prevent over compression.

27.4.4 Mounting Arrangement

- a) The transformers shall be provided with two nos. bi-directional skids and pulling eyes integral with the tank body for fixing the transformer tank on base frame.
- b) These skids shall be such that the bottom of the tank is at a sufficient height above base frame for cleaning purposes. The transformer shall be provided with uni/bi-directional, flat/flanged rollers of suitable size.

27.4.5 Conservator Tank

- a) The conservator tank shall have adequate capacity to accommodate oil preservation system and volumetric expansion of the total cold oil volume in the transformer and radiators for a change in temperature from minimum ambient air temperature of 5⁰C to 50⁰C.
- b) The conservator shall be bolted into position so that it can be removed for cleaning purposes.
- c) The conservator tank shall be fitted with a silica-gel filter breather.
- d) The conservator shall be fitted with magnetic oil level gauge with two independent low level electrically insulated alarm and trip contacts. The oil level at 30⁰C shall be marked on the gauge.

27.4.6 Pressure Relief Device

- a) The transformers shall be provided with the single diaphragm type of explosion vent and a pressure relief device of spring loaded type.
- b) An equalizer pipe shall be connected to explosion vent from the conservator.
- c) The pressure relief device shall be of sufficient size for rapid release of any pressure that may be generated in the tank. The device shall operate at a static pressure less than the hydraulic test pressure of transformer tank. Means shall be provided to prevent ingress of rain water. An extension pipe fitted above the device shall direct the major flow of ejected oil downwards and permit its removal without disturbing the device.

BUCHHOLZ RELAY

A double float type Buchholz relay conforming to IS: 3637 shall be provided. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for

checking its operation. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the transformer in service. The device shall be provided with two potential free contacts, one for alarms on gas accumulation and the other for tripping on rise of pressure.

27.4.7 Temperature Indicator

a) Oil Temperature indicator (OTI)

The transformer shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, potential free alarm and trip contacts, maximum reading pointer and resetting device and shall be mounted in the marshalling box. A temperature sensing element suitably located in a pocket in the top oil shall be furnished. This shall be connected to the OTI by means of capacity tubing. Accuracy class of OTI shall be 2°C or better. The OTI shall have full scale deflection of at least 240°C and shall have linear graduation to read every 2°C.

b) Winding Temperature Indicator (WTI)

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 2^\circ\text{C}$ or better. It shall comprise the following:

- i) Temperature sensing element
- ii) Image coil and bushing current transformer
- iii) Auxiliary CTs if required to match the image coil, shall be furnished and mounted in the marshalling box.
- iv) 150 mm local indicating instrument with max. reading pointer mounted in marshalling box. It shall have two adjustable potential free contacts, one for winding temp. high alarm and one for trip, in addition to the contacts required for control of cooling equipment.
- v) Automatic ambient temperature. Compensation
- vi) All contacts shall be adjustable on a scale and suitable for connection in 240V circuit. These shall be accessible on removal of the cover.
- iv) The WTI shall have a full scale deflection of at least 240°C and shall have linear graduations to read every 2°C.

27.4.8 Winding

- a) The conductors shall be of electrolytic grade copper.
- b) All windings shall be fully insulated.
- c) The insulation of transformer windings and connections shall be as per relevant IS.
- d) The maximum fault level to which the transformers may be subjected is 750 MVA.

- e) All bus bars and leads shall be adequately supported in insulated cleats or frames from the clamping structure.
- f) The studs, set screws or bolts provided for securing cleats or frames shall be effectively locked.
- g) Bus bars and leads shall be supported throughout their length to ensure they will not move under normal service or transport or be forced from the prescribed position during any short circuit.

27.4.9 Insulation Materials

- a) Class 'A' insulating materials specified in IS: 1271 or latest version shall be used.
- b) **Insulating Oil**
 - i) The insulating oil supplied with the transformer shall conform to the requirements of IS: 335. No inhibitors shall be used in the oil.
 - ii) Prior to filling the oil in the main tank suitable number of samples shall be tested for BDV, moisture content, resistivity at 90⁰ C, tan delta at 90⁰ C and interfacial tension. The oil samples taken from the transformer at site shall conform to the requirements of IS: 1866.
 - iii) The manufacturer shall despatch the transformer without / with filling of oil to take care of the weight limitation on transport and handling facility at site. Ten percent (10%) extra oil shall be supplied for topping up, in non returnable sealed containers suitable for outdoor storage.

27.4.10 Earthing terminal

Two earthing terminals suitable for connecting 50 x 8 mm mild steel flat shall be provided at positions close to the two diagonally opposite bottom corners of tank. These grounding terminals shall be suitable for bolted connection. Two earthing terminals shall also be provided on marshalling box and any other equipment mounted separately.

27.4.11 Oil Preservation System

- a) The transformers shall be provided with conservator preservation system. The top of the conservator shall be fitted with a silica gel filter breather. It shall be so designed that:
 - i) Passage of air is through dust filter and silica gel
 - ii) Silica gel is isolated from atmosphere by an oil seal
 - iii) Moisture absorption indicated by a change in colour of the tinted crystal can easily be observed from a distance
 - iv) Breather shall be mounted not less than 1400 mm above rail top level.
- b) The Transformers shall be provided with diaphragm sealing type oil preservation system. The rubber diaphragm shall be suitably sized to

accommodate total change in the oil volume from minimum ambient temperature (5⁰C) to 110⁰ C. The diaphragm shall withstand full vacuum intake.

27.4.12 Terminal arrangement

a) Porcelain Bushing

- i) The minimum clearances in air between the phases and between the phase and earth potential of the porcelain bushings shall be in accordance with IS 2026 (Part 5): 2011 Reaffirmed In : 2016.
- ii) Bushing terminals shall be provided with suitable terminal connectors of approved type and size for ACSR/aluminum tubular conductors as specified in the annexure.
- iii) All transformer bushings shall be of solid porcelain with rain sheds conforming to IS:8603.
- iv) The removal of bushing shall be possible without disturbing the current transformers, secondary terminals and connectors or pipe work.

b) Cable Boxes and Disconnecting Chambers

- i) Wherever cable connections are specified, suitable air insulated type cable boxes of sufficient sizes shall be provided to accommodate cable termination. Cable boxes shall be designed and installed such that it shall be possible to move away the transformer without disturbing the cable termination leaving the cable box on external supports. The support for the cable box shall be of galvanized iron.
- ii) Cable boxes shall have terminal connectors of adequate size and bolt holes to receive cable lugs.
- iii) The bidder shall provide earthing terminals on the cable box to suit 50 x 8 mm GI flat.
- iv) All necessary cable terminating accessories such as supporting brackets, power cable lugs, hard ware etc. shall be provided by the bidder.
- v) Cable boxes shall have removable top cover and ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.
- vi) Cable boxes shall have degree of protection of IP-52.

27.4.13 Current transformers

- a) Bushing CTs shall be provided. It shall be possible to remove the turret mounted CTs from the transformer tank without removing the tank cover.
- b) The current transformers shall comply with IS: 2705. Protective class of CT with accuracy not less than 5% shall be provided for restricted earth fault protection.

- c) All secondary leads of bushings mounted CTs shall be brought to a terminal box near each bushing and then wired up to transformer marshalling box. The CT terminals shall have shorting facility.

27.4.14 Terminal marking

The terminal marking and their physical position shall be in accordance with IS: 2026.

27.4.15 Termination Arrangement for Neutrals

- a) The transformer shall be restricted earthed at the secondary neutral.
- b) The neutral terminal brought on to a separate neutral bushing shall be connected to associated neutral grounding pit by a neutral grounding resistor, which shall be supplied and installed by the bidder.

27.4.16 ON load tap change switch (OLTC)

- i) The transformer shall be provided with an on-load tap changer having a range of $\pm 10\%$ with 16 steps of 1.25% each. The tap changer shall be effectively designed for remote electrical, local electrical and local manual operation.
- ii) The tap changer shall include the following:-
- a) Oil immersed tap selector and arcing switch provided with resistor.
 - b) Motor operated mechanism.
 - c) Control and protection device.
 - d) Local normal operating device.
 - e) Local tap changer position indicator.
- iii) The tap changer shall be designed such that the contacts do not interrupt arcs within the main tank of the transformer. The oil filled compartment of tap selector switch shall be provided with means of releasing the gas produced due to arcing. It shall be designed so as to prevent the oil of tap selector compartment from mixing with the oil of the transformer compartment from mixing with the oil of the transformer tank. Operating mechanism of OLTC shall be designed such that only one step is actuated by each command and subsequent step is actuated by new or repeat command.
- iv) The transformer shall give full load output at all taps. The tap changer shall be provided with out of step protection.
- v) The following accessories shall be provided with tap changer:
- a. Raise and lower push button (remote).
 - b. Tap position indicator (remote)
 - c. Indication lamp showing tap changing is in progress.
 - d. Motor starter contactor with O/L and single phasing protection.

- e. Contactor for forward and reverse.
- f. Raise/lower operation on local electrical control.
- g. Raise//lower limit switches.
- h. Anti-condensation heater with switch.
- i. Provision and accessories for local manual operation.
- j. Interlock between manual and electrical operation.
- k. Tap position indicator.
- l. Operation counter.

27.4.17 Radiator

The radiators shall be detachable type, mounted on the tank. Each radiator shall be provided with the following:

- a) A drain valve at the bottom
- b) An air release plug at the top
- c) Shut off valve at each point of connection to the tank. The location and configuration of radiators shall be subject to purchaser's approval.

27.4.18 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be provided with each transformer to accommodate:
 - i) Temperature indicators
 - ii) Terminal blocks for incoming and outgoing cables
- b) The sheet steel used shall be at least 2.0 mm thick. The box shall be free standing floor mounted type and have a sloping roof. The degree of protection shall be IP 53
- c) The temperature indicators shall be so mounted that the dials are not more than 1600 mm from ground level.
- d) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicator readings.
- e) All cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and the associated compartment shall be sealed in suitable manner to prevent the ingress of moisture, rodents, insects etc. from the cable trench. Gland plates, cable lugs, cable glands, etc. shall be provided and installed by the bidder.
- f) The marshalling box shall be supplied with space heater and cubicle lighting with ON-OFF switches and associated fuses.
- g) It shall be located in such a way that, the front shall not face the transformer. It shall be mounted at least 500 mm above the ground level.
- h) The gland plate shall be made into two detachable halves, for facilitating termination of incoming and outgoing cables separately.

27.4.19 Painting

The internal and external surfaces including oil filled chambers and structural work shall be painted with oil and weather resistant non fading paint of light grey color corresponding to shade no. 631 of IS : 5. Primary paint shall be as per IS : 104 and intermediate and final coats of paint shall be as per IS : 2932.

27.4.20 Bolts and nuts

All bolts and nuts exposed to weather shall be of hot dip galvanized or cadmium plate or zinc passivated steel. All bolts, nuts and washers in contact with nonferrous part which carry current shall be of phosphor bronze.

27.4.21 Control wiring

- a) All controls, alarms, indicating and relaying devices provided with the transformer shall be wired by the bidder up to the terminal blocks inside the marshalling box. The bidder shall supply and install the required 1100 V grade heavy duty PVC insulated, steel wire armoured, PVC sheathed, multi core cables with copper conductors of the least 2.5 mm^2 conforming to IS : 1554. The cables shall be properly supported.
- b) All devices and terminal blocks within the marshalling box shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagrams.
- c) Not more than two (2) wires shall be connected to one terminal. At least 20% spare terminals shall be provided. Each terminal shall be suitable for connecting two numbers 2.5 mm^2 stranded copper conductor from each side.
- d) Terminal blocks for CT secondary shall have shorting facility.

27.4.22 Nitrogen injection fire prevention system (NIFPS)

Nitrogen injection fire prevention system (NIFPS) shall be an integrated safety system designed for oil filled transformers in order to prevent tank explosion and the fire during internal faults and also extinguish the external oil fires on transformer top cover due to tank explosion and /or external failures like bushing fires, OLTC fires.

The system shall drain a pre- determined quantity of oil from the tank top through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and reduce the temperature of top oil surface below flash point to extinguish the fire. Conservator tank oil shall also be isolated during bushing bursting, tank explosion and oil fire to prevent aggravation of fire.

The system shall have to be designed to operate automatically with manual override. It shall be designed with dedicated backup power supply so as to respond incase of power supply failure.

27.4.23 Fittings

The following fittings shall be provided with all the transformers:

- a) Rating and diagram plate.
- b) Terminal marking plate
- c) Two earthing terminals
- d) Lifting lugs
- e) Jacking lugs
- f) Drain valve with plug 50mm.
- g) Dehydrating breather
- h) Buchholtz relay with alarm and trip contacts with one shut off valve on conservator side - 50 mm.
- i) Plain oil level indicator with minimum marking.
- j) Magnetic oil level indicator with two electrical contacts, one for alarm and other for tripping.
- k) Thermometer pocket
- l) Marshalling box
- m) Off load tap changing switch
- n) Oil filling hole with cover
- o) Conservator
- p) Air release device and explosion vent.
- q) Oil temperature indicator with one electrical contact for alarm.
- r) Winding temperature indicator with one electrical contact for trip and additional contact for switching on cooler fans.
- s) Skids and pulling eyes on both sides
- t) Rollers -Flanged bi-directional 1435 mm.
- u) Bushings with metal parts and gaskets
- v) Filter valve at the top of the transformer tank
- w) Inspection cover

27.5 Performance

a) Operating Conditions

- i) The transformers shall be capable of being loaded in accordance with IS :2026 up-to load of 150%. There shall be no limitation imposed by bushings, tap changer etc.
- ii) The transformers shall be capable of being operated continuously without danger on any tapping at the rated KVA with voltage variation of $\pm 10\%$ corresponding to the voltage of the tapping.

b) Fault Conditions

- i) The transformer and all accessories including CTs shall be capable for

withstanding any external short circuit at bushing terminal without damage for two (2) seconds.

- ii) Transformers shall accept, without injurious heating, combined voltage and frequency fluctuations which produce on over condition of 120% for one (1) minute. Bidder shall indicate 150% over voltage.
- iii) Noise level when energised at normal voltage and frequency with all auxiliary equipment running shall not exceed, when measured under standard conditions, the value specified in NEMA standard publication TR-1.

c) Impedance

The impedance on principal tapping shall be guaranteed to be as indicated in Annexure - VI.

d) Losses

Transformer losses shall be as per CBIP (Central Board of Irrigation and Power) Manual Pub-295 and IEEMA standards. The tolerance of losses of each transformer shall be in accordance with IS 2026.

27.6 Soak Pit and Burnt Oil Pit :

Soak pit and Burnt oil pit for drainage of transformer oil in case of fire is required as per IS/CBIP. Accordingly in addition to conventional drainage valve a solenoid valve shall be provided.

ANNEXURE - VI

Particulars of Technical Specifications

1	Rated Capacity	:	40000 kVA (ONAN)
2	Type of transformer	:	Core type oil immersed
3	Frequency	:	50 Hz \pm 3%
4	No. of phases	:	3
5	Location	:	Outdoor
6	Type of cooling	:	ONAN
7	Type of oil	:	Mineral oil
8	Rated capacity at the main tappings	:	Rated kVA as at sl.no.1
9	Rated Voltage	:	
	HV Winding	:	132000 Volts \pm 10%
	LV Winding	:	33000 Volts \pm 10%
10	Highest system voltage		
	HV Winding	:	145000 Volts
	LV Winding	:	36000 Volts
11	Impedance voltage at rated current		As per Standard
12	Method of system earthing :		

	HV Winding	:	Nil
	LV Winding	:	Star – (Solid)
13	Rated Insulation level:		
	One minute power frequency withstand voltage	:	245 kV rms for 132 kV and 70 kV rms for 33 kV side
	Switching impulse withstand test voltage with standard full wave for windings for 1/50 microsecond.	:	650 kV rms for 132 kV and 170 kV rms for 33 kV side
	Lightning withstand voltage for winding for 1.2/50 microsecond	:	650 kV rms for 132 kV and 170 kV rms for 33 kV side
14	Connection symbol		DY11
15	Earthing of neutral terminals		Required for LV windings
16	Tap changer type		OLTC (On HV side)
17	Tapping voltage percentages (On HV side)		$\pm 10\%$ with 16 steps of 1.25% each
18	Terminal Arrangement:		
	HV side	:	Weather proof porcelain bushings
	LV side	:	Weather proof porcelain bushings
19	a) Temperature rise (over Ambient) in Oil	:	50 ^o C
	b) Temperature rise (over Ambient) in Winding	:	55 ^o C
20	Type of Winding	:	Double wound copper
21	Details of Auxiliary supply voltage for		
	a) Alarms / Relays	:	240V AC
22	Standard applicable for transformer	:	IS : 2026
23	Standard applicable for oil used	:	IS : 335

28.0 Specification for 30 KV Surge Type Lightning Arrestors

28.1 Scope

This specification covers requirements for 30 kV Surge type Lightning Arrestors at site and suitable for outdoor application.

The 30 kV Surge type Lightning Arrestors shall comply with the latest revision of IS 15086 (Part 4): 2017 /IEC 60099 Part-4 except where modified or extended by the provision of this specification and with the relevant parts of standards mentioned in clause 2.4.3.1.2.

Any material and component not specifically stated in this specification but necessary for trouble free operation of the equipment and accessories specified herein shall deemed to be included.

28.2 Other Relevant Standards

The other relevant Indian standards are as under:

IS 15086 (Part 4): 2017 /IEC60099 Part-4	:	Metal Oxide Surge type lightning Arrestors without gaps for AC Systems
IEC 60099 Part-5, 2018		Selection and application recommendations
IS: 15086 Part-5,2020		Application guide for nonlinear resistor type surge arrestors.
IEC 60270	:	Partial Discharge Measurement.
IS 2071 (Part 1) : 2016/ IEC 60060-1 : 2010	:	Methods of HV Testing
IS 5350 (Part 1): 1970 Reaffirmed In: 2019	:	Dimensions for outdoor porcelain post insulators.

28.3 Design Criteria

The 30 kV Surge type Lightning Arrestors shall be suitable for 33000V ($\pm 10\%$), 3-phase, 50 Hz ($\pm 3\%$) power supply. The nominal discharge current carrying capacity has been specified in **Annexure-VII** at the rated voltage and frequency.

28.4 Constructional Features

These surge arrestors shall be of Heavy Duty, Station Class and Gapless metal oxide (Zinc Oxide) type.

The arrestors shall be composed of units of non-linear resistors made of Zinc oxide.

The Arrestors supplied shall be suitable for heavily polluted atmosphere.

A leakage current monitor with surge counter shall be provided with each surge arrester.

28.5 Performance

Electrical Features

The lightning arrester shall ensure:

- a) Continuous operation at rated voltage (30 kV & 50 Hz) while carrying out effectively and without damage the automatic extinction of the follow up current.
- b) Continuous operation within variation for voltage between $\pm 10\%$, and frequency variation between $\pm 3\%$ and combined voltage and frequency variation of 10%.
- c) The arrestors shall divert any switching surge in excess of basic insulation level at the relevant nominal system voltage and cut off follow-up current of power frequency.

