SECTION – VII

TABLE OF CONTENTS

DISCLAMIER:

1. 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 twenty (20) days 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.
2. Solar Energy Corporation of India Limited (SECI), the Employer, reserves the right to modify, amend or supplement this NIT documents including all formats and Annexures.
3. 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.
4. 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, interfacing panels, switch gears & other associated equipment, BESS etc., to complete the power generation and evacuation to the designated substation, in the present 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 authorized representatives.

Place:

Date:

(Signature)
Name and Designation of bidder

SECTION - VII

SUB-SECTION A

SCOPE OF WORKS

TABLE OF CONTENTS

1 Project Particulars

Particulars	Description
Design and Engineering	
Project AC Capacity	88 MW
Power Transformer Capacity	100 MVA
Solar Plant AC Capacity	88 MW
DC Capacity	123.2 MWp
Supply of PV Modules	Supply of PV Modules at the Project Site shall be in the Scope of the Owner. The Owner shall deliver PV Modules at the Project site. However, for the purpose of bidding contractor may consider **585Wp** TOPCon module of **21.65%** efficiency with dimensions 2382mm x 1134mm. **Note:** Variation in contract price due to actual module supplied by Owner shall be calculated as per **Contract Price Variation Clause** of this Tender Document mentioned elsewhere.
Cumulative Inverter (PCU) AC Capacity (Solar)	XX MVA to deliver 88 MW with PF range -0.95 to +0.95 at 50°C at Point of Interconnection (POI).
Origin of Supply Items	As per MNRE Order on Public Procurement (Preference to Make in India) to provide for Purchase Preference (linked with local content) in respect of RE Sector dated 9th February, 2021 and subsequent amendments
Module Mounting Structure Type	South Facing, Fixed Tilt
Design life of power plant	25 Years
O&M period	5 Years
Site Location and Land Details	
Location	Varavoo Kaval (Taluka: Challakere)
District	Chitradurga
State/UT	Karnataka
Latitude & Longitude	14.400556° N, 76.560833° E
Altitude	609 m
Available Land Area	Refer to **SA-A: Tentative Land Layout**
Type of Land	Land Leased by SECI
Project Ownership	Solar Energy Corporation of India Limited

Access	
Nearest Urban Area	Challakere
Nearest Highway	NH-150A (Challakere–Hiriyur section passes through Challakere)
Nearest Railway Station	Challakere Railway Station (CHKE)
Nearest Airport	Kempegowda International Airport, Bengaluru
Power Evacuation	
Point of Interconnection (POI)	220 kV Bay at the 765/400/220 kV Davangere PGCIL Substation Co-ordinates- 14.4884°N, 76.2955°E
Evacuation at POI	88 MW
Plant Metering Point	At the Point of Interconnection Refer **SA-B: Indicative SLD**
Plant End Substation Switching Scheme (220 kV)	Double Bus Scheme with Bypass-Isolator Refer **SA-B: Indicative SLD**
Design Parameters	
Design Ambient Temperature	50°C
Basic Wind Speed (IS 875-3)	33 m/s
Seismic Zone (IS 1893-1)	Zone II
Corrosion Class	C3
Solar - Functional Guarantee (at 220kV Plant End Substation)	
For Operational Acceptance	OTF >= 1 Refer **GA-H: FG Test Procedure** **Note:** In case of OTF<1 during OTGT, Liquidated Damages shall be as per relevant clause of **GA-H: Functional Guarantee Test Procedure**
During O&M Period	The bidder shall guarantee the Target Generation (GTN) as per to ANNEXURE-2: Generation Guarantee of SS-F: O&M Agreement. **Note:** In case of shortfall during O&M Period, Liquidated Damages shall be as per relevant clause of SS-F: O&M Agreement
Other Details	
Water and Power for Construction	To be arranged by the Contractor

2 Brief Scope of Work

Scope of Supply & Work includes design & engineering, procurement & supply of equipment and materials (excluding PV Modules), testing at manufacturers works, multi – level inspections, packing and forwarding, supply, receipt, unloading and storage at site, associated civil works, services, permits, licences, installation and incidentals, insurance at all stages, erection, testing and commissioning for **88 MW (AC) Solar PV Power Plant**, and performance demonstration with associated equipment and materials on turnkey basis along with 5 (five) years comprehensive operation and maintenance from the completion date of OTGT.

All works shall be executed as per Technical Specifications provided in Section VII Sub-Section-B (Electrical Systems) & Sub-Section-C (Civil, Mechanical & Plumbing Works) along with Sub-Section-D (General Annexures) & Sub-Section-E (Specific Annexures).

3 Design and Engineering

3.1 The Contractor shall prepare the detailed design basis report (DBR), PERT Chart (up to at least 3 levels) and Master Drawing List (MDL). The Contractor shall submit a copy to Employer/Owner for review and approval prior to detail engineering.