ANNEXURE -VII

Technical Parameters for 30 KV Surge Type Lightning Arrestors

1.	Nominal system voltage	:	33 kV
2.	Highest system voltage	:	36 kV
3.	Rated Voltage	:	30 kV
4.	Nominal discharge current	:	10 kA
5.	System	:	3 Phase, 50 C/S, Neutral restricted earthed
6.	Type	:	Gapless.
7.	Location	:	Outdoor as per the drawing
8.	Mounting	:	Bracket mounted on structure
9.	Other requirements	:	i) Grounding terminal ii) Post insulator conforming to IS 5350: Part 3 : 1971 (Reaffirmed Year : 2019)
10.	Line terminals	:	Each terminal should be suitable to accept ACSR/Al tubular bus and it should be suitable both for vertical takeoff.
11.	Standards to conform	:	IS 15086 (Part 4): 2017 /IEC 60099 Part-4

29.0 Specification for 33 KV Off Load Isolator and Earthing Switch

29.1 Scope

This specification covers requirements for 33 kV, Off Load Isolator and Earthing Switch suitable for outdoor application.

The 33 kV, Off Load Isolator and earthing switch shall comply with the latest revision of IS: 9921 except where modified or extended by the provision of this specification and with the relevant parts of standards mentioned in clause 2.4.3.2.2.

Any material and component not specifically stated in this specification but necessary for trouble free operation of the equipment and accessories specified herein shall be deemed to be included.

29.2 Other Relevant Standards

The other relevant Indian standards are as under:

IS/IEC 62271-102:2003 Reaffirmed In: 2018	:	High-Voltage Switchgear and Control gear Part 102 Alternating Current Disconnectors And Earthing Switches
IS 9921: Part 1: 1981 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 V - Part I : General and Definitions
IS 9921: Part 2 1982 (Reaffirmed Year: 2012)		Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 V: Part 2 Rating
IS 9921: Part 3: 1982 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1000 V - Part III: Design and Construction
IS 9921: Part 4: 1985 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (isolators) and Earthing Switches for Voltages Above 1000 V - Part 4: Type Tests and Routine Tests
IS 9921: Part 5: 1985 (Reaffirmed Year: 2012)		Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 v - Part 5: Information to be Given with Tenders, Enquiries and Orders
IS 3043: 2018	:	Code of practices for earthing.

IS 11353: 1985 (Reaffirmed Year: 2017)		Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS 5350: Part 3: 1971 (Reaffirmed Year: 2019)		Dimensions of Indoor and Outdoor Porcelain Post Insulators and Post Insulator Units for Systems with Nominal Voltages Greater Than 1000 V - Part III: Outdoor Pedestal Post Insulators
IS/IEC 60168: 2000	:	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass for Systems with Nominal Voltages Greater than 1 000 V
IS 13134: 1992 Reaffirmed In: 2018	:	Guide for selection of Insulators in respect of pollution conditions.
IS:2486	:	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 volts.
IS/IEC 60137: 2017	:	Insulated Bushings for Alternating Voltages above 1000 V
IEC 61109:2008	:	Insulators for overhead lines - Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V - Definitions, test methods and acceptance criteria

29.3 System Details

The rotating units shall be supported by thrust/taper roller bearings. All moving parts shall be fitted with non-ferrous bushes. The operating mechanism shall comprise of suitable bars and GI pipes of adequate length brought down a pole to a handle provided with galvanized guides. The same shall have arrangement for padlocking as OFF and ON position of the switch.

29.4 Design Features

The design of isolators shall be in accordance with the latest practice. However following points shall be taken into consideration.

Electrical Features

- a) The 33 kV, Off Load Isolator and Earthing Switch shall be suitable for

33000V, 3-phase, 50 Hz power supply.

- b) The isolator shall be designed for an operating temperature of 70⁰C.
- c) All similar components shall be interchangeable and shall be of same type and rating for easy maintenance and low spare inventory.
- d) Continuous operation at rated current at specified ambient conditions.
- e) Continuous operation within variation for voltage between $\pm 10\%$ and frequency variation between $\pm 3\%$ and combined voltage and frequency variation of 10%.
- f) The rated current carrying capacity, breaking and making capacity of the Isolator has been specified in **Annexure-II**
- g) The isolator, when earthing switches are used, shall have arrangement for fixing the same. The earthing switch shall have independent manual drive with mechanical interlock to prevent mal-operation.

Interlock

Interlocking arrangement shall be provided with the control of circuit breaker to prevent on load operation of the isolator. In this, necessary numbers of auxiliary contacts shall be provided on the isolator.

Mechanical Features

The isolator should be fitted with Arching horns to interrupt light load and magnetizing current on transformer.

The Isolator shall be designed to withstand severe weather conditions and should be capable of withstanding electro-dynamic stresses due to short circuit.

The incoming and outgoing terminals connections should be suitable for Al Tubular Bus.

29.5 Constructional Features

Switch Blades

The blade shall be made of hard drawn electrolytic copper strips liberal section to give extra strength and thermal capacity. All copper parts should be silver plated and ferrous parts metallized to give smooth finish.

Main Bearing

The main bearing ball thrust or taper roller bearing supporting the main rotating insulator operating shaft shall be adjustable in the field if necessary. The insulator shall be bolted to the top of the sheet steel base of fabricated construction. All working parts shall be made of non-rusting steel or specially treated to resist corrosion and the hole shall be brass bushed.

29.6 Fittings and Spares

All standard fittings shall be provided

ANNEXURE -VIII**Technical Parameters for 33 KV, Off Load Isolator
With Earthing Switch**

1.	Nominal system voltage	:	33 kV
2.	Highest system voltage	:	36 kV
3.	Rated Current	:	As per requirement
4.	Rated Voltage & Frequency	:	33 kV, 50 Hz
5.	No. of Phases	:	3
6.	Rated short time current	:	25 kA (rms) for 1 seconds
7.	Rated Current of earthing switch	:	As per requirement
8.	Rated Insulation Level		
8.1	One minute power frequency withstand voltage	:	70 kV rms
8.2	Lightning impulse withstand voltage	:	170 kV peak
9.	Type of interlock between Isolating and earthing switch	:	Integral Mechanical
10.	Operating mechanism	:	Manual, off load, air break gang operated outdoor with or without earth switch
11.	Mounting	:	Structure mounted
12.	Type	:	Horizontal mounted centre, post rotating, manually operated, double break with centre post rotating type with or without earth switch
13.	No. of phases per set	:	Three
14.	Contacts	:	Contact shall be designed to withstand rated current without over-heating. The switch shall have self-aligning hard drawn electrolytic copper contact.
15.	Reference standard	:	IS:9921
16.	Application	:	Outdoor
17.	Earthing switch	:	Shall be provided
18.	Supporting insulator	:	The supporting insulator shall be 3 nos. of post type brown glazed porcelain insulator per phase and tested in accordance with IS/IEC 60168 : 2000
	Accessories	:	Base channel of hot dipped galvanized iron

19.		:	Operating down rod with complete mechanism
		:	Operating handle, mounting base, pad lock system
		:	Square rod of phase gang operation
		:	Post insulators conforming to IS 5350 : Part 3 : 1971 (Reaffirmed Year : 2019)
		:	Earth Switch

30.0 33 KV Outdoor Structure Mounted Vacuum Circuit Breaker with Indoor Remote-Control Panel

30.1 Scope

This specification covers requirements for 33000V Vacuum Circuit Breaker suitable for use in outdoor switchyard with indoor control panel.

The circuit breaker shall comply with the latest revision of **IEC 62271-100:2021** except where modified or extended by the provision of this specification and with the relevant parts of standards mentioned in clause **2.4.3.9.2**.

Any material and component not specifically stated in this specification but necessary for trouble free operation of the equipment and accessories specified herein shall be deemed to be included.

30.2 Other Relevant Standards

The other relevant Indian standards are as under:

IEC 62271-100:2021	:	<u>High-voltage switchgear and control gear - Part 100: Alternating-current circuit-breakers</u>
IEC 60273:1990	:	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 5561: 2018	:	Specification for electric power connectors
IS 2629: 1985 Reaffirmed In: 2016	:	Recommended practice for hot- dip galvanizing and steel
IS 2633: 1986 Reaffirmed In: 2016	:	Method for testing uniformity of coating on zinc coated articles
IS 9135: 1979 Reaffirmed In: 2017	:	Guide for testing of circuit breakers with respect to out-of- phase switching
IS 3043: 2018	:	Code of practices for earthing.
IS 11353: 1985 (Reaffirmed Year: 2017)/ IS 5578 : 1984 Reaffirmed In : 2016	:	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals

IEC 60947-5-1:2016	:	<u>Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices</u>
IS 8603 : 2008 Reaffirmed In : 2019	:	Dimensions for porcelain transformer bushings for use in heavily polluted atmospheres 12/17.5 kV, 24 kV and 36 kV (First Revision)
IS 2705 (Part 1): 1992 Reaffirmed In : 2017	:	Current transformers - Specification: Part 1 general requirements (Second Revision)
IS: 10118	:	Code of practice for selection, installation and maintenance of Switchgear and Control gear.
IS: 4794	:	Push Button Switches
IS 12021: 2015	:	Specification of Control transformers for switchgear and control gear for voltages not exceeding 1000 V A.C.
IS/IEC 60137: 2017	:	Insulated Bushings for Alternating Voltages above 1 000 V
IEC 60168:1994, AMD2:2000	:	<u>Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V</u>
IEC 60529:1989, AMD 2000	:	<u>Degrees of protection provided by enclosures (IP Code)</u>
IEC 60270	:	<u>Partial Discharge Measurement</u>
IEC 60060	:	<u>High Voltage Test Technique</u>

30.3 Design Criteria

The Circuit Breaker shall be suitable for a power supply of 33000V ($\pm 10\%$), 3-phase, 50 Hz ($\pm 3\%$) with a combined variation of voltage & frequency up to $\pm 10\%$.

All similar components shall be interchangeable and shall be of same type and rating for easy maintenance and low spare inventory.

The current carrying capacity shall be continuous and the breaking and making capacity of the circuit breaker shall be as specified in **Annexure-III**

30.4 Construction

The unit shall consist of outdoor circuit breaker with interrupter units and operating mechanism box and indoor control panel for remote operation.

Interrupter Unit with Operating Mechanism Box

- i. The interrupter units together with the HV connections shall be enclosed in a sealed housing (preferably of porcelain) conforming to IP-65 protection **IEC 62271-100:2021**. Three such assemblies suitably separated for adequate phase clearances shall be mounted on a base-frame with a common operating shaft. This assembly along with the operating mechanism is intended to locate line terminals at a safe height above the ground.
- ii. All the control actuating devices shall be installed in the operating mechanism box.
- iii. The breaker shall be provided with alarm and lockout for low gas pressure.
- iv. The interrupter contacts shall be silver plated copper or copper chromium.
- v. ON/OFF push buttons shall be provided in the operating mechanism.
- vi. The breaker shall be equipped with motorised spring charge and closing mechanism along-with manual charging facility. The motor provided in the mechanism box shall be 230 V AC. The closing shall be electrical as well as manual.

Operation of the breaker from control panel

- i. The breaker shall be electrically operated from a remote control panel.
- ii. The necessary circuitry for ON/OFF/TRIP indication, spring charged or free indication and operation counter shall be provided in the control panel.
- iii. Terminal blocks for control cables shall also be provided in the control panel for interfacing with interlocks, if any.

Tripping Mechanism

- i. Breakers shall be provided with C.T. operated I.D.M.T. and instantaneous relay.
- ii. The tripping mechanism shall be trip free. The trip circuit shall be operated by 110 V D.C. control power.

Duty Cycle

The duty cycle is O - .3 sec - CO - 3 min - CO.

30.5 Performance

The design of the circuit breaker and accessories shall be in accordance with the latest standard practice and shall be such as to facilitate inspection, cleaning, repairs and maintenance and shall ensure safety operations under situation of sudden variations of loads and voltages.

Electrical Features

The breaker shall ensure

- a) Continuous current carrying capacity at specified ambient conditions.
- b) Operation within variation of voltage and frequency as mentioned earlier.
- c) The insulation levels conforming to the values given in relevant code.

Mechanical Features

The breaker shall be able to withstand the thermal and electromagnetic stress arising out of fault level of 25 kA (rms) for 1 second.

30.6 Protections and Interlocks

- i. All circuit breakers shall have programmable numeric type relays having suitable range. The following protections shall be provided for circuit breakers controlling different type of feeders.

Sl. No.	Type of Feeder	Protection to be provided
1	Incomer	Overload, short circuit and earth fault & CBCT operated earth leakage relay.
2	Transformer control	Overload, short circuit and earth fault and auxiliary relays for Buchholz, Differential protection, Oil and Winding temperature protections.
3	Bus coupler	Directional protection.
4	Outgoing	Overload, short circuit and earth fault.

- ii. Sufficient number of NO + NC auxiliary contacts shall be provided for the protections and interlock.
- iii. Necessary mechanical and electrical interlocking shall be provided among associated breakers and isolators for safe operation of the system.
- iv. While the breaker is in Off position, there shall be provision for earthing the current carrying parts of the Circuit breaker along with interlock arrangement for preventing accidental switching-on of the breaker.

30.7 Remote Control Panel

- i. The panel shall conform to relevant code.

- ii. The panel shall be indoor type having cubicle construction with relays, indication, mimic and metering facilities. The unit shall be fabricated with steel of minimum thickness of 2 mm for load bearing sections and 1.6 mm for non-load bearing sections respectively. The unit shall be located indoor with control wiring termination for remote control of the breaker from the indoor sub-station.
- iii. The control panel shall be freestanding type with bottom cable entry. The enclosure shall be dust and vermin proof with no access to ingress of moisture with IP 52 protection and two coats of primer and final paints, danger notice, body earthing and locks.
- iv. The panel shall be suitable for ready installation on embedded MS channels flushed with the floor or for direct installation on a leveled floor through grouting holes.
- v. All protective relays provided for the circuit breaker shall be housed in the indoor control panel.
- vi. For remote control the following features shall be provided:
 - a) 2-Way remote selector switch having three positions - Local / Neutral / Remote
 - b) 2-Way breaker control switch having three positions - On/Neutral/Off.
- vii. Indications shall be as under:
 - a) ON/OFF/TRIP with reset button.
 - b) Spring charged or free
 - c) Interlock operated
- viii. Mimic displays shall be provided on the panel as under:
 - a) Trip on overload
 - b) Trip on earth fault
 - c) Trip on short circuit
- ix. Digital microprocessor based power meter with adequate memory shall be provided for measurement, monitoring and management of different electrical parameters as follows.
 - j) Voltage.
 - k) Line current
 - l) Active power
 - m) Reactive Power
 - n) Apparent Power
 - o) Power factor
 - p) Frequency
 - q) Total Energy
 - r) kW & kVA demand

- x. Installation of outdoor Circuit Breaker unit, indoor control panel and interfacing between control panel and outdoor Circuit Breaker unit shall be in the scope of the bidder.
- xi. Proposed PT connected with bus bar in the substation shall be used for the purpose of metering and protection.

30.8 Name Plate

The name plates of the circuit breaker and its operating device shall have suitable marking as under:

Manufacturer

Type designation and serial number

Rated voltage

Rated frequency

Rated normal current

Short circuit withstand capacity

Rated short circuit breaking current

Rated making current.

Rated supply voltage of closing and opening devices

Operating duty

Supply voltage of indication and mimic.

Weights

Rated operating sequence

Year of manufacture

ANNEXURE -IX

TECHNICAL PARTICULAR OF 33000 V VACUUM CIRCUIT BREAKER

1.	Installation	:	Outdoor Structure mounted
2.	Number of Poles	:	3
3.	Rated Voltage	:	33000 V ($\pm 10\%$)
4.	Rated current (A)	:	As per requirement
5.	Frequency	:	50 Hz
6.	Symmetrical breaking capacity	:	750 MVA
7.	Short time current for 1 Sec.	:	25 kA (rms minimum)
8.	One minute power frequency withstand voltage	:	70 kV rms
9.	Lightning impulse withstand voltage	:	170 kV peak
11.	Operating Mechanism	:	Motor operated spring charged. Trip free mechanism along

			with ON / OFF / TRIP Indication.
12.	Manual/Electrically operated	:	Manual and Electrical
13.	Tripping arrangement	:	110 V DC shunt trip mechanism.
14.	Meters to be provided on the panel	:	Digital Power Meter.
15.	Protections to be provided	:	i) Short circuit ii) Overload iii) Earth Fault iv) Under voltage
16.	Indications on Control panel	:	ON, OFF, TRIP, LOCKOUT, CONTROL SUPPLY, SPRING CHARGED.
17.	Terminal arrangement		
a)	Incoming	:	ACSR conductor/tubular bus
b)	Outgoing	:	ACSR conductor/tubular bus
18.	Control Supply	:	110 V DC
19.	Auxiliary power supply	:	230V AC
20.	Control wiring	:	1.5 mm ² (minimum), 660 V, PVC, Copper conductor.

31.0 SPECIFICATION FOR 33 KV CURRENT TRANSFORMERS

31.1 The 33 KV grade mineral oil filled single-phase current transformer shall operate in conjunction with suitable 33 KV Vacuum circuit breaker to control, protect and measure the electrical power supply of the system. The current transformer shall confirm to IS 2705 (Part 1): 1992 Reaffirmed In: 2017 and also to the following technical parameters:

31.2 Other Relevant Standards

The other relevant Indian standards are as under:

IS 2705 (Part 1): 1992 Reaffirmed In : 2017	:	Current transformers - Specification: Part 1 general requirements (Second Revision)
IS 4201: 1983 Reaffirmed in: 2016		Application guide for current transformer (First Revision)
IEC 61869-2:2012		Instrument transformers - Part 2: Additional requirements for current transformers

ANNEXURE-X

TECHNICAL PARAMETERS

1	Nominal system voltage	:	33 kV rms
2	Highest system voltage	:	36 kV rms.
3	Frequency	:	50 Hz
4	No. of phases	:	3
5	Application	:	Outdoor
6	Ratio	:	As per requirement
7	Mounting	:	Shall be suitable for mounting on structures.
8	Class of accuracy	:	
	e) Core-I		1.0
	f) Core-II		5 P10
	g) Core-III		PS
9	Purpose :		
	a) Core-I	:	Metering
	b) Core-II	:	Protection
	c) Core-II	:	Protection

10	Rated burden :	
	a)Core –I	: As required
	b) Core-II	: As required
	c) Core-II	: As required
11	Rated insulation level :	
	a) One minute power frequency with stand voltage	: 70 KV (RMS)
	b) Impulse withstand test voltage with standard full wave	: 170 kV (Peak)
12	Accuracy limit	10 for protective cores (Core nos. II and III) and less than 5 for metering Core (Core No.I).
13	Short time current rating for 1 seconds	: 25 KA

31.3 List of Fitting and Accessories

The supply of the current transformers shall be complete with the following accessories:

- 1 Primary terminals
- 2 Nitrogen filling valve with cap.
- 3 Oil level indicator
- 4 Secondary terminals
- 5 Secondary terminal box
- 6 Lifting lugs
- 7 Cable Gland
- 8 Primary reconnection links
- 9 Oil filling plug
- 10 Oil drain plug
- 11 Earthing terminals
- 12 Abnormal pressure release device
- 13 Rating and diagram plate

32.0 SPECIFICATION FOR 33 KV POTENTIAL TRANSFORMER

32.1 The $33/\sqrt{3}$ KV/ $110/\sqrt{3}$ Volts single phase, mineral oil filled outdoor type potential transformers are required for supply of power to the measuring and protective devices in the 33 KV control panels and relay modules of the sub-station. The potential transformers shall conform to IEC 61869-1:2007 and also to the following technical parameters:

32.2 Other Relevant Standards

The other relevant Indian standards are as under:

IEC 61869-1:2007	:	<u>Instrument transformers - Part 1: General requirements</u>
<u>IEC 61869-3:2011</u>	∴	<u>Instrument transformers - Part 3: Additional requirements for inductive voltage transformers</u>
IS 4146: 1983 Reaffirmed In: 2016	:	Application guide for voltage transformers (First Revision)

Annexure-XI

32.3 Technical Parameters:

1	Nominal system voltage	:	33 kV rms
2	Highest system voltage	:	36 kV rms.
3	Frequency	:	50 Hz
4	No. of phases	:	3
5	Application	:	Outdoor
6	Mounting	:	Pedestal
7	Transformation ratio	:	
	a) Core-I	:	$33/\sqrt{3}$ KV / $110/\sqrt{3}$ V
	b) Core-II	:	
8	Class of accuracy	:	
	a) Core-I	:	1
	b) Core-II	:	3 P
9	Purpose :	:	
	a) Core-I	:	Metering
	b) Core-II	:	Protection
10	Rated burden :	:	
	a)Core –I	:	As required
	b) Core-II	:	As required

11	Rated insulation level :		
	Impulse withstand test voltage with standard full wave	:	170 kV (Peak)
12	Short time current rating for 1 seconds	:	25 KA

32.4 List of Fitting and Accessories

The supply of the Potential Transformers shall be complete with the following accessories:

- 1 HT terminals
- 2 Nitrogen filling valve with cap.
- 3 Oil level indicator
- 4 Secondary terminal box with HV neutral terminal
- 5 Lifting lugs
- 6 Oil filling plug
- 7 Earthing terminals
- 8 Earthing terminal box.
- 9 Oil drain plug
- 10 Abnormal pressure release device
- 11 Rating and diagram plate

33.0 Specification for Earthing & Lightning Protection System for MCS / Pooling Substation

33.1 Scope

- i. This specification covers the requirements for earthing system.
- ii. Earthing system shall be strictly in accordance with IS 3043 : 2018, IEEE 80 and Indian Electricity Rules/Acts.
- iii. Any material, component or accessory not specifically stated in this specification but necessary for trouble free operation shall be deemed included.

33.2 System Description

- i. The earthing system shall consist of earth pits and earthing conductors located in sub-station.
- ii. Independent pits shall be provided for earthing of transformer neutrals and down conductors of lightning masts. Inter connected pits shall be provided for base frame of each modules, frame earthing of all equipment and cable trays/ladders, metallic conduits, steel tubular poles, trusses & structures over which cables run.
- iii. The earthing system shall be designed to have impedance to ground as low as possible and shall not exceed 1 ohm and the step and touch potentials shall be within safe limits. The outdoor switchyard shall have earthing as tabulated below:

Equipment	Earth conductor buried in earth	Earth conductor above ground level & in built up trenches
a) Main earth grid	40 mm dia MS Rod	65 x 8 mm GI flat
b) All H.T. Equipment	Not applicable	50 x 6 mm GI flat
c) 415 V/230 V Switch boards	Not applicable	50 x 6 mm GI flat
d) LT motors above 125 kW 31 kW to 125 kW 1 kW to 30 kW Fractional Horse Power	Not applicable Not applicable Not applicable Not applicable	50 x 6 mm GI flat 25 x 8 mm GI flat 25 x 6 mm GI flat 8 SWG GI wire
e) Columns, structures, cable trays, bus duct enclosures, steel tubular poles & Towers	Not applicable	25 x 8 mm GI flat
f) Gantries and other non-current carrying metal parts	Not applicable	25 x 6 mm GI flat

The grid should have minimum earth resistance value within the specified limit i.e. below 1 ohm. Earth pits shall be constructed with earth electrodes and chemical earthing compound.

Earth pits shall be covered with top cover of cast iron. Earth pits/ Earthing electrodes will be provided around the substation outdoor yard which will be interconnected by suitable size Galvanised iron flats/ strips laid in the ground. Test link and Watering arrangement shall also be provided with earth pit. The fencing and structural members in the outdoor yard will be connected to this earth grid.

Earthing of lightning arrestor/lightning mast shielding to their respective earth pit shall be done through insulated cable of suitable size.

The metal bodies of all the outdoor switchyard equipment shall be connected to the earth grid by GI strip at two places. The neutral of transformers shall be earthed through separate earth pits. The substation fencing and the lighting masts shall also be earthed separately through separate earth electrodes. The metal bodies of all the indoor equipment shall also be earthed by GI flats at two places.

There shall be provision for easily disconnecting the earthing electrode temporarily for measurement of earth pit resistance purpose. Metallic sheath, screens/shields and armour of all cables shall be earthed at both the ends at the equipment where the cables are terminated. Suitable earthing clips shall be provided as required.

Required number of earth pits will be provided around the substation building and will be inter connected with the help of suitable size galvanised Iron strips / flats buried below the ground at required depth. The control cubicles and other equipment will be connected to this earth grid.

Required number of earth electrodes will be provided and connected to over head earth wire (shield wire) provided for direct lightning stroke shielding protection through suitable size of insulated conductor.

Suitable arrangement for watering the earth pits shall also be provided if conventional earth pits are provided.

33.3 Construction

The primary requirements of the earthing system are as follows:

- i. Neutral of a transformer shall be effectively connected to an independent earth pit through neutral grounding resistor by copper flat of suitable size.
- ii. Down conductor of a lightning mast shall be effectively connected to an independent earth pit by GS flat of suitable size
- iii. Frame work of equipment shall be effectively connected to nearest pit by two separate GS flats.
- iv. Each earth pit shall have GI pipe electrode not smaller than 40 mm. The buried length of the electrode shall not be less than 2.5 meters. Each electrode shall be buried vertically in an earth pit of minimum 300mm x 300 mm area and 3 meters depth preferably by using homogenous mixture of bentonite clay and soil in the ratio of 1:3. The distance between two earth pits

shall be maintained at least double the length of the electrode pipe and earth pits shall be constructed away from drains. The design and size of earth pit shall be as per IS: 3043 (current).

- v. All conductors for earthing shall be made of Galvanized Steel (GS).
- vi. The joints of the conductors shall be preferably welded. For rust protection the welds shall be treated with Barium Chromate. Welded surfaces shall be painted with Lead primer and Aluminium paint followed by coats of Bitumen paints.
- vii. The grids inter connecting the pits shall have an area not less than 300 Sq mm and be buried at a depth not exceeding 600 mm below the soil. 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. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.
- viii. Each pit shall be provided with a cast iron top cover for inspection & identification.
- ix. The earth conductors shall be free from pitting laminations, rust, scale and other electrical, mechanical defects.
- x. The Bidder shall design and install the grounding system in the entire sub-station Complex. Excavation in rock / soil or both and back good earth filling required for the construction shall be in the scope of the bidder.
- xi. Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system each of 100% capacity. Metal pipes and conduits shall be effectively earthed at two points. Metallic sheaths, screens, armour of all cables shall be earthed at both ends.
- xii. Each continuous laid out lengths of cable tray shall be earthed at minimum two places by GS flats to the earthing system, the distance between earthing points shall not exceed 30 metre. Different sections of cable trays shall be connected by low resistance connecting links.
- xiii. 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.
- xiv. 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.
- xv. For panel and switch earthing inside the substation building, two numbers continuous earth bus will run along the inner wall of the substation building.

- xvi. Resistance of the joint shall not be more than the resistance of the equivalent length of conductor.
- xvii. A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench / foundation / underground pipes at crossing. Earthing conductors crossing the road can be installed in hume pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as air, water, pipe lines, steel reinforcement in concrete, it shall be bonded to the same.
- xviii. Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding/cleating at interval of 1000 mm and 750 mm respectively.
- xix. On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth termination shall be measured in presence of Purchaser's representatives. Any equipment required for testing shall be furnished by Bidder.

33.4 Lightning Protection System

Lightning protection system shall be in strict accordance with IEC 62305 .

- i. Lightning spike/arrestor shall be provided on any structure having height 11 meter or more. The height of the spike/arrestor above its fixing point on the structure shall be 2 meter. The spacing between two adjacent spike/arrestor shall not be less than 20 meter.
- ii. Lightning conductor shall be of 25 x 6 mm GS strip when used above ground level. It shall be connected through test link with earth electrode/earthing system.
- iii. The Bidder shall furnish the details including typical arrangement drawings for the lightning protection system offered.
- iv. a) Down conductors shall be as short and straight as practicable and shall follow a direct path to earth. Down conductor shall not be connected to other earthing conductors above ground level. The size of down conductor of each mast shall not be lower than 25 x 8 mm. Each down conductor shall be effectively connected to independent earthing pit.
b) Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be inaccessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.
c) All joints in the down conductors shall be of welded type.
- v. a) All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.

- b) The lightning protection system shall not be through cables, conduits and metal enclosures of electrical equipment.
- c) Lightning conductors shall not pass through or run inside GI Conduits.
- d) Testing link shall be made of galvanised steel of size 25 x 6 mm.

CHAPTER-V

CIVIL AND STRUCTURAL WORKS

This section of Technical Specifications describes detailed technical and functional requirements of all civil and allied works included in the scope of work **Standards & Codes.**

All design and construction of civil works shall conform to relevant Indian standards such as BIS, IRC, MORTH, NBC etc.

Design of steel structures shall conform to IS: 800, 801 or 802 as applicable. Design of concrete structures shall conform to IS: 456. For design of liquid retaining structure IS: 3370 shall be followed. Only in case of non-availability of Indian standard, equivalent American or British standard may be used for design with prior approval of the Engineer and the contractor shall submit proper justification for the same along with his request to the Engineer for review and approval, and the decision of the Engineer shall be final and binding.

All the design/ drawings shall be prepared/ approved either by in-house Engineering Team of the contractor (or by his Engineering Consultant) with qualified engineering staff with relevant experience in successful design of solar SPV plants.

The design calculations for MMS, RCC structure, Steel structure, Foundation system including piling, Road work, Drainage work, etc. shall be submitted for prior approval of Engineer before commencement of construction.

As per project requirements, the Employer may ask for approval of all civil designs and drawings by a Chartered Civil/ Structural Engineer.

The design calculations shall be supplemented with a neat sketch showing the structure geometry, node and member nos., lengths of various typical members, support points and type of supports, types of materials & type of sections with properties considered in analysis & design. The report shall also include back-up calculations for various loads adopted in design, brief write-up on primary load cases and design load combinations considered and conclusions on design results (with supporting sketches) for easy reference and clarity. Where a computer program (other than STAAD) is used for analysis and design, the contractor shall include a write-up on the computer program used along with examples for validation check. Design Input (format suitable to the program used and also in STAAD format) and output file shall also be given in the design report and in soft copy to facilitate its review and approval by the Engineer.

The methodology for construction of MMS and its foundations, Road & drainage works and Procedure for pile load test shall also be submitted for prior approval of Engineer before start of these works.

1.0 Topographical Survey

- 1.1 Bidder shall conduct the Topographical Survey for the allocated plot in the proposed solar project. The scope of work and technical specification for the same is as below:
- 1.2 The Topographical survey shall be conducted at 20m x 20m grid, or depending upon the site conditions
- 1.3 The Contractor shall carry the Bench Mark from nearest GTS Bench mark or any other established source like Railway station, Permanent PWD/ WRD structure etc. as approved by the Engineer, by fly-levelling and establish two permanent bench marks (PBM) at site. All subsequent transfer of levels shall be carried out with respect to these PBMs. The work shall also include constructing permanent reference pillars (RP) at suitable locations. These reference pillars shall be labelled permanently with their respective coordinates and reduced levels for future use. The Permanent Bench Marks (PBM) and reference pillars (RP) shall be shown on the survey drawings.
- 1.4 The survey work shall be carried out in UTM grid system. The contractor shall also establish the latitudes and longitudes and UTM coordinates of all the corners of the project site. At least 50m width of the adjoining plots and surrounding areas shall also be covered in the survey for correlation with adjoining plots and facilities. The grids for the survey work shall be established in N-S & E-W direction.
- 1.5 Positions, both in plan and elevation, of all natural and artificial features in the area like waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably symbols of survey of India Maps). All hills and valleys within the area/areas are to be surveyed and plotted on maps by contours. Any unusual condition or formation on the ground, locations of rock outcrops (if visible on the surface) and springs/falls, sand heap/dune, possible aggregate deposits etc. shall also be noted and plotted on contour maps. The C/L coordinates of existing road & cross drainage (CD) works (culverts etc.) at intermediate points & at corners/intersections and width of carriage way of the road shall be recorded with their position on the contour maps.
- 1.6 The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Engineer's review before submission of final contour map. The contour interval shall be as required for proper representation of the topography however it shall not be more than 0.5m. The Contractor shall submit survey maps of the site in 1:10,000 scale indicating grid lines and contour lines, demarcating all

permanent features like roads, railways, waterways, buildings, power lines, natural streams, trees, sand dunes etc. Present use of the site i.e. mining, quarrying, agriculture etc., existing drainage pattern of the site, possibility of water logging and high flood level of the area shall also be captured in the document. The project plot boundary with coordinates of all corner points along with coordinate grid of 50m x 50m interval shall be marked on the contour map.

2.0 Geotechnical Investigations

- 2.1 Bidder shall be responsible for detailed Geotechnical investigations at the proposed project site for the purpose of foundation design for various buildings, structures, HT lines, MMS etc. and other design/ planning requirements. The investigation work shall be carried out through any Govt. approved/ NABL accredited agency. The contractor shall submit the credentials of the proposed agency along with relevant certificates in support thereof for verification/ approval of the Investigation Agency by the Engineer.
- 2.2 The scope of work includes execution of complete soil exploration including boring and drilling with rotary drilling rig, standard penetration test (SPT), collecting disturbed (DS) and undisturbed samples (UDS), collecting ground water samples, trial pits, electrical resistivity tests (ERT), field & laboratory CBR tests, conducting laboratory tests on collected samples of soil & ground water and preparation and submission of report. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20% met within a borehole (BH). SPT test shall be conducted at every 1.5m interval or at change of strata. The starting depth of SPT shall be 0.5m from ground level. UDS shall be collected at every 1.5m interval or at change of strata. The min. size of trial pit shall be 2.0mx2.0mx2.5m deep.
- 2.3 The field investigations shall mainly include drilling of min. 5m deep BHs (50% of total No. of boreholes shall be 10m deep), conducting SPT and collecting Disturbed (DS) and Undisturbed samples (UDS), conducting in-situ CBR test for approach road to the plant, internal roads & peripheral road; Trial pits (TP) and Electrical resistivity tests (ERT). Number and location of BHs, California bearing ratio (CBR) tests, ERTs and TPs shall be decided as per the project layout, site topography and soil conditions in consultation with the Employer. The proposed locations shall fairly represent the total project site to get the complete required geotechnical information. The BH near MCR and ICR shall be 10m deep. There shall be minimum 1 no. of BH per 5 acres of the area (However, total number of boreholes shall not be less than 5), 3 nos. of Trial pits, 5 nos. of CBR test & ERT, 5 nos. of Ground water samples for laboratory investigations. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient nos. (Note- In case the project plot is divided in to number of discrete blocks separated from each other, min. 3 nos. of bore holes, 2 trial pits, 2 ERT and 2 CBR tests shall be taken per such block with at least 1 No. of BHs per 5 acres as specified above).

- 2.4 The proposed Geotechnical investigation plan indicating proposed locations of TPs, BHs, water sample collection points, CBR test & ERT shall be submitted to the Employer for review and approval before start of work.
- 2.5 Laboratory tests shall be conducted on DS & UDS samples and ground water samples in sufficient no. & shall include, Soil classification, Grain size analysis including Hydrometer analysis, determination of Bulk and dry density, Specific gravity, Natural moisture content, Atterberg limits, Tri-axial shear tests (Unconsolidated Undrained – UU) on UDS, Undrained shear test, Consolidation tests, Unconfined compression tests (UCS), Free swell index, chemical analysis of soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, Organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc. Laboratory CBR test on soaked samples shall also be conducted on min. 5 no. of soil samples to ascertain the suitability of soil for sub-grade and requirement of any treatment of subgrade soil in case of CBR <2% as per IRC requirements.
- 2.6 After completion of field and laboratory work, the contractor shall submit a Geotechnical Investigation Report for Engineer's approval. All bore log details and lab test results shall be presented in the report as per provisions of relevant BIS standards indicating BH coordinates, Existing GL, Depth of water table, Method of drilling etc. The report shall include a Map showing the locations of various field tests including coordinates, calculations and recommendations for foundation type and safe bearing capacity (SBC) for various Plant buildings (ICR, MCR etc.) and Open installations, Switch Yard structures & Sub-Station (as applicable), Transformer foundation, HT lines (as applicable), MMS foundation etc. corresponding to settlement of 25mm.
- 2.7 The report shall include the study for "Liquefaction potential assessment of the ground and suggestions for any ground improvement measures" as required.
- 2.8 The report shall also include ground water analysis (water sample collected from bore well) to ascertain its suitability for construction purposes, recommendations for type of cement, grade of concrete & minimum cement content as per prevalent soil characteristics with respect to presence of aggressive chemicals and environment exposure conditions as per relevant BIS specifications. However, minimum grade of concrete shall be as specified under Cl.14 'Concrete Works'.
- 2.9 In case the contractor wishes to adopt concrete pile foundation for MMS supports the Geo-tech. report shall also include the calculations, based on soil properties, for safe pile capacity under direct compression, lateral load and pull out as per IS:2911. For single pile, Lateral load capacity shall be min. of the values obtained as per IS:2911 & Brom's method corresponding to free pile head. The report shall also include recommendations about type of pile, its depth and dia. to be used.
- i In coastal areas and in marshy or swelling type soil, under reamed or driven precast concrete pile shall be used. In case contractor wishes to use helical

- piles the design, fabrication and installation shall conform to IBC (International building code).
- ii The contractor shall carry out field trials for initial load test on pile to verify the pile design to confirm the safe load carrying capacity under direct compression, Lateral load and Pull out. The min. of the two values (design value as per soil characteristics & field test results) shall be adopted.
 - iii The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area etc. However, minimum 5 nos. of piles shall be tested {min. 3 nos. in each block (block size < 25 acre) and min. 5 nos. in each block (block size .25 acres) if the plant site is divided in discrete blocks separated from each other} under each category of load.
 - iv The locations of test piles shall be distributed over the plant site and to be finalized in consultation with Engineer. In case the MMS column is fixed using base plate- anchor bolt assembly, the adequacy of provided pile reinforcement in job (working) pile corresponding to the set of test loads shall be reviewed by the contractor for any additional requirement of reinforcement and the same shall be provided in the pile to be cast for initial load test.
 - v In case the Contractor proposes to embed the Column leg in the pile for fixing, the test pile shall be provided with embedded column leg as per approved design and any dowels as required for application of test load. The drawing for the Test pile shall be submitted to Engineer for his approval before casting the test pile. The load test on pile shall be conducted after min. of 28 days from the date of casting. In case the contractor desires to conduct the test earlier than 28 days, he may use suitable higher-grade concrete or if there is substantial evidence from earlier cube test results on design grade concrete to demonstrate the early gain of required compressive strength prior to application of the test load.
 - vi However, under no circumstances the test shall be conducted before 15 days of the date of casting the pile. All the dial gauges and hydraulic jack assembly shall be properly calibrated as per the requirements of relevant BIS standards and valid calibration certificate to this effect from Govt. / NABL accredited Test agency shall be submitted to the Engineer before use.
 - vii The contractor shall submit detailed methodology for conducting the tests in line with IS: 2911 (Part 4) for Engineer's approval before commencement of any test. After completion of these tests the contractor shall compile the test results and submit the report in a proper format as specified in the BIS standard with recommendations/ conclusions for Engineer's approval. The pile work shall start only after approval of the final pile design duly verified/ confirmed with initial load test results.