3.2 The contractor shall estimate the Plant Generation/Energy Yield based on Solar Radiation and other climatic conditions prevailing at site using the industry standard simulation software. Simulation report shall be submitted along with the design basis report.

3.3 All documents and drawings (soft copy) shall be submitted to the Employer/Owner for review and approval. Every drawing shall also be submitted in '*.dwg' format. In case of design calculations done in spread sheet, editable (working) soft copy of the spread sheet shall also be submitted along with 'pdf' copies during every submission. The Employer/Owner shall return the document / drawing to the Contractor with category of approval marked thereon. Two nos. of hard copies of approved documents and drawings shall be submitted to the Employer/Owner. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.

- Category-I: Approved
- Category-II: Approved subject to incorporation of comments
- Category-III: Not approved. Re-submit for approval after incorporation of comments
- Category-IV: Kept for record/ reference

- Category-IV (R): Re-submit for record/ reference after incorporation of comments

(**Note:** Approval of document 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)

3.4 The contractor shall submit basic design data, design documents, drawings and engineering information including GTP and test reports to Employer/Owner or its authorized representative for review and approval from time to time as per project schedule. The documents typically include, but not limited to, the following:

- Detailed technical specifications (GTP) of all the equipment
- General arrangement and assembly drawings of all major equipment
- Schematic diagram for entire electrical system (DC, AC and auxiliary systems)
- GTP & G.A. drawings for all types of components, 220 kV, 132 kV, 66 kV or 33 kV switchgears (as applicable) & other interfacing panels
- Test reports (for type, routine and acceptance tests)
- Relay setting charts
- Design calculations and sheets (civil, mechanical, structural and electrical designs)
- Geo technical investigation data and Topographical survey report including topographical survey data in digital format (Excel file) and Contour plan of the area.
- GA drawings of the entire project including equipment rooms/ inverter control rooms, office cum control room, roads, storm water drainage, sewage networks, security gate, fire protection system, perimeter fencing, transformer yard fencing etc.
- Transmission line drawings and erection plans as per DISCOM / STU / CTU guidelines
- Quality assurance plans for manufacturing (MQP), Standard Operating procedure (SOP) and field activities (FQP)
- Detailed site EHS plan, fire safety & evacuation plan and disaster management plan.
- Detailed risk assessment and mitigation plan.
- O&M Instruction's and maintenance manuals for major equipment
- As-built drawings / documents and deviation list from good for construction (GFC)

3.5 Design of associated civil, structural, electrical & mechanical auxiliary systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for Earth- mat, Bus Bar & Spacers indoor and outdoor lighting/ illumination etc., GTP and GA drawings for the major equipment including 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.

3.6 All drawings shall be fully corrected to match with the actual "As – Built" site conditions and submitted to Employer/Owner after commissioning of the project for record purpose. All as-built drawings must include the Good for Construction deviation list.

3.7 The Contractor shall submit technical connection data, inter alia, generator data for fault studies, dynamic simulation data, details of data & voice communication within one month of signing the LOA. In case, technical data is subjected to change during detailed engineering, the contractor shall furnish the tentative technical data within one month of signing the LOA & shall furnish the final technical data not later than six (6) months from award of work.

3.8 The technical connection data shall be submitted as per “Detailed Procedure for Connectivity and GNA’ under Regulation 39.1” of the Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022.

3.9 The Contractor shall submit the detailed and plant level Equivalent PSS/E Model of the SPV Plant to demonstrate performance under steady-state and dynamic state at the Point of Interconnection in accordance with requirements for connectivity under GNA Regulations notified by CERC. This model will be provided to Grid India / CTUIL for analysis before grant of First Time Charging (FTC) clearance from Grid India/ CTUIL.

3.10 The Contractor shall also submit a study report analysing the response of the plant in case of transients (HVRT, LVRT, VAR injection & absorption, etc)

3.11 The contractor shall ensure that Generating Plant comply with "Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007” & subsequent amendments. The plant shall be capable of reactive power support in line with regulations & its amendments/clarifications.

3.12 The contractor shall ensure that Generating Plant comply with "Central Electricity Authority (Grid Standards) Regulations, 2010” & subsequent amendments.

4 Procurement & Supply

The scope of procurement and supply including testing at manufacturer's works, packing, transportation, transit insurance, receipt, unloading, storage at site of equipment and materials for Grid Interactive Solar PV Power Plant with associated system shall include but not limited to the following.

4.1 **Supply of Solar PV Modules is not in the scope of the EPC Contractor**. It shall be the responsibility of the Owner to supply PV Modules at Project site, between 11 (eleven) to 13 (thirteen) months from date of award of the Contract. However, for the purpose of bidding, the