3.0 Other Investigations

- 3.1 Bidder shall also obtain and study other input data at proposed project site for design of the project from metrological department/ local govt. authorities. This shall include data related to Rainfall, Maximum & Minimum ambient Temperature, Humidity, HFL etc.
- 3.2 The contractor shall carry out Shadow Analysis at proposed site and accordingly design strings and array layout with optimum use of space, material and man power. In case of large variations in topography, the study shall also include the effect of topographical variations on array layout and MMS structure design adequacy and stability. The contractor shall submit all the details/ design to the Engineer for review/ approval.
- 3.3 The contractor shall also identify potential quarry areas for coarse and fine aggregates to be used for concrete and shall carry out the concrete mix design for concrete grades to be used in construction of all concrete works. The concrete mix shall be designed for each source of cement and aggregates as per relevant BIS Standard. The concrete mix design shall be carried out through NABL accredited Laboratory or any Govt. agency approved by the Engineer.
- 3.4 In case the contractor proposes to use RMC, the same shall conform to IS: 4926. The Contractor shall submit the Concrete mix design proposed to be used by the RMC for review and approval by the Employer. (Reports of periodic quality tests for the supply concrete batch shall be maintained by the RMC supplier as per approved Quality Plan and the same shall be submitted to the Employer for review and record).

4.0 Area Grading and Land Development

- 4.1 The Finished Grade Level (FGL) of the proposed plant shall be fixed with reference to the highest flood level (HFL) and surrounding ground profile at proposed site to avoid flooding of plant site. The data regarding HFL at proposed site shall be obtained from the metrological department by the contractor. In case of absence of this data, the contractor shall assess the required information through local site reconnaissance. The area at and around (up to 25m beyond external wall/ area including access road & parking whichever is minimum) all buildings/ plinth for open installations (LCS, MCS etc.), transformer yard and switch-yard shall be uniformly levelled at suitable RL (i.e. FGL) to be finalized considering topography and HFL at site. The minimum plinth level of all buildings/open installations shall be 450mm above FGL. Module mounting structure foundation/ Pile cap or any other pedestal shall be min. 200mm above FGL. Top of transformer foundation pedestal shall be min, 500mm above the FGL.
- 4.2 A detailed drawing for site levelling and grading (if necessary) shall be submitted by the contractor before commencement of construction of all buildings, plinth for open installation and transformer/switchyard works. The estimated volume of cutting and filling shall also be marked on the Grading drawings for reference. The

final grade levels to be adopted for different blocks shall be clearly marked on the Plant Layout/ Array Layout drawing.

- 4.3 It is envisaged that the MMS are installed on natural/ existing ground without any levelling or grading of the area. Contractor shall accordingly consider the effect of the existing ground slope on the design of MMS structure as specified elsewhere in the specifications. If any ground undulations at column locations are observed the same shall be filled up with PCC (1:3:6) up to surrounding ground level immediately after pile installation before start of erection of other MMS members. In case of pile, the PCC fill shall extend min. 500mm outside pile cap all around and remaining area may be filled up with local soil properly compacted.
- 4.4 The contractor is responsible for making the site ready and easily approachable by clearing bushes, felling of trees (mandatory permissions/ licenses/ statutory clearances from competent authorities if required for cutting of trees, blasting or mining operations, disposal of waste material etc. shall be obtained by the contractor), cutting, filling with selected excavated earth or borrowed earth including identifying borrow areas. Except in exceptional cases (with approval of the Engineer), filling shall be made up of cohesive non-swelling material. The filling for levelling/ reclaiming the ground/ area shall be done in layers not more than 150mm of compacted thickness in case of cohesive soils and 250mm compacted thickness in case of granular (sandy) soils with compaction up to 95% (of modified proctor density) and 80% (of relative density) respectively. The slope at edge of graded areas shall not be steeper than 1:1.5 (1 Vertical: 1.5 Horizontal) in cutting and 1:2 (1 Vertical: 2 Horizontal) in filling. In case of filling with rock material, the edges shall be provided in line with provisions of relevant BIS standard.
- 4.5 It shall be ensured that the land is grading and levelling is done properly to ensure for free flow of surface run-off and the grade levels shall be fixed with respect to high flood level at site, drainage pattern and system requirements. It shall be ensured that the land is used optimally to have maximum solar power generation considering full utilization of the plot areas. It is advisable to follow the natural flow of water at the ground as far as possible for drainage design.
- 4.6 In case the filled up earth is brought from outside the plant or borrow areas (when the material inside plant area is not found suitable for grading work or if directed by the Engineer), the contractor shall carry out all required soil investigations to ascertain the suitability of the borrowed soil for land development and filling purposes. Contractor's scope shall also include arranging land lease, getting all necessary statutory approvals for mining, payment of necessary challan etc. Excess earth, if any, shall be disposed of properly at location as directed by the Engineer.

5.0 Roads

- 5.1 Suitable approach road (as applicable) from nearest public road up to plant Main gates, Access road from Main gates to Main control cum office room (MCR) at Main control station (MCS), Internal roads all along 33 KV OHTL connecting MCS

and other facilities/ buildings/ open installations like Local control station(s) (LCS)/ Inverter control room(s) (ICR), Sub-station & Switch yard (as applicable) etc. shall be provided for safe and easy transportation of men, material and equipment during construction and maintenance.

- 5.2 The Approach Road connecting nearest public road and the Main gate shall be of 4.0m wide carriage way with 0.5m wide shoulders on either side. The access road connecting Main gate and MCS / MCR and internal access road(s) all along 33 KV OHTL connecting LCS / MCS to various facilities/ buildings/ open Installations shall be of 3.0m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 150 mm above FGL to avoid flooding of roads during rains. The roads shall be provided with alongside drains as per design requirements of drainage system for effective disposal of storm water and to avoid cross flow of storm water over the road. The roads shall be designed as per IRC SP-72 corresponding to traffic category T3 and critical field CBR value of the subgrade. Shoulder shall be of min. 150mm thickness.
- 5.3 However, following minimum road section details shall be followed:
- i Topping: Surface dressing with gravel or gravel-soil mixture conforming to Cl. 402 of MORD specifications for rural roads published by IRC (MORD specs). However, for sites with average annual rainfall > 1500mm, either 2 course surface bituminous dressing conforming to Cl. 505 of MORD specs or 20 mm thick open graded pre-mix carpet + Type – B or Type –C seal coat conforming to Cl. 506 of MORD specs. shall be provided.
 - ii Base course WBM (CBR>100%) conforming to Cl. 405 of MORD specs: 75mm compacted thick, Grade III.
 - iii Base course WBM (CBR>100%) conforming to Cl. 405 of MORD specs: 75 mm compacted thick, Grade II.
 - iv Granular/ gravel sub-base course (CBR>20%), conforming to Cl. 401 of MORD specs: 175 mm compacted thick, compacted to 100% of max dry density.
 - v Compacted subgrade: 300mm thick below sub-base (non-expansive soil with max. dry density > 1.65 kN/m³) conforming to Cl 303 of MORD specs, compacted up to 98% of standard proctor density in layers of 150mm thickness. In case of expansive soils like black cotton soil suitable treatment as per Cl. 403 of MORD specs shall be provided before laying sub-base course.
 - vi Gravel Shoulders conforming to Cl 407 of MORD specs: 150mm compacted thick, compacted to 100 % of max. dry density.
- 5.4 Soaked CBR value of sub-grade shall not be less than 2%. Where the CBR of the subgrade is less than 2 % a capping layer of 100 mm thickness of material with a minimum CBR of 10 % is to be provided in addition to the sub-base required for CBR of 2 %. When the subgrade is silty or clayey soil and the annual rainfall of the area is more than 1000 mm, a drainage layer of 100 mm over the entire formation

- width should be provided conforming to the gradation given in Chapter 6 of IRC SP-20. This layer will form a part of the designed thickness of sub-base.
- 5.5 In case of no-availability of murrum in the nearby areas of the project site, suitable other screening/ blending material for WBM construction may be used conforming to provisions of IRC SP 20.
 - 5.6 The construction of road shall conform to MORD specifications for Rural roads published by IRC.
 - 5.7 Drain, cable or any other crossing shall be provided with RCC box or precast concrete pipe culvert. The culvert design shall conform to relevant IRC standard. The pipes for road culverts shall be of minimum class NP3 conforming to IS 458 with min. soil cover of 750mm above the pipe. In case of soil cushion less than 750mm the pipe shall be provided with 100 mm thick M20 reinforced concrete encasement with 10 dia. reinforcement rods @ 150mm c/c both ways. However, the water supply pipe for module cleaning and service/ drinking water shall be routed through medium class GI steel pipe of required dia. conforming to IS: 1161.
 - 5.8 Minimum dia. of casing pipe to be used at any facility like electric cable, water pipe line etc. shall be 150mm.
 - 5.9 Maintenance pathways of min. 1.0 m width shall be provided between SPV arrays for easy movement of maintenance staff, tools, equipment and machinery, washing of modules etc. The pathway area shall be generally levelled and well compacted manually/ mechanically. Areas of depression, valley zones or wherever there is noticeable change in topography, shall be levelled using well compacted good earth matching the top finished surface with ground topography/ grade to avoid accumulation of water in the region and allowing its free flow to keep the area devoid of mud/ sludge.
 - 5.10 There shall be no peripheral road. However, about 2.5m wide corridor shall be left along inside of the plant boundary suitably maintained clean of any vegetation and shall be provided with adequate illumination for movement of security personnel. Any undulations shall be made good with locally available coarse-grained material to have fairly level passage way.
 - 5.11 The design and drawings for approach road, all internal roads and culverts shall be submitted to the Engineer for approval before execution.

6.0 Surface/ Area drainage

- 6.1 Bidder shall design and construct storm water drainage network for smooth disposal of storm water from the plant to the nearest available drainage outlet.
- 6.2 The storm water drainage system shall be designed and planned to ensure no water stagnation in the plant.
- 6.3 The plant drainage system shall be designed for maximum hourly rainfall intensity and relevant time of concentration.
- 6.4 The design shall conform to the provisions of IRC SP 42 and best Industry practices. (The design rainfall shall be taken as max. hourly rainfall at 25 years return period at project site as provided in the Isopluvial map of the relevant

- subzone annexed with Flood Estimation Reports of Central Water Commission (CWC).
- 6.5 The coefficient of run-off for estimation of design discharge shall be considered as per catchment characteristics, however it shall not be less than 0.6.
 - 6.6 The drainage scheme shall be designed considering the plant plot area and the surrounding catchment area contributing to the plant area drainage as per the topography.
 - 6.7 The storm water drainage system shall be a network of open surface drains (with rectangular or trapezoidal cross section) and shall generally be designed to follow the natural flow of water and ground contours.
 - 6.8 Suitable size plant peripheral drain as per design (min. 500mm wide x 500mm deep) along inside of plant boundary wall/ fence shall be provided for smooth channelization of outside storm water and to avoid flooding in the plant. The size of all internal and road side drains shall not be less than 450mm (bottom width) x 500mm (depth).
 - 6.9 All trapezoidal drains shall have side slopes not steeper than 1:1 and shall be lined with either brick or RR masonry/ concrete or stone slabs as suitable to the site conditions. The min. Thickness of the lining shall be 115mm for brick masonry, 75mm for concrete slabs, 150mm for RR masonry and 100mm for stone slabs. The lining shall be in CM (1:4) and the joints shall be raked and pointed with CM (1:3), however, the joints in lining of plant peripheral drain may be left without pointing.
 - 6.10 In case of rectangular drain, the thickness of the wall shall be checked against structural stability under action of the design loads as specified in Cl. No. 10.0 'Design Loads'. However, Min. thickness shall be 230mm for brick masonry, 300mm for RR masonry and 125mm for RCC work, except for garland drain around buildings where the min. wall thickness can be 115mm, 200mm and 100mm respectively for brick masonry, RR masonry and RCC work.
 - 6.11 The structural design of drains shall be as per provisions of relevant BIS standards and good industry practice.
 - 6.12 The drain outfall shall be connected to the nearest existing natural drain(s)/ water body outside plant premises and it shall be ensured that the drainage water shall not re-enter the plant nor encroach/ flood in the adjacent property/ plot.
 - 6.13 The proposed drainage scheme along with design calculations and drawings shall be submitted to the Engineer for review/ approval before start of construction.
 - 6.14 The contractor shall also explore for providing rain water harvesting system for water conservation by constructing suitable collection wells along the drains or through provision of detention ponds or percolation/recharge pit etc. The scheme for rain water harvesting along with design calculations shall be submitted for approval.

7.0 Plant Layout

- 7.1 The contractor shall submit drawing showing proposed Project Plant and SPV module Layout.
- 7.2 The Plant and SPV module layout shall be a comprehensive drawing showing various requirements of the project like, Reference coordinate grid, Geographical and Plant North, Layout of boundary fence including coordinates of all corner points, Location of main entrance gate and any other access gates as per project needs, Block wise FGL, Layout of main approach road to the plant, Internal roads, Security Room/ cabin (s), all Buildings and Open installations with coordinates, Temporary Storage yard/ facility to be used by the contractor during construction, Proposed Array layout, Lightning arrester, UG/Over ground water Tank(s), Storm water drains, Corridor for buried cables etc.
- 7.3 The cable corridor shall be laid through clear gap between arrays and shall not be laid below modules for easy maintenance.
- 7.4 All the facilities and buildings shall be presented with suitable Legend.
- 7.5 The drawing shall be in suitable scale to have proper representation of the information.
- 7.6 The Plant & SPV module layout drawing shall be submitted by the contractor for review/ approval by the Engineer.

8.0 Design Loads

- 8.1 Unless otherwise specified elsewhere, Dead load, Live load, Wind load and Seismic load for buildings and structures shall be considered as per provisions of relevant BIS standards.
- 8.2 The following minimum imposed load as indicated for some of the important areas shall, however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

S. No.	Area	Imposed (Live) Load
1	Roof	1.50 kN/ Sqm
2	Building floors (GF) & Grade Slab	10.00 kN/ Sqm
3	RCC Floors (General)	5.00 kN/ Sqm
4	Outdoor platforms, Stairs, Landing and Balconies, Walkway, Chequered plate & Grating (except cable trench cover)	5.00 kN/ Sqm
5	Road culverts & allied structures over drain & pipe crossings subjected to vehicular traffic	Design for Class – ‘AA’ loading (Wheeled & Tracked both) and check for Class ‘A’ loading as per IRC Standard

6	Underground structures such as Sump, Pit, Trench, Drain, UG tank etc.	In addition to Earth pressure and Ground water table at FGL, a surcharge of 20kN /Sqm (10kN/Sqm for drains) shall also be considered. The structure shall be designed for following criteria – (a) Inside empty with outside fill+ surcharge and water table at GL & (b) Inside water with no fill & water table outside
7	Pre-cast and chequered plate cover over cable trench	4.00 kN/ Sqm
8	Main access & Internal Roads	As per IRC SP 20 corresponding to vehicular traffic of 150 commercial vehicles per day and critical in-field CBR

8.3 Primary Loads

- i Dead Load (DL)
- ii Live Load (LL)
- iii Wind Load (WL) – Both along $\pm X$ & $\pm Z$ horizontal direction
- iv Seismic Load (EL) – Both along $\pm X$ & $\pm Z$ horizontal direction

- 8.4 Basic wind speed (V_b) at project site shall be taken as per IS 875 (part-3) unless otherwise specified elsewhere.
- 8.5 To calculate the design wind speed (V_z), the factors K_1 (probability factor or risk coefficient), K_2 (terrain roughness and height factor) and K_3 (topography factor) shall be considered as per IS 875 (Part-3) (However, minimum values for K_1 , K_2 and K_3 shall be 0.94, 1.0 and 1.0 respectively)
- 8.6 Topography factor 'k3' shall be taken as 1.0 upto upwards slope of 3° . For topography with upward slope greater than 3° , the value of 'k3' shall be calculated as per Annexure- C of IS 875 (Part-3).
- 8.7 In case of plant site within 60 km of sea coast, the importance factor for cyclonic region, 'k4' shall be taken as 1.15.
- 8.8 To calculate the design wind pressure 'pd', factors 'ka' (area averaging factor) and 'kc' (combination factor) shall be taken as 1.0. (The factor 'kd' shall be taken as 1.0 in case of plant site within 60km of sea coast).
- 8.9 The Seismic Load shall be considered corresponding to Earth quake zone at site as per IS: 1893 (Part- 4) with Importance factor 1.5. Ductile detailing as per IS 13920 shall be followed in concrete structures except in case of concrete support structure upto plinth level supporting open installations of inverter transformers

and control panels at ICR/LCR, wherein the detailing shall conform to IS 456 and SP 34.

8.10 Notes for MMS Design

- i WL shall be considered as detailed below for estimation of WL under primary loads:
 - WLx (downward), WLz (downward): Load due to positive pressure on design tilt angles of MMS members for wind acting in both ($\pm X$, $\pm Z$) directions.
 - WLx (upward), WLz (upward): Load due to negative pressure on design tilt angles of MMS members for wind acting in both ($\pm X$, $\pm Z$) directions.
 - WLx (member load), WLz (member load): Load due to wind action on side (exposed) face of respective MMS members (drag force) for wind acting in both ($\pm X$, $\pm Z$) directions.
 - a. $\pm WLx$ (member load, transverse to MMS table): Load due to wind action of column, front and back bracing, longitudinal bracing.
 - b. $\pm WLz$ (member load, along length of MMS table): Load due to wind action of column, rafter front and back bracing, longitudinal bracing.
- ii For estimation of design wind loads on purlins (Table 8 of IS 875- Part 3), WL (downward) and WL (upward) on modules (laid in the profile of mono slope canopy) shall be applied such that the center of pressure should be at ($0.3 \times$ length of canopy) from windward end (for simplicity, the wind load distribution may be taken as triangular with max. value at windward end). Solidity ratio (ϕ) shall be taken as 0.5.
- iii In design of MMS (for height of structures less than 10 m from ground), 20% reduction in wind pressure as per Note under Cl. 6.3 of IS 875 – Part 3 is not permitted in case of purlins (members supporting modules), which shall be designed against action of WL corresponding to full wind pressure.

8.11 Design Load combinations

- i Appropriate Load factors in LSM design for concrete structures and appropriate Factor of safety in WSM design (ASD) for all steel structures including MMS shall be considered as per relevant BIS standard. No increase in permissible stress is permitted in design of MMS.
- ii Following load combinations shall be considered in design:
 - For MMS Design:
 - a. DL+LL
 - b. DL+LL \pm WLx (upward) \pm WLx (member load)
 - c. DL+LL \pm WLx (downward) \pm WLx (member load)
 - d. DL+LL \pm WLz (upward) \pm WLz (member load)
 - e. DL+LL \pm WLz (downward) \pm WLz (member load)
 - f. DL+LL \pm ELx
 - g. DL+LL \pm ELz
 - For RCC and Steel structures except MMS:

- a. DL+LL
 - b. DL+LL ± WLx
 - c. DL+LL ± WLz
 - d. DL+LL ± ELx
 - e. DL+LL ± ELz
- iii All buildings, structures and foundations shall be designed to withstand loads corresponding to worst design load combination.

9.0 Foundations (General)

- 9.1 Contractor shall design all foundations for buildings, equipment, HT line Towers, Switch yard structures, Transformer, MMS & other structures as per relevant BIS standards and recommendations of Geotechnical investigation report.
- 9.2 No foundation for MMS, buildings, switchyard equipment and structures, substations, HT line towers, transformers, etc. shall rest on filled-up ground. However, minor structures like cable trench, cable rack, pipe pedestal, etc. may rest on filled-up soil with max. safe bearing capacity for design considerations not more than 3 T/Sqm.
- 9.3 Min. depth of foundation for all buildings and plinth for open installations shall be 1.5 m below NGL. For all other structures, min. depth of foundation shall be 1.0 m unless specified otherwise.
- 9.4 All foundations of a building shall be founded at same RL (Reduced level) with respect to foundation depth below lowest NGL (Natural ground level) in the building area. The Levels shall be obtained with reference to the already established TBM using digital survey instrument such as Total Station/ Auto Level.
- 9.5 All design & drawings shall be submitted to the Engineer for approval before execution.

10.0 MMS Foundation

- 10.1 Module mounting structure (MMS) may be supported on isolated/ strip footing or pile foundation.
- 10.2 **Bored cast-in situ, Driven precast or under reamed Concrete pile**
- i In case the contractor proposes to provide bored cast-in-situ concrete pile; the type, dia. and length of pile shall be as per recommendations of Geotechnical investigation report corresponding to prevalent soil characteristics at site. However, the min. dia. and depth of the pile shall be 300mm (Min 350 mm for column depth more than 175 mm) and 1800mm respectively except when very hard strata/ rock ($N > 100$) is encountered at a higher level, the pile shall be extended in to the hard strata minimum 1.5 times the diameter of the pile with total depth of the pile not less than 1200mm below cut-off level.

- ii As specified above, the MMS support shall project minimum 200mm above FGL (Finished grade level) to avoid any damage to the MMS column/sub support due to direct contact of rain water/ surface run-off. This shall be ensured through either single stage construction of entire pile length including portion above FGL or by providing a collar (to be cast in second stage) which shall project min. 75mm in plan beyond the pile face and shall extend min. 250mm below GL.
- iii For proper bonding, the surface of first stage concrete shall be made rough by trowelling and cleaning out laitance and cement slurry by using wire brush on the surface of joint immediately after initial setting of concrete. The prepared surface should be clean watered to get saturated dry condition when fresh concrete is placed against it. The prepared surface shall be applied with a suitable bonding agent before construction of pile cap/ collar as required.
- iv In case the column post/stub is supported through base plate-anchor bolt assembly, the same shall only be provided through RCC pile cap to be designed as per provisions of relevant BIS standard with min. clear overhang of 75mm. The pile shall be embedded min. 50mm in the pile cap and the pile reinforcement shall be extended in to the pile cap for proper anchorage.
- v In case of collapse of foundation strata during drilling of the pile bore, removable steel liner shall be used to maintain design depth and diameter of the pile for proper concreting.
- vi The design & installation of piles shall conform to IS: 2911.
- vii The bore shall be free from water before pouring of pile concrete. For under water concreting tremie shall be used.

10.3 Helical/ Screw Pile

- i The design, manufacture, testing and installation of Helical/ Screw pile shall conform to ICB-2009 and Practice Note 28- "Screw Piles: Guidelines for Design, Construction & Installation, ISSN 1176-0907 October 2015 (IPENZ Engineers New Zealand)".
- ii The design of pile shall be undertaken and verified by a suitably qualified geotechnical or structural Chartered Engineer with experience in the design of helical/screw piles.
- iii The pile shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by installation into the ground and service loads.
- iv The steel grade for pile shaft, helix plates and other accessories shall be with min. Fy 350 MPa. Min. thickness (BMT) of shaft and helix plate shall be 6 mm and 8 mm respectively in case of coastal installations and soils containing aggressive chemicals and at other project sites it shall be respectively 5 mm and 6 mm. Cap plate and col base plate shall be min. 12 mm thick and of min. grade E-250 conforming to IS:2062. 12.3.5

- v All materials shall be hot dip galvanized conforming to relevant BIS standard with Tender for Design, Engineering, Procurement & Supply, Construction & min. thickness of galvanization 80 microns.
- vi Wherever the pile shaft is required to be infilled with concrete grout, the same shall be of min. grade M30 (anti shrink).
- vii The allowable axial design load (Direct compression & Pull out), Pa, of helical piles shall be the least of the following values:
- Sum of the areas of the helical bearing plates times the bearing capacity of the soil or rock comprising the bearing stratum.
 - Capacity determined from well-documented correlations with installation torque.
 - Load capacity determined from initial load tests.
 - Axial capacity of pile shaft.
 - Axial capacity of pile shaft couplings.
 - Sum of the axial capacity of helical bearing plates affixed to pile.
- viii The lateral allowable load capacity of the pile shall be calculated using P-Y analysis and shall be verified with field trials. The allowable design lateral load shall be equal to the min. of
- the total lateral load producing max. lateral deflection of 5mm and
 - 50% of the total lateral load at which the lateral displacement increases to 12mm.
- ix Dimensions of the central shaft and the number, size and thickness of helical bearing plates shall be sufficient to support the design loads.
- x The Design Report shall include following details.
- Design loads
 - Geotechnical Strength Reduction Factors and supporting methodology
 - List of design standards
 - Design methodology and how specific loads such as seismic, lateral and settlement are addressed
 - Founding stratum
 - Estimated length
 - Connection design and details between pile shaft & pile cap plate and Col base plate
 - Pre-production and production load testing to support design including acceptance criteria.
- xi Helical piles shall be installed to specified embedment depth and torsional resistance criteria as per design. The torque applied during installation shall not exceed the maximum allowable installation torque of the helical pile.
- xii Special inspections shall be performed continuously during installation of helical pile foundations. The information recorded shall include installation

equipment used, pile dimensions, tip elevations, final depth, final installation torque and other pertinent installation data as required.

- xiii The installation of piles shall be done by an agency having adequate experience in helical pile construction.
- xiv The method statement for pre-production load testing (initial test) and construction of Helical Pile shall be submitted for review and approval. The method statement shall comply following requirements:

- Helical pile pre-production load testing

The Piling Contractor shall provide a method statement for the pre-production load testing. The method statement shall be submitted 2 weeks prior to pile installation for testing and shall contain the following information (as a minimum):

- a. Program of the testing, detailing the timing and sequence of each load test including any additional investigations proposed
- b. The general arrangement of the equipment
- c. A method for measuring the displacement at the head and toe of each test pile
- d. Template for the Pile load test report
- e. Confirming the criteria for determining the acceptability of the compression, tension and lateral load tests
- f. A contingency plan in the event that a load test is deemed not acceptable
- g. A procedure for verifying the capacity for each individual pile, this may include correlating the installation torque for each pre-production pile with the load test results
- h. All pile load tests shall be supervised by suitably experienced personnel, who are competent to operate, monitor and record each test throughout its duration. Each pile load test shall be continuously monitored throughout its duration.

- Helical Pile Construction

The contractor shall provide a method statement for each piling operation to be undertaken in executing the Works. The method statement shall describe all proposed equipment and detail the construction sequence. The method statement shall be submitted with the tender and shall contain the following information (as a minimum):

- a. Programme of the works, detailing the timing and sequence of individual portions of the works
- b. Full details of the installation plant to be used, including manufacturer's information and proof of servicing/recent upkeep and calibration

- c. Proposed phasing of excavation/filling operations such that the design stresses in the piles (and any supporting frames) are not exceeded
 - d. The contingency plan to be adopted, to minimize disruption and delay, in the event of encountering obstructions
 - e. Anticipated noise levels (measured in dB) and vibration levels (measured in mm/sec) arising from piling operations (if applicable)
- xv The Piling Contractor shall nominate a suitably experienced, professionally qualified engineer, as the “Piling Supervisor”.
- xvi Unless specified else were, the field trials for initial load tests on concrete and helical/ screw pile shall conform to IS: 2911 (Part 4) & Practice Note-28 (IPENZ Engineers New Zealand) as applicable.
- xvii Contractor shall also carry out routine tests on 0.5 % of the total no. of working/ job piles as per provisions of IS: 2911 (Part 4). In case of unsatisfactory results, min. no. of routine tests may be increased up to 2% of the total no. of working/ job piles as per the directions of the Engineer.

11.0 Module Mounting Structure (MMS)

- 11.1 The module mounting structure design shall generally follow the existing land profile. The top of the table shall be in one plane.
- 11.2 In MMS analysis, the column support shall be assumed at EGL/NGL.
- 11.3 The contractor shall carry out detailed study of its effect on array layout, shadow analysis and structural stability of MMS.
- 11.4 The structure shall be designed to allow easy replacement of any module and shall be in line with site requirements.
- 11.5 The MMS stub/ column, rafter, purlin, ties and bracing members shall conform to following Indian standards.
- IS: 2062 – Hot rolled Medium and High tensile structural steel
 - IS: 811 – Cold formed light gauge structural steel sections
 - IS: 1161 – Steel tubes for structural purposes
 - IS: 4923 – Hollow steel sections for structural use
 - Minimum grade of steel for sections conforming to IS: 811 & IS: 4923 shall be E350 conforming to IS: 2062 and YSt 310 conforming to IS: 1608 respectively.
- 11.6 The contractor can also propose new light gauge structural steel or structural aluminum sections other than specified in IS: 811 subject to approval of the Engineer. In this case the contractor shall submit his proposal stating the technical advantages of the proposed sections for Engineer’s review along with supporting

- literature and sample design calculations conforming to present specifications at the time of bidding.
- 11.7 Aluminum-Zinc Alloy metallic coated steel strip or sheet of grade YS350 and minimum coating class AZ200 conforming to IS 15961 : 2012 may also be used for fabrication of purlin sections. In such a case, all the sections of the base metal exposed after cutting of members and punching of holes shall be provided with sprayed aluminium and zinc coating conforming to IS 5905.
- 11.8 The minimum thickness excluding anti corrosive treatment (BMT) of various elements of MMS structure shall be as following:
- Stub/ column – 3.15mm,
 - Rafter – 2.5mm &
 - Purlin – Minimum thickness of the purlin section excluding anti corrosive treatment (BMT) shall be 1.5 mm. Aluminum-zinc alloy metallic coated steel strip or sheet of grade YS350 and min. coating class AZ150 conforming to IS-15961:2012 may also be used for fabrication of purlin sections. In such a case, all the sections of the base metal exposed after cutting of members and punching of holes shall be provided with sprayed aluminum and zinc coating conforming to IS-5905.
 - Other members – 2.0 mm
- 11.9 The primary loads and load combinations for design of MMS structure shall be as specified under Clause No. 8. The design shall be done by Working stress method and no increase in allowable stress shall be permitted.
- 11.10 The maximum permissible deflection/ side sway limits for various elements of MMS under serviceability conditions shall be as following:
- Lateral deflection/ side sway for Column – Span/ 240
 - Vertical deflection for Rafter and Purlin – Span/ 180
 - Lateral deflection for Purlin – Span/240
- 11.11 In case of natural frequency in first mode less than 5 Hz, the design of the MMS structure shall also be checked against dynamic effects of wind as per provisions of IS – 875 (Part-3) using gust factor method.
- 11.12 The purlins shall be provided with min. following tie/sag rods or angles or channels:
- no., in the mid of each span and shall connect all the purlin members
 - no., diagonal, at each corner in end spans
- 11.13 Lateral restraint to compression flange if any due to PV panels is not permitted in purlin design.
- 11.14 The vertical diagonal bracing shall be provided in end spans and every alternate span of each unit (table) of MMS.
- 11.15 MMS shall support SPV modules at a given orientation & tilt and shall absorb and transfer the mechanical loads to the ground properly.

- 11.16 Welding of structure at site shall not be allowed and only bolted connections shall be used.
- 11.17 The MMS structure shall be hot dip galvanized with minimum GSM 610 kg/ sqm and/or minimum coating thickness of 80 microns for protection against corrosion. Galvanization shall conform to IS-2629, 4759 & 4736 as applicable.
- 11.18 It is to ensure that before application of this coating, the steel surface shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or any foreign material likely to interfere with the coating process.
- 11.19 The bidder shall ensure that inner side is also provided with galvanization coating.
- 11.20 The galvanization shall be done after fabrication of members and cutting of holes to ensure galvanization of all cut/ exposed edges.
- 11.21 In case the proposed section is made up of Aluminum, anodized coating shall be Gr. AC25 and shall conform to IS: 1868.
- 11.22 The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels at the same time.
- 11.23 Two numbers of anti-theft fasteners of stainless steel on two diagonally opposite corners for each module shall be provided. All fasteners both for MMS connections and fixing of PV Module shall be adequately protected from atmosphere and weather prevailing in the area.
- 11.24 Fasteners and washers to be used for erection of mounting structures and those for fixing Module over MMS shall be of stainless-steel grade SS 304 with property class A2-70 conforming to relevant ISO standard and must sustain the adverse climatic conditions to ensure the life of the structure for 25 years.
- 11.25 Min. diameter of bolt for MMS connections shall be 10mm (12 mm in case of single bolt connection for seasonal tilt) except at column-rafter connection, where it shall not be less than 12mm (not less than 16mm in case of single bolt connection for seasonal tilt). In case of fixed tilt, min. two number of bolts shall be provided at each joint.
- 11.26 Modules shall be clamped or bolted with the structure properly. The material of clamps shall be Al / SS having weather resistant properties. Clamp/bolt shall have EPDM rubber washer and shall be designed in such a way so as not to cast any shadow on the active part of a module.
- 11.27 The MMS foundation shall be designed as per Cl. No. 10.
- 11.28 MMS column post supported on secured foundation shall be fixed with galvanized high strength "J" bolts conforming to specifications of IS: 4000/ IS: 1367 and relevant IS code Installation of foundation bolts and embedment of column leg in foundation concrete shall be done by using template to ensure proper alignment or Column post would be embedded inside the pile directly and then pile is casted. The underside of base plate shall be provided with anti- shrink grout.
- 11.29 In case the contractor proposes to extend the column leg to embed it in the pile/pedestal as an alternate fixing arrangement, the column member shall be extended for full depth of the pile (100mm cover at tip of the pile) with an end plate of min. 4mm thickness to be welded at the bottom of column leg. (However, for plants in coastal area or in case of marshy soil the column post shall be supported

- only with base secured to foundation through base plate and anchor bolt assembly and no embedment of column leg in foundation is permitted)
- 11.30 The array structure shall be grounded properly using maintenance free earthing kit.
- 11.31 The bidder/manufacturer shall specify installation details of the PV modules and the support structures with appropriate diagram and drawings.
- 11.32 The Bidder should design the structure height considering highest flood level at the site and the finished grade level. The minimum clearance between the lower edge of the module and the finished grade shall be the higher of
- i Highest flood level + 100mm and
 - ii 500 mm, as applicable
- 11.33 The length of one unit (Table) of MMS shall not generally be more than 20m.
- 11.34 The contractor shall submit the detailed design calculations and drawings for MMS structure, bill of materials and their specifications/ standards to the Employer for approval before start of fabrication work as per the engineering work program (L2 schedule) as finalized during kick-off meeting.
- 11.35 The length of any cold formed section (CFS) shall not be more than 5.5 m.
- 11.36 The front and back bracing members shall be connected to rafter or column through gusset plate and shall not be connected directly to the column or rafter.
- 11.37 The purlin splice shall be near the zone of contra-flexure, i.e. within a distance of 0.15L to 0.25L from the support, where L is the respective span within which splicing is located.
- 11.38 The purlin splice shall comprise of flange and web splice plates and splice design shall conform to Annexure-F of BIS:800. For simplicity in fabrication, the splice member may be of CFS channel section without lips (CU). There shall be min. four number of bolts on either side of joints in web zones and one number of bolt on either side of joint in flange zones.
- 11.39 For same member type, same section shall be used.
- 11.40 When any sag or tie member to the purlin (rod, angle or channel) is provided, it shall not be considered in modelling the structure for analysis except its effect as lateral support to the purlin members in strength design.

12.0 Concrete Works

- 12.1 Construction of all RCC works shall be done with approved design mix as per IS 456 and the materials used viz. Cement, coarse & fine aggregate, Reinforcement steel etc. shall conform to relevant BIS standards.
- 12.2 The min. grade of concrete shall be M25 (M30 in coastal areas/marshy soil) for all RCC works except liquid retaining structures like underground water tank, septic tank, etc. where minimum grade of concrete shall be M30 (M35 in coastal areas/marshy soil).
- 12.3 Cement higher than 43 Grade shall not be used in construction.

- 12.4 Unless otherwise specified elsewhere, PCC shall be of min. grade M10 (nominal mix 1:3:6) except for mud mat, back filling of ground pockets or leveling course which shall be of grade M7.5 (nominal mix 1:4:8).
- 12.5 Reinforcement steel shall be of high strength TMT bars of grade Fe500 D conforming to IS: 1786.
- 12.6 Unless specified otherwise for grouting works anti shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound shall be used. The grout shall be high strength grout having min. characteristic strength of 35 N/mm² at 28 days.

13.0 Miscellaneous Steel Works

- 13.1 Unless otherwise specified elsewhere, all structural steel work shall be designed as per provisions of IS: 800 with working stress method of design (WSD) or limit state method of design (LSM).
- 13.2 Structural steel hot rolled sections, flats and plates shall conform IS: 2062, structural Pipes shall be medium (M)/ high (H) grade conforming to IS: 1161, chequered plate shall conform to IS: 3502 and Hollow steel sections for structural purposes shall conform to IS: 4923.

14.0 Building, Plinth for Open Installations and Others

- 14.1 Plant buildings and plinth for open installations are required to be constructed for housing the electrical equipment/ panel, Control room cum office cum store for operation and maintenance of the Plant. Security room to secure the plant from any theft/ burglary/unauthorized entry.
- 14.2 Unless otherwise specified elsewhere, all buildings and plinth for open installations except Security room/ cabin shall have RCC framed structure. Masonry partition walls shall be provided for Kitchen, Pantry, Battery room and Toilet units. For other rooms AL Glass partitions shall be provided. The plinth for open installations and equipment area shall be designed with OEM requirements. The security room/ cabin(s) shall be of prefabricated structure.
- 14.3 All buildings shall have provision of adequate windows for natural light & ventilation, fire safety provisions and shall be designed as per provisions of National building code (NBC).
- 14.4 The contractor shall submit the proposed equipment layout drawings to the Engineer for approval before development of Architectural drawings. The building layout, exterior elevations shall be aesthetically designed following good architectural practices to get a pleasant look. Horizontal/ vertical bands through projections/ groves in external plaster may be provided to break the monotony. Roof slab shall have projection of 450mm beyond external walls with RCC parapet wall of 450 mm clear height all-around which shall form a projected band at roof

level. For weather protection all doors and windows shall be provided with 450mm wide RCC chajja. However, chajja for rolling shutter shall be 750mm wide.

- 14.5 The PEB shall be made of structural steel construction with double skinned metal roofing and wall cladding of appropriate profile. PEB shall be complete with painting, metal fascia, metal gutter, rain water down comers, sun-shades, openings, etc., along with associated structural steel, cladding and roofing work insulation, Trims & Flashings. Each item of PEB like panels, masonry, plastering, flooring, foundation, fittings etc. shall be suitable for complete life of solar plant. The construction methodology for PEB shall also be submitted to the Employer/Owner for approval before start of works.

Component	Description	Reference Standard
Primary Structural Members: including the transverse rigid frames, columns, corner columns, end wall wind columns, beams, truss member, base plate.	Steel frame members with minimum thickness 4 mm with minimum yield strength of 345 MPa	IS2062 min Grade E250 Quality BR/ ASTM A572-12 Grade 50
Secondary Members: including the purlins, Girts, eave struts, bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.	Minimum thickness 3.15 mm members shall have minimum yield strength of 250 MPa.	IS 811 or ASTM A1003-12 steel sheets conforming to ASTM A1011-12b Grade 50
Wall Cladding	Insulated wall cladding or roofing shall consist of double skin metal cladding with Poly Urethane Foam (PUF). PUF must be made of continuous method PU foam and must be CFC free, self-extinguishing, fire retardant type with density 40 +/-2 kg/m ³ and thermal conductivity 0.019-2.2 W/(m.K) at 10°C. The PUF panels shall be a factory made item ready for installation at site.	
Design Parameters and Design Loads		
	Self-Weight of Structure including Purlins, Sheeting, Girts, Bracings, weight of turbo ventilators to be added as Dead load etc.	

Dead Load	Imposed Load (Live Loads) Live loads shall be as per IS – 875. For sloped roofs up to 10 deg. it shall be 0.75 kN/m ² .
Wind Load	Design wind speed factors shall be as per IS: 875-III, however the minimum value of these factors shall be considered as K1 = 1.0, K2 = 1.0 & K3 = 1.0 for the design of PEB.
Earthquake Load	All PEB structures shall be designed for Seismic forces. Vertical Deflection and Horizontal Sway Limits: Limiting Deflection: The limiting permissible vertical deflection for structural steel members shall be as per IS 800 2007. The limiting permissible horizontal deflection for as per IS 800 2007 code where 'h' is height of building at eaves.
Paint and Coating	Steel shall be colour coated with total coating thickness of 25 microns (nominal) dry film thickness (DFT) comprising of silicon modified polyester (SMP with silicon content of 30% to 50 %) paint or Super Durable Polyester (XRW) paint of 20 microns (nominal) on one side (exposed face) on 5 micron (nominal) primer coat and 10 microns (nominal) SMP or Super Durable Polyester paint over 5 micron (nominal) primer coat on other side. SMP and polyester paints system shall conform to Product type 4 as per AS/ANZ 2728. The structural steel shall be hot-dipped galvanized, conform to IS: 4759 or relevant Indian standard
Plinth Protection	750mm wide plinth protection minimum 75 mm thick of cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) over 75 mm bed of dry brick ballast 40 mm nominal size well rammed and consolidated and grouted with fine sand including finishing the top smooth, shall be provided around the Pre- Engineered Building.
Rolling shutter	Rolling shutter (Hand operated) shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling centres with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS:2108 and shall be designed to withstand a wind load without excessive deflection. Metal rolling shutters and

	rolling grills as IS: 6248.
Windows Frame	Aluminium black powder coated section, frame shall be of 92x31 mm, minimum 16G thick as per approved design. Tinted glass and aluminium grill shall be provided.
Roof Insulation and type	Both metal sheets shall have an under insulation of minimum 70 mm thick PUF with density 40 +/- kg/m ³ and thermal conductivity 0.019-2.2 W/(m.K) at 10°C with gutters and down take pipes along with Flashing & Top cap of required size and colour complete with all necessary hardware. Roof shall be projected at-least 300 mm from the wall. Stiffening ribs / subtle fluting for effective water shedding and special male / female ends with full return legs on side laps for purlin support and anticapillary flute in side lap shall be provided. Both upper and lower sheets shall be separated through spacers and fastened through zinc /zinc-tin coated self- drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations. Contractor may also alternatively make the PEB roofing with composite slab (RCC slab with permanent formwork). The composite slab scheme, design and drawings shall be subject to approval from Employer/Owner before start of work.
Wall Insulation	All voids of external and internal metalled walls shall have an under insulation of minimum 60 mm thick PUF with density 40 +/- kg/m ³ and thermal conductivity 0.019-2.2 W/(m.K) at 10°C with proper supports etc. as approved. Both the walls should be separated by spacers system made up of cold formed steel bars and fastened through zinc /zinc-tin coated self-drilling screws.

- 14.6 In case of presence of termites at the project site, an anti-termite treatment shall be provided for all foundation pits and building plinth in MCR building conforming to IS:6313 to control entry of termites.
- 14.7 Painting and white wash/ colour wash for the buildings shall conform to relevant BIS standards. The make and colour shade of the finish shall be as advised and approved by the Engineer.

15.0 Fire Extinguishers, Sand buckets and Sign Boards and Danger Boards

- 15.1 All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. LiquefiedCO₂/ foam/ ABC type fire extinguisher shall be upright type of capacity 10kg conforming to IS: 2171, IS: 10658.
- 15.2 The fire extinguisher shall be suitable for fighting fire of Oils, Solvents, Gases, Paints, Varnishes, Electrical Wiring, Live Machinery Fires, and all Flammable Liquid & Gas.
- 15.3 Sand buckets shall be wall mounted made from at least 24SWG sheet with bracket fixing on wall conforming to IS: 2546.
- 15.4 All buildings shall be provided with required no. of sand buckets as per relevant BIS standard and NBC. 4 No. of Bucket stands with four buckets on each stand shall be provided in the Transformer Yard.
- 15.5 The sign board containing brief description of major components of the power plant as well as the complete power plant in general shall be installed at appropriate locations of the power plant as approved by Engineer.
- 15.6 The Signboard shall be made of steel plate of not less than 3 mm. Letters on the board shall be with appropriate illumination arrangements.
- 15.7 Safety signs, building evacuation plan and direction signs, assembly points shall also be placed at strategic locations.

16.0 Transformer Yard Civil Works

- 16.1 Transformer and equipment foundations shall be founded on block foundation depending on the final geotechnical investigation report and functional requirements.
- 16.2 In case of transformer oil tank capacity ≥ 2000 litres, the transformer foundation shall have its own soak pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil in case of emergency. The retention capacity of the soak pit shall be equal to volume of the transformer oil (excluding free space above gravel) and it shall be filled with granite stone gravel of size 40mm, uniformly graded, with 200 mm free space above gravel fill.
- 16.3 In case of transformer oil tank capacity more ≥ 20000 litres, the soak pit shall be connected to a separate burnt oil pit through discharge pipe (300 mm dia) and shall be suitably sized to accommodate full oil volume (excluding free board above inlet pipe) of the transformer connected to it, without backflow. In this case the capacity of the soak pit may be reduced to min. 1/3rd of the total transformer oil volume. The burnt oil pit shall be further connected to oily water drainage system. The water shall be discharged into the nearest drain by gravity flow or pumping after suitable treatment as per statutory and code provisions.
- 16.4 Both, the transformer soak including side walls and the burnt oil pit shall be of RCC and shall be provided with sump (min. 500 mm x 500 mm x 400mm deep) and slope of 1:50 in concrete screed of 1:1 – ½:3 to the floor slab towards the

- sump pit. The oil collection pit shall be provided with 20mm dia. MS rung ladder with 2 coats of epoxy paint over 2 coats of primer, a manhole & removable RCC cover. The inside of oil collection pit shall be plastered with 6 mm thick CM 1:6 and painted with 2 coats of epoxy paint over 2 coats of primer.
- 16.5 The area around the transformer and equipment shall be covered with uniformly graded granite stone gravel of size 40mm.
- 16.6 The area shall be provided with galvanized chain link fence of height min 1.8m with 3.75m wide gate. The Chain link fencing (diamond shape) shall be as per Code No. 16.70.1 of DSR -2018.
- 16.7 The Gate of size 3.5m shall be of MS pipe (medium class conforming to IS: 1161) frame with hard drawn steel wire fabric mesh (50x50mmx3mm thick conforming to IS: 1566) including all accessories and fittings. MS angle posts shall conform to IS 2062.
- 16.8 In addition to main gate a wicket gate of MS pipe (medium class conforming to IS: 1161) frame with 1.0 m width with hard drawn steel wire fabric (50x50x3mm thick conforming to IS: 1566) shall be provided for man entry for maintenance purpose.
- 16.9 The transformer yard fencing work shall conform to CEIG requirements.
- 16.10 The requirement of fire barrier wall between transformers shall be as per Electricity Rules and IS: 1646 recommendations. Minimum wall thickness shall be 230mm for RCC wall and 300mm for masonry wall.

17.0 Potable Water Supply & PV Module Cleaning System

- 17.1 The contractor shall design and install the effective module cleaning system.
- 17.2 A regular supply of suitable quantity of water shall be ensured by the contractor to cater day-to-day requirement of drinking water and for cleaning of PV modules during entire O&M period. The Contractor is advised to ascertain the availability of good quality ground water at site for construction, drinking and module cleaning purpose. In case of non-availability of ground water source, the contractor shall explore the option of supply of water through water tankers. In case the water quality is not suitable for drinking or module cleaning purpose, the Contractor shall install suitable water treatment facilities.
- 17.3 The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at least once in two week or at closer frequency as per the soiling conditions prevailing at site, in order to operate the plant at its guaranteed plant performance. The contractor shall construct underground / over ground water storage with minimum capacity of 5 KL for each LCS or of the capacity required for one time cleaning of all the panels whichever is higher. Successful bidder shall submit the detailed calculation for the same and take approval from the employer / CMPDI.
- 17.4 Water used for drinking & PV module cleaning purpose shall generally be of potable quality and fit for cleaning the modules with TDS generally not more than 75 PPM. In case of higher salt contents, the water shall be thoroughly squeezed off to prevent salt deposition over module surface. However, water with TDS more

- than 200 PPM shall not be used directly for module cleaning without suitable treatment to control the TDS within acceptable limits. The water must be free from any grit and any physical contaminants that could damage the panel surface.
- 17.5 If required, for settlement of any grit/ unacceptable suspended particles in the water a settling tank shall be installed before the inlet of the storage tank. Suitable arrangement for discharge/ disposal of sediment/ slush shall be provided in silting chamber by gravity disposal in surface drain or with provision of sludge sump and pump of adequate capacity.
- 17.6 The module cleaning system shall include construction of RCC tank or supply and installation of Ground mounted PVC tank (s) of required storage capacity, pumps (including 1 No. standby pump), water supply mains and flexible hose pipes, taps, valves (NRV, Butterfly valve, Ball valve, Gate valve, PRV, scour valve etc.), Water hammer arrester(s), pressure gauge, flow meter etc. as per the planning & design.
- 17.7 In case of over ground water storage tank, the contractor shall check its effect on plant performance through shadow analysis. The PVC storage tank shall conform to IS: 12701. The valves shall conform to IS: 778. A suitable metal sheet canopy for protection from direct sunlight shall be provided over the tank area.
- 17.8 The water supply mains could be either of GI, uPVC or HDPE, however, the vertical pipe connecting supply main to the discharge point shall be of GI.
- 17.9 Masonry chamber shall be provided for Main gate valve at pump end. Whereas, as per requirements, at other locations either a masonry or GI/ HDPE pipe chamber may be provided.
- 17.10 Module cleaning procedure and pressure requirement at discharge point shall be as per the recommendation of PV module manufacturer. However, discharge pressure at outlet shall not be less than 5 kgf/cm²(0.5 MPa)
- 17.11 All the pipes thus laid shall be buried in ground at least 150mm below FGL or laid above ground clamping on suitable concrete support blocks. In case of above ground piping only GI pipes shall be used.

18.0 Underground Water Tank

- 18.1 The top of the UG tank shall be 250 mm above FGL.
- 18.2 The tank shall have clear free board of 300mm above MWL.
- 18.3 The tank bottom shall have a slope of 1:100 towards drainage sump (500x500x500 mm deep). The slope shall be provided either in structural slab or in screed concrete (1:2:4) trawl finished. 1000x1000 mm size Manhole in roof slab and 20 mm MS rung ladder shall be provided for easy access to the storage tank and silting chamber for periodic cleaning. The manhole shall be covered with RCC precast cover. 50x50x6 mm MS angle with lugs shall be provided around precast cover and tank slab opening for edge protection. Rungs shall be painted with 2 coats of epoxy paint over 2 coats of primer.
- 18.4 The underground RCC tank shall be designed for following load conditions:

- i External earth pressure + hydrostatic pressure due to ground water table (to be considered at FGL for design purposes) + Surcharge of 20 kN/ Sqm and Tank Empty.
 - ii Tank full up to MWL and no external loads
- 18.5 The design shall conform to IS: 3370 with maximum crack width of 0.1mm for wall, bottom slab and roof slab. Min. grade of concrete shall be M30 (M35 in coastal areas, marshy and saturated soils) conforming to IS: 456. Suitable construction joints shall be provided as per provisions of IS: 3370 (Part 1). Water proofing admixture conforming to relevant BIS standard and of approved make shall be added to concrete as per manufacturer's recommendations.
- 18.6 The underground water tank shall be tested for water tightness as per the provisions of IS 3370 (Part-4). In case any leakage is noticed the same shall be repaired by injection of cement grout installing suitable nozzles around affected areas. Outside face of water tank in contact with water and soil and underside of roof slab shall be painted with 2 coats of epoxy paint.

19.0 General

- 19.1 The Contractor is advised to ascertain the availability of good quality ground water at site for construction, drinking and module cleaning purpose. In case of non-availability of ground water source, the contractor shall explore the option of supply of water through water tankers. In case the water quality is not suitable for drinking or module cleaning purpose, the Contractor shall install suitable water treatment facilities.
- 19.2 The Contractor is advised to inspect the sites and study the nature of soil, topography and other conditions to decide the extent of scope of area grading, ground compaction, and foundation system to be provided before submission of the Bid. The Employer shall not be responsible for any variations in soil characteristics and other conditions, between those observed during preliminary site visit and detailed investigations to be carried out by the Contractor during contract execution.

CHAPTER-VI

PROCEDURE FOR PLANT TESTING, COMMISSIONING PERFORMANCE GUARANTEE TEST AND MANDATORY SPARES

This document lays down the procedures, requirements and templates for conducting commissioning tests and inspection of the Plant Facilities after installation and for subsequent re-inspection, maintenance or modifications in accordance with the Tender Specifications, IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection)- and industry best practices.

1.0 Codes and Standards

1.1 The Testing and Commissioning Procedures shall, in general, comply with the following standards:

- i IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection).
- ii IEC 60364-6:2016 - Low voltage electrical installations - Part 6: Verification.
- iii IEC 61829:2015: Photovoltaic (PV) array - On-site measurement of current-voltage characteristics.
- iv IEC 60904-4:2019 Photovoltaic devices - Part 4: Reference solar devices - Procedures for establishing calibration traceability.
- v IEC TS 60904-1-2:2019 - Photovoltaic devices - Part 1-2: Measurement of current- voltage characteristics of bifacial photovoltaic (PV) devices
- vi IEC 62305-3– Protection against lightning - Part 3: Physical damage to structures and life hazard.
- vii IS/IEC 61557: Part 2: 2007 - Electrical safety in low voltage distribution systems up to 1000 V ac and 1500 V dc - Equipment for testing, measuring or monitoring of protective measures: Part 2 insulation resistance.

2.0 Commissioning

2.1 The Commissioning Procedure defined in this document aims to:

- Verify that the power plant is structurally and electrically safe.
- Verify that the power plant is structurally and electrically robust to operate for the specified lifetime of a project.
- Verify that the power plant operates as designed and its performance is as expected.

2.2 General Requirements before Starting the Commissioning Process

- The modules shall be stabilized (sufficiently exposed after 200 kWh/m² reaching the PV plane)

- The tests shall be conducted under stable weather conditions
- The process shall be witnessed by the Owner or their duly appointed representative.
- Soiling losses shall not be accounted for in the assessment of Results. Therefore, adequate Module cleaning exercise shall be undertaken prior to commencement of Commissioning process.
- The required equipment such as Earth resistance tester, IV curve tracer, Insulation tester, Digital multimeter, Clamp meter, Digital lux meter etc. shall be used during the commissioning process.

All testing equipment shall possess valid calibration certificate issued from approved laboratories.

3.0 Procedure for Performance Testing

- 3.1 The Contractor shall meet the ‘Net Electrical Energy Generation Guarantee’ as specified in this tender on annual basis considering the Reference Global Average Radiation. The Contractor shall demonstrate “Actual Delivered Energy” at feeding point as compared to the ‘NEEGG’ for every year from the date of starting of O&M Period.
- 3.2 Performance Ratio as determined through the PR Test Procedure specified here should not be less than 0.75 during Performance Guarantee Acceptance Test. However, the bidder shall ensure “actual delivered energy” at feeding point shall be as per the NEEGG mentioned in the Volume-I of the NIT.
- 3.3 The Performance Ratio Test to prove the guaranteed performance parameters of the power plant shall be conducted at site by the Contractor in presence of the Company’s authorized representative. These tests shall be binding on both the parties to the contract to determine compliance of the equipment with the guaranteed performance parameters. This monitoring will be performed on the site under the supervision of the Company/ Company's representative.
- 3.4 The test will consist of guaranteeing the correct operation of the plant over 30 days, by the way of the efficiency rate (performance ratio) based on the reading of the energy produced and delivered to the grid and the average incident solar radiation. PR shall be demonstrated against the installed DC Capacity.
- 3.5 The Efficiency or performance ratio (PR) of the PV Plant is calculated as follows (according to IEC 61724)

$$PR = \frac{Y_A}{Y_R} * [1 - \alpha * (T_{average} - T_{cell})]$$

$$Y_A = E_{ac} / P_{Nom}$$

$$Y_R = IR_{Site} / IR_{STC}$$

Where;

Y_A = Final PV system yield (representing the number of hours that the system would need to operate at its rated output power P_{Nom} to contribute the same energy to the grid as was monitored).

Y_R = Reference yield (representing the number of hours during which the solar radiation would need to be at STC irradiance levels in order to contribute the same incident energy as was monitored).

E_{ac} = AC energy injected into the grid during a clearly specified amount of time (kWh).

P_{Nom} = Installed nominal peak power of modules (Nameplate rating at STC) (kWp);

IR_{Site} = Irradiation on the module plane of array during a clearly specified amount of time (measured with a pyranometer installed on the plane of array, POA) (kWh/sq. m)

IR_{STC} = Irradiance at STC (kW/ sq. m); 1000W/m²

$T_{average}$ = Average cell/ module temperature (°C) over a period of time.

T_{cell} = STC cell/ module temperature (°C); 25°C

α = Temperature coefficient of power (negative sign) corresponds to the installed module(%/°C) (as per PV Module Datasheet)

3.6 In case the pyranometer is found to be working erratically then immediately the Contractor shall take necessary steps to rectify and/or recalibrate the instrument to the satisfaction of CMPDI/WCL. However, for the dispute period for which such error has occurred and until the instrument is recalibrated to the satisfaction of CMPDI/WCL, data from any one of the following list of sources as decided by CMPDI/WCL will be used:

- A separate pyranometer installed by the Contactor near the site, if available.

OR

- Average of two closest solar power projects, as identified by CMPDI/WCL.

OR

- Nearest weather station of a Govt. entity.

3.7 “Actual Delivered Energy” from the plant supplied by the Contractor shall be noted for every month and summed up for entire year. For this purpose, the net delivered energy at the feeding point (Injecting Substation) shall be taken into account.

- 3.8 The measured value of energy shall be compared with 'Minimum NEEGG' value for each Contract Year.
- 3.9 Modules alignment and tilt angle shall have to be calculated to provide the maximum annual energy output.
- 3.10 Average Global Horizontal Irradiation of the proposed area is as tabulated below:

Sl. No.	Area	Solar Radiation (kWh / m2)
1.	Kanhan area	1775.61

- 3.11 The Contractor shall share with CMPDI/WCL all the radiation, generation, etc. parameters details and all other factors necessary for CMPDI/WCL to corroborate the estimate. CMPDI/WCL has the right to cross verify data submitted by the Contractor by all possible means/sources.

4.0 Performance Guarantee Test / Underperformance / Loss of Generation during Operation and Maintenance

- 4.1 The available instrumentation and control equipment will be used during such tests and the engineer-in-charge or his/her authorised representative will ensure calibration of all such measuring equipment and devices as far as practicable. However, unmeasurable parameters shall be taken into account in a reasonable manner by the engineer-in-charge or his/her authorised representative. The engineer-in-charge or his/her authorised representative will apply proper corrections in calculation, to take into account conditions, which do not correspond to the specified conditions.
- 4.2 Any special equipment, tools and tackles required for the successful completion of the performance guarantee tests shall be provided by the contractor, free of cost. The accuracy class of the instrumentation shall be as per the relevant clause of documents.
- 4.3 A Performance Ratio Guarantee test shall commence within 60 days of the commissioning of Plant Facilities to demonstrate that the plant has achieved minimum 0.75 Performance Ratio. This will be one of the pre-conditions for the Plant Operational Acceptance. Performance Ratio (PR) test period would be continuous measurement of 30 consecutive days. The test shall be conducted in accordance with the IEC-61724. The report shall contain all the measured energy and Met data values, calculations, results and conclusions.
- 4.4 Any extension of time beyond the above 60 days shall be mutually agreed upon. The PG test shall be conducted based on PG test procedure to be submitted by the contractor and approved by CMPDI/WCL. This test shall be binding on all the parties of the Contract to determine compliance of the equipment with the functional guarantee.

- 4.5 Performance Ratio should be shown minimum of 75% at the time of performance guarantee for initial commissioning acceptance. The PR will be measured at Inverter output level.
- 4.6 During this PR test, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of a breakdown, the test may be resumed once the complete system is rectified and working properly.
- 4.7 Interruptions due to communication breakdown only may be exempted based on specific approval to the effect that generation is not affected and in case of equipment failure, the test shall be extended for affected no. of days, up to 5 days.
- 4.8 Effect of any meteorological parameters on guaranteed generation shall not be considered except of solar radiation.
- 4.9 The measured global solar radiation of the period for the outage of the power evacuation system shall be excluded to calculate the cumulative global Insolation for the month. Under such situation, the radiation corresponding to the warm-up time of inverter as per data sheet shall also be adjusted to arrive at the cumulative global insolation for the month.
- 4.10 **For 70 MW solar power plant, at the time of the Guaranteed Performance Test, any shortfall in the Performance Ratio (PR) (minimum of 0.75) will attract imposition of Penalty. For any shortfall in PR below 0.75 by the bidder, a penalty of 1% of the EPC Contract Value (including taxes & duties) shall be levied (i.e., 1% penalty will be imposed in case the Contractor fails to achieve minimum 0.75 performance ratio).**
- 4.11 The guaranteed performance figures of the plant shall be proved by the contractor during the performance guarantee tests. Should the results of these tests show any decrease from the guaranteed values, the contractor shall take corrective measures, to modify the equipment as required to enable it to meet the guarantees. All cost for modifications including labour, materials and the cost of additional testing to prove that the equipment meets the guarantees, shall be borne by the contractor.
- 4.12 In case the PR tested as mentioned above remain below than 0.75, the Contractor shall make all necessary corrections in minimum possible time and again commence the above test, within 7 days, so as to demonstrate the PR equal to or more than 0.75. Each time, the penalty at the rate specified above in **Clause No. 4.10** shall be levied on the Contractor. The penalty shall be deducted from the Bank Guarantee and pending payments.
- 4.13 **Calculation of the Energy loss due to the Grid Failure/Outage**
Generation loss due to Grid outage for the reason not attributable to the Contractor, Energy loss for that period of the outage shall be excluded to calculate the total energy generation from the plant. Any instances of grid failure need to be mentioned in the monthly report and those instances need to be authorised by Engineer-in-charge or his/her authorized representative. A separate Register shall be maintained by the bidder throughout the contract Period to record such events

with relevant details like Timing, Cause and the Measured Average GHI values etc. at the time of grid failure as tabulated below:

Sl. No.	Days of a Month	Time at which the grid failure in	Time at which Value after inverter is in Sleep Mode	Total time of grid outage/ Failure (in minutes)	Average Solar Radiation (Tilted Plane)- kWh/m ² at time of grid failure	Energy Loss due to the Grid failure (in kWh)
1.	1 st	T1	T2	T=T2-T1	ASR	EL
2.	2 nd					
3.	3 rd					
29	29 th					
30	30 th					
31	31 st					
Average						

Energy loss will be calculated by considering the **Performance Ratio (PR) of previous day for the subsequent period** for the grid failure time period (T) as under:

Energy loss (EL) in (kWh) = [PR x ASR x A x PV Module Efficiency]

Where,

PR - Performance Ratio (P.R.) of previous day for the subsequent period.

ASR- Average Solar Radiation (Tilted Plane)- kWh/m²

A - Active area of the PV module (m²)

- 4.14 Energy loss due to the Grid Failure/Outage as mentioned in **Clause 4.13** shall be adjusted with the '**Minimum NEEGG**' while calculating the shortfall in energy. Therefore, the compensation of units (kWh) for under-generation shall be as follows:

'Under-Generation(kWh)' = ['Minimum NEEGG' - Energy loss (EL) due to Grid Outage]

- 4.15 Penalty on underperformance shall be charged on the Minimum NEEGG. For each Contract Year, the Contractor shall demonstrate "Actual Energy Delivered" at the Feeding Point as compared to the Minimum NEEGG.

If for any Contract Year, during O&M period it is found that the "Actual Delivered Energy" is less than 'Minimum NEEGG' (as mentioned in NIT; Vol-I) for the particular year, the Contractor shall pay the compensation to WCL with an amount equivalent to INR (Average Industrial Energy Charge Rate in INR/kWh payable by WCL to the DISCOM x1.5) per kWh for 'Under-Generation(kWh)'.

- 4.16 'Average Industrial Energy Charge Rate' during O&M period will be calculated as under:

Sl. No.	Parameter	Denotation
1.	Energy Rate (INR /kVAh) (Averaged over preceding twelve months)	A
2.	Power Factor @ 0.9 (Fixed)	B
3.	Electricity Duty charges (in percentage) (as applicable)	C
4.	Average FPPPA / FCA Charges (in percentage) (as applicable)	D
5.	Other levies/Duties/Charges (INR /kWh) (as applicable)	E
Average Industrial Energy Charge Rate (Rs. /kWh) = [(A/B)*{1 + (C/100) + (D/100)}] + E		

Example:

The following example will further clarify the methodology of calculating 'Average Industrial Energy Charge Rate' of the particular year.

Sl. No.	Parameter	Denotation	Values
1.	Energy Rate (INR /kVAh) (Averaged over preceding twelve months)	A	7
2.	Power Factor @ 0.9 (Fixed)	B	0.9
3.	Electricity Duty charges (in percentage)	C	40%
4.	Average FPPPA / FCA Charges (in percentage)	D	10%
5.	Other levies/Duties/Charges (INR /kWh)	E	0.1
Average Industrial Energy Charge Rate (INR/kWh) = [(7/0.9)*{1 + (40/100) + (10/100)}] + 0.1			
= INR 11.766/kWh			

Therefore, Average Industrial Energy Charge Rate in the above example is **INR 11.766 per kWh.**

- 4.17 Locations/sites indicated in the NIT may vary depending upon the actual site and if requires, another suitable location/sites may be decided in consultation with WCL to meet the proposed installed capacity.
- 4.18 In case the Project fails to generate any power continuously for three months any time during the O&M period, it shall be considered as an "Event of Default".
- 4.19 Upon occurrence of any Event of Default mentioned in **Clause 4.18** herein above, WCL shall have the right to encash the entire amount of Performance Guarantee (as per clause no. 21.3, Section-II, Instructions to bidders) and withheld any other pending payment.
- 4.20 The Company reserves the right to perform random audits of the plant anytime during the entire O&M period. If any discrepancy is found between the measured parameters, the difference between the measured parameters by WCL from secondary sources and the weather monitoring system installed by the Contractor

at the site will be factored in calculating the adjusted NEEGG during the entire year. However, WCL will have the final authority to decide on this matter.

5.0 Handing over of the Plant

- 5.1 At the end of the contract period, the contractor shall hand over the plant and equipment back to the owner in completely safe and healthy condition and without any pending defect.
- 5.2 The items supplied by WCL on returnable basis, spares parts (from mandatory spares), consumables, tools, documents etc. shall be returned back to WCL. Else suitable recoveries shall be made from the Contractor's bills.
- 5.3 After O&M period, WCL may at its discretion decide to extend the existing O&M contract on mutually acceptable terms & conditions or undertake the O&M of the Solar Power Plant on its own.

6.0 Safety Management

- 6.1 Bidder shall follow safety procedures for the safety of the personnel and the equipment during erection, testing, commissioning, operation and maintenance (O&M) during the contract period as per the regulatory requirements and the as per the original equipment manufacturer's recommendations.
- 6.2 All the expenses, charges towards compliance of the safety norms by the bidder are deemed to be included in the bid price. No additional claims shall be entertained towards meeting the safety requirements.
- 6.3 Safety sign board to be provided near outdoor transformer yard, HT switchgear and all such risk zone areas.

7.0 Mandatory Spares

- 7.1 The general requirements pertaining to the supply of mandatory spares is as follows.
- 7.2 Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the project, unless specified otherwise, and the fraction will be rounded off to the next higher whole number.
- 7.3 The Owner reserves the right to buy any or all the mandatory spares parts.
- 7.4 Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise.
- 7.5 Wherever the requirement has been specified as a 'set' it will include the total requirement of the item for a unit, module or the station or as specified.
- 7.6 Spares, if used, during the O&M period shall be replenished by the Contractor.
- 7.7 All the mandatory spares shall be handed over to the Employer in working condition at the end of O&M period.
- 7.8 The Bidder shall include in his scope of supply all the necessary Mandatory spares as described below in the table or elsewhere in the tender document. These

mandatory spares are not limited as per the table shown below, if required more, that may also be considered during bidding process by the bidder.

Sl. No.	Equipment/Material	Quantity (for each type and rating)
1.	PV Modules	0.5% of total supply
2.	String Monitoring Unit	1% of total supply
3.	Connectors (including Y-connector if used)	1% of total supply
4.	Power Conditioning Unit	
i)	String Solar Inverter (Ground Mounted)	As per OEM recommendation
ii)	Solar Inverters (Roof Top), if Applicable	As per OEM recommendation
5.	Inverter Transformer (For each LCS)	
i)	HV bushing with metal parts and gaskets	1 set
ii)	LV bushing with metal parts and gaskets	1 set
iii)	Complete set of gaskets	1 set
6.	HT Switchgear (For each LCS)	
i)	Vacuum pole	1 set
ii)	Closing coil	1 no.
iii)	Tripping coil	1 no.
iv)	Spring charging motor	1 no.
v)	Relay	1 no.
vi)	Current Transformer	1 no.
vii)	Voltage Transformer	1 no.
viii)	MCCB	1 no.
ix)	MCB	1 no.
x)	Fuse	10% of total supply
xi)	Indicating lamp	10% of total supply
xii)	Push button	10% of total supply
xiii)	Rotary switch	10% of total supply
7.	LT Switchgear (For each Location)	
i)	Fuse	10% of total supply

Sl. No.	Equipment/Material	Quantity (for each type and rating)
ii)	Relay	1 no.
iii)	Current Transformer	1 no.
iv)	Voltage Transformer	1 no.
v)	Indicating lamp	10% of total supply
vi)	Push button	10% of total supply
vii)	Rotary switch	10% of total supply
8.	Solar Cable	5% of total supply
9.	DC Cable	5% of total supply
10.	AC Cable	5% of total supply
11.	Communication Cable	5% of total supply

Annexure and Drawing

List of equipment for Main Control Station (MCS)

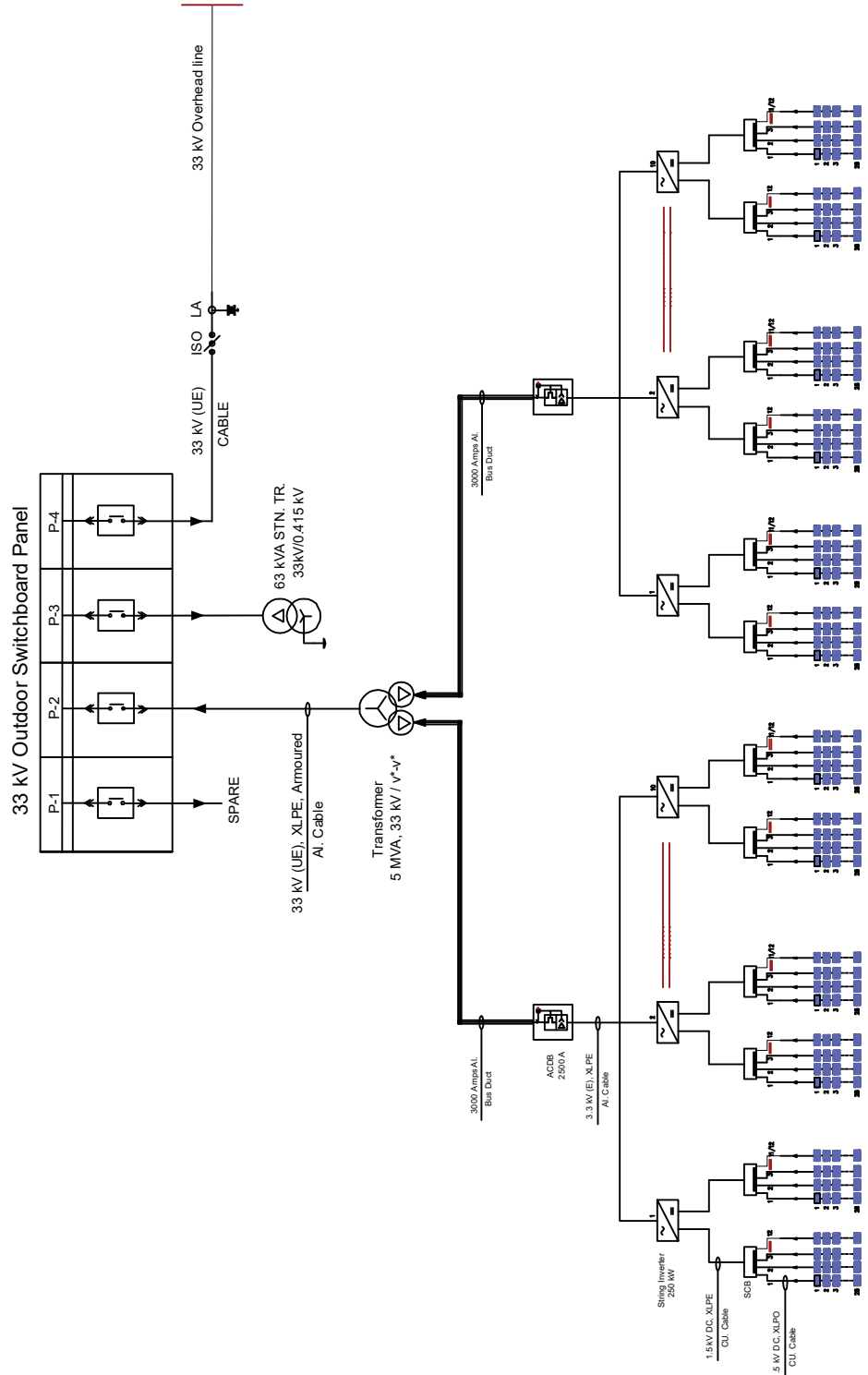
Sl. No.	Name of Items	Unit	Total Qty
1.1	Lightning Arrestor (LA), Station class, 120 kV, 10 kA, with surge monitor/counter suitable for 132 kV solidly earthed supply (Each set consisting of 3 nos.)	Sets	4
1.2	Isolator, 3 pole outdoor type, 31.5 kA, 132 kV, Motorised conforming to IS 1818 (current)		
	(i) With earth switch, 800 A (nominal) rating	Sets	2
	(ii) Without earth switch, 800 A (nominal) rating	Sets	2
1.3	SF6 circuit breaker 132 kV, 630 A, 31.5 kA, outdoor type, gang operated spring charge mechanism.	Sets	2
1.4	Single phase current transformer outdoor type, oil cooled with CTR 250/1-1-1-1 A for 132 kV system with 5 cores for metering and protection. Each sets consists of 3 nos.	Sets	2
1.5	Indoor type control & Relay panel including instrumentation for above incoming 132 kV feeders, 132kV side of transformers and Bus Coupler	Nos.	2
1.6	Power Transformer, 40 MVA, 132kV/33kV YN-yn-0 with on load tap changer, HV and LV neutrals effectively earthed outdoor type conforming to IS 2026 (current) having with all accessories as per IS-3639 (current)	Sets	2
1.7	Control panel Indoor type for On Load Tap Changer (RTCC Panel) for 132/33 kV Transformer	Sets	2
1.8	Isolator, 3 pole, outdoor type 33 kV, 2000 A, without earth switch conforming to IS-1818 (current) with cranking type mechanism	Sets	12
1.9	Isolator 3 pole outdoor type, 33kV, 800 A (isolators with outgoing feeders are to be fitted with earth blade) conforming to IS-1818 (current).	Sets	6
1.10	Isolator, 3 pole, outdoor type 33 kV, 800 A with HG fuse conforming to IS-1818 (current) with cranking mechanism	Sets	4
1.11	Single phase current transformer, outdoor type, oil cooled with required CT ratio for 33 kV system with 3 cores for metering and protection	Sets	9
1.12	Potential transformer, outdoor type, 33 / $\sqrt{3}$ kV/110/ $\sqrt{3}$ V core for metering and protection 100 VA each for 33 kV, 3 phase system	Nos.	2
1.13	Vacuum Circuit Breaker (VCB), 33 kV, 800/1250 A, 25 kA, outdoor type, having IDMT relay for O/L and E/F protection, Ammeter etc with indoor type Control and relay panel with instrumentation.-	Nos.	9
1.14	Lightning arrestor, station class, 30 kV, 10 kA suitable for 33 kV solidly earthed supply (Each set consisting of three nos.)	Nos.	10
1.15	Transformer outdoor type, plinth mounted, ONAN cooled with off-load tap changer, conforming to IS-2026 (current) 200kVA, 33kV/415V Dy-11 Group	No.	1
1.16	Transformer outdoor type, plinth mounted, ONAN cooled with off-load tap changer, conforming to IS-2026 (current) 200kVA, 33kV/230V(L-L) Dy-11 Group	No.	1
1.17	Insulators, ACSR zebra conductor, Strung busbar for 132 kV and 33 kV side (Main and Auxiliary), Steel hardware, clamps, terminal connectors etc for 132 and 33 kV side	Lot	LS
1.18	Mat Earthing system for switchyard including earth pits, galvanised strips/flats for interconnection, GI spikes and pipe electrodes, water pipes, valves & pipe fittings etc	Lot	LS
1.19	Lightning protection system consisting of spikes, earth pits, galvanised strips/flats, down earth conductors, Shield conductors, saddles, hardware etc including watering arrangement, pipe, valves, pipe fitting etc.	Lot	LS
1.20	Power distribution board, 3 Ph- neutral, 415 V indoor type with required no. of MCCBs/MCBs etc	No.	1
1.21	110 V Rechargeable Battery, Lead acid type 200AH, 2 nos. float cum boost charger (1 working and 1 stand by), wooden racks etc.	No.	1
1.22	DC power distribution board, 110 V with required MCCBs/MCBs etc	No.	1
1.23	Lighting main distribution board, 230 V(L-L) indoor type with required no. of MCCBs/MCBs etc	No.	1

1.24	Luminaires	Lot	
	(i) Lighting of substation building - Energy efficient recessed light fittings - 1x15/18W, 2X15W/18W LED lamps complete with the fittings, DC light fixtures along with 4 Nos 90W(min) LED Lamps fitted on Substation Building.		LS
	(ii) 11 m height steel tubular poles along with luminaries with 90W LED lamps along with control gear, brackets etc for outdoor yard illumination..	LS	LS
	(iii) Lighting mast, 16 m height, along with required nos. luminaries with 200 W LED Lamps, control gear etc. for outdoor yard lighting	LS	LS
	(iv) Accessories such as sub distribution boards, junction boxes, 200 W LED flood light fittings with brackets, individual control cables, PVC conduits/casings, back up fuses, switches sockets, ceiling roses, single core PVC cable with copper conductors (for internal connections), flexible wire etc.	LS	LS
	(v) Inverter cum battery charger along with battery for emergency lighting suitable for operation at 230V AC inside substation building	LS	LS
1.25	Cables and Accessories	LS	
	(i) LT Power cable, 3 / 4 core PVC SWA, stranded copper conductors, 1100 V grade of suitable size, (not less than 10 sq mm size)	No.	LS
	(ii) Lighting cable, PVC SWA, copper conductors, 1100 V grade of suitable sizes	LS	LS
	(iii) Control cable, PVC SWA, copper conductors, 1100 V grade of suitable size (not less than 2.5 sq mm)		LS
	(iv) Cables for internal wiring of 1.5 sq mm to 6sq.mm size, PVC insulated copper conductor lighting cables.		LS
	(v) Cable trays, cable racks, binding material, cable glands, cable terminal lugs, nuts, bolts, washer, cable jointing and termination kit etc	LS	LS
1.26	Misc. Items	LS	
	(i) Split type room air conditioners, 2 ton capacity (5 star/inverter AC) including servo stabiliser of rated capacity with digital indicator for in but and output voltage, industrial type plug sockets, fuses, control MCBs	Lot	LS
	(ii) 63 kVA Diesel Generator with 3 ph, 50 hz, 415 V output supply to be installed in the DG room of the substation	No.	1
	(iii) Exhaust fan 600 mm sweep in battery room, oil filtration unit room, bath room		Lot
	(iv) Ceiling fans, 1200 mm sweep 5 star BLDC motor along with electronic regulators in Engineer in charge room, testing room, battery room, control room, Engineer's room, other rooms etc.		Lot
	(v) Supply of Fire fighting equipment system consisting of Nitrogen injection for Transformers 20 MVA Transformers		2
	(vi) Supply of fire/smoke detection alarming system for switch room, DG room, oil filtration room, oil storage room and Pump and sump house		LS
	(vii) Fire fighting system consisting of hydrant system (hydrant points, fire hose cabinets along with fire hose, pumps, pipes, pipe fittings etc), portable Co2 and dry type chemical powder fire extinguishers, trolley mounted dry type chemical powder fire extinguishers, sand buckets, power supply arrangement for pumps etc.		LS
	(viii) Two stage high vacuum transformer oil purifier cum filtration M/c, on line, tyre mounted, 2400 lph capacity, heavy duty flexible hose pipe of required length, associated electricals suitable for operation on 415V, 3 phase 50 Hz, required flexible cable of 4 core copper conductors, coupler etc		1
	(ix) Vacuum cleaner, domestic type, 35 lps, 2100 mm water gauge, wheel mounted, electricals suitable for operation on 230V, 1 Ph, 50 Hz supply, hose pipe, other accessories, suitable flexible cable etc		1

1.27	Other Miscellaneous item may comprises of i) Insulating Mat for indoor panels ii) Loto station system/kit- 01 no, iii) Electrical layout or single line diagram, iv) Electrical shock treatment chart, v) DO'S and DON'T chart, vi) Earth pit connection diagram in retro refractive radium type display. vii) Danger plate viii) Furniture & Fittings		LS
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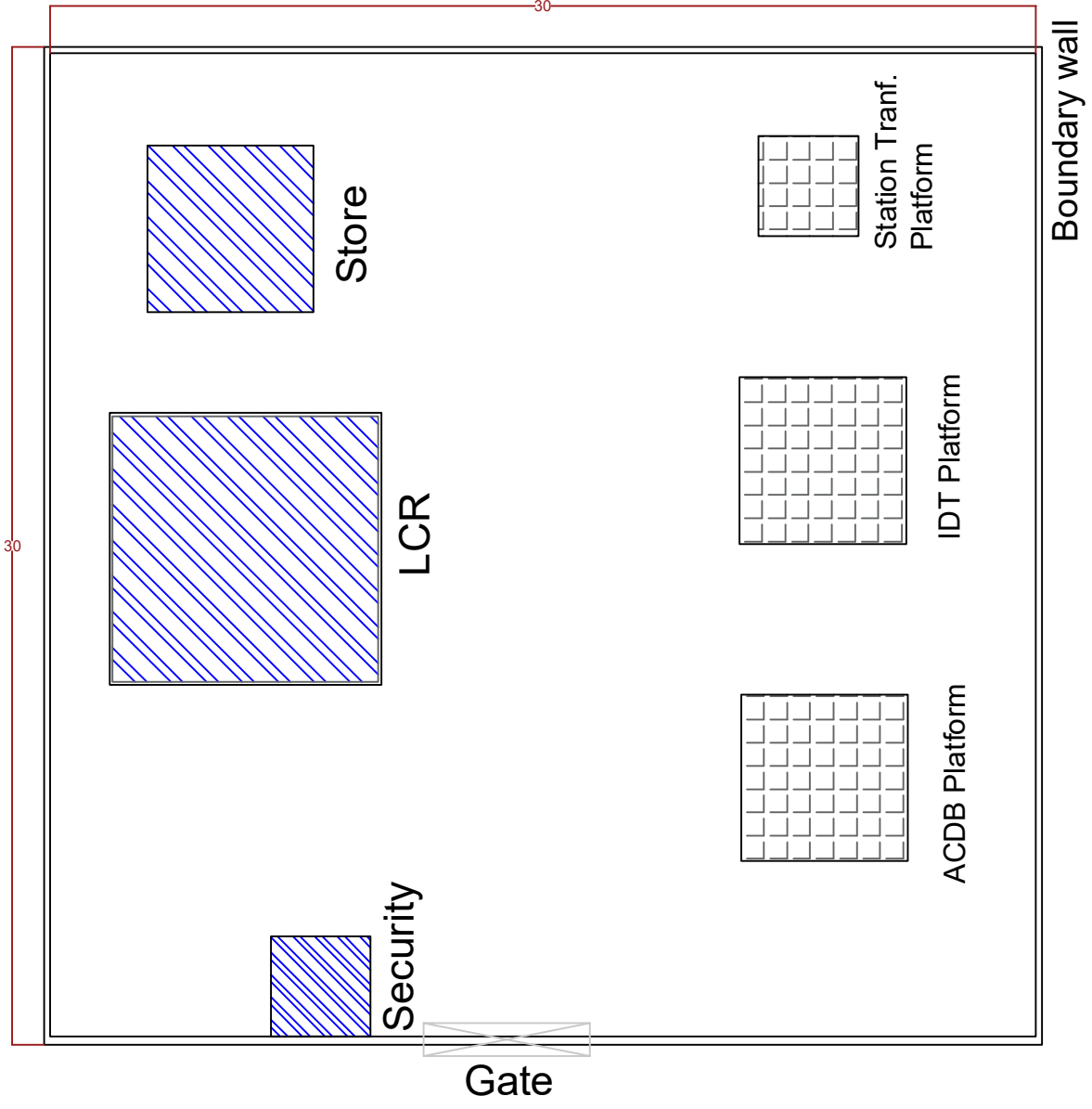
L E G E N D

S/L NO	ITEM	D E S C R I P T I O N
1.		P.V MODULES
2.		SOLAR CENTRAL INVERTER
3.		ACB
4.		SURGE PROTECTION DEVICE
5.		POWER TRANSFORMER
6.		INDOOR 33 kV VCB
7.		33 kV, ISOLATOR
8.		33 kV, LIGHTING ARRESTOR
9.		STATION TRANSFORMER
10.		SCB (String Combiner Box)



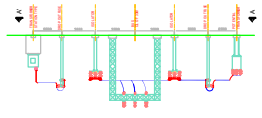
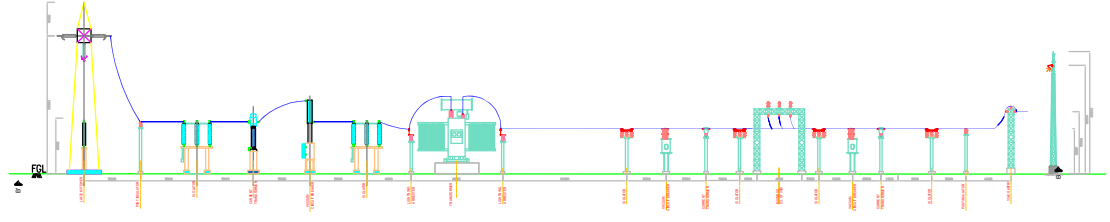
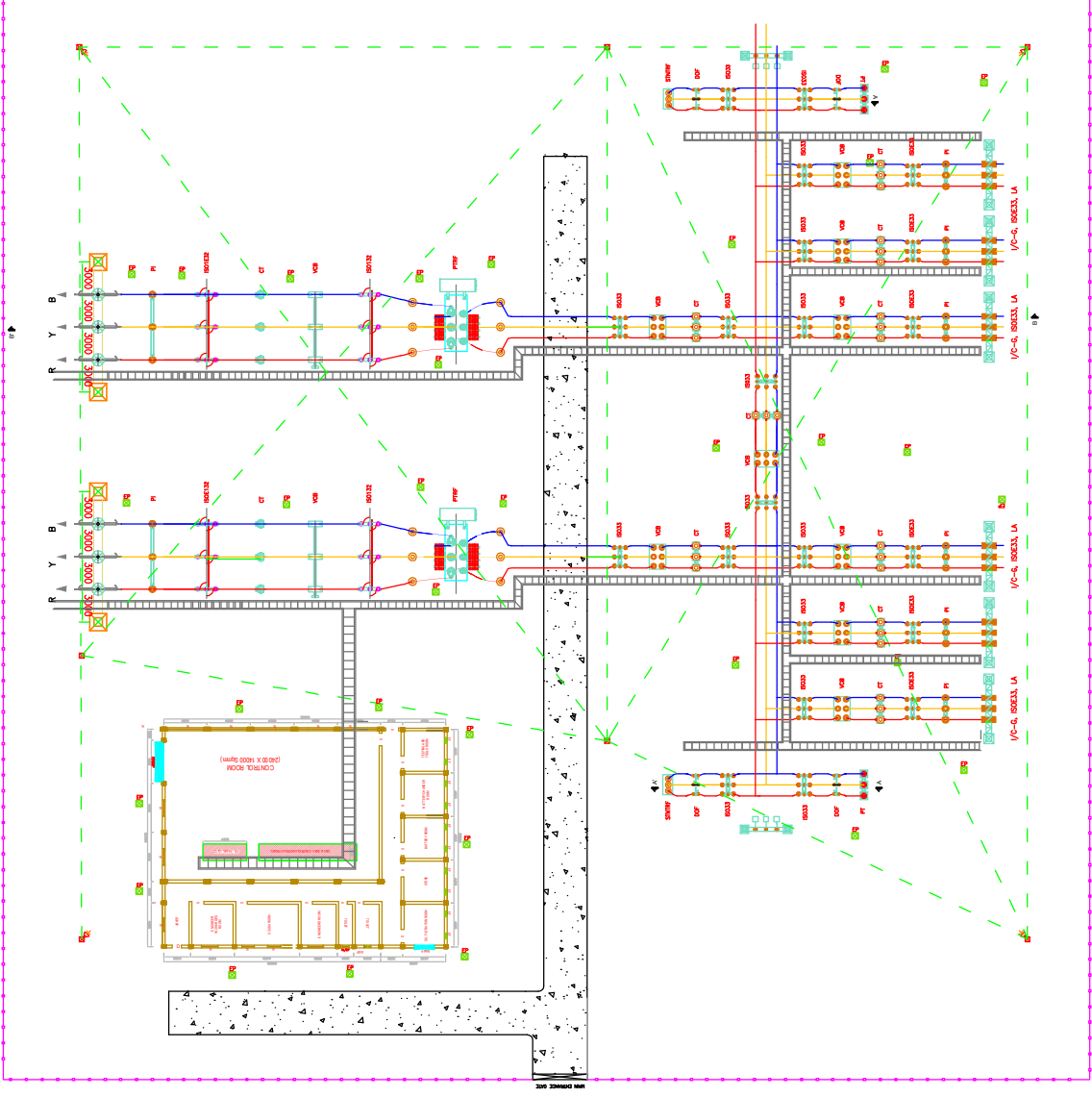
Drawing - 1 : Single line diagram of Local Control Stations (5 MW / 7 MWp)

Note:- This drawing is for bidding purpose only



Drawing - 2 : Typical Layout of the Local control station

Note:- This drawing is for bidding purpose only

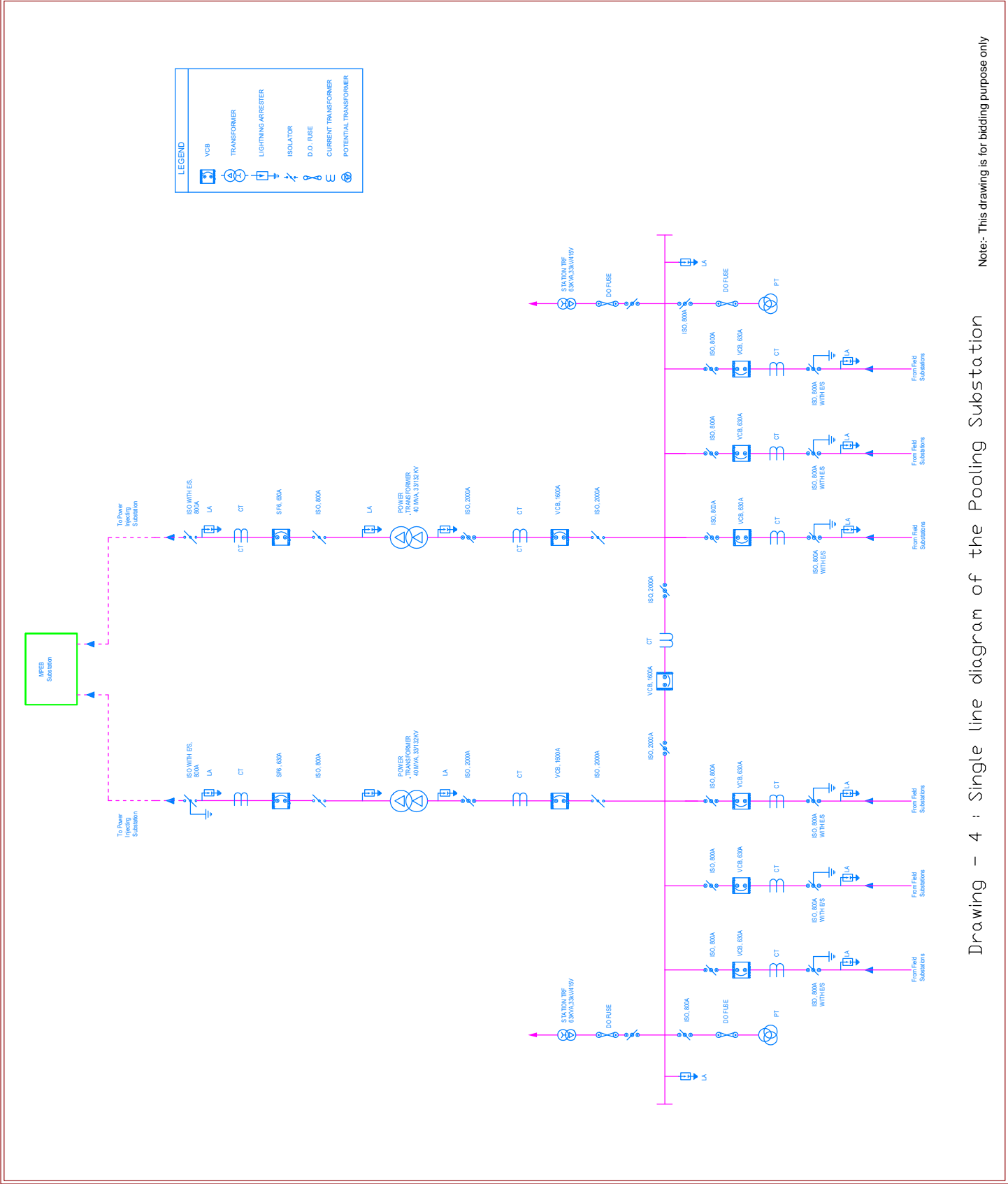


LEGENDA

SYMBOL	DESCRIPTION
[Symbol]	1. BUSBAR
[Symbol]	2. CABLE
[Symbol]	3. TRANSFORMER
[Symbol]	4. REACTOR
[Symbol]	5. CIRCUIT BREAKER
[Symbol]	6. FUSE
[Symbol]	7. RELAY
[Symbol]	8. METER
[Symbol]	9. SWITCH
[Symbol]	10. TERMINAL BOX
[Symbol]	11. ELECTRICAL PANEL
[Symbol]	12. CONTROL ROOM
[Symbol]	13. DRIVEWAY
[Symbol]	14. WALL
[Symbol]	15. COLUMN
[Symbol]	16. FLOOR
[Symbol]	17. CEILING
[Symbol]	18. ROOF
[Symbol]	19. GROUND
[Symbol]	20. ELEVATION

Drawing - 3 : Typical Layout of the Pooling Substation

Note:- This drawing is for bidding purpose only



Drawing - 4 : Single line diagram of the Pooling Substation

Note:- This drawing is for bidding purpose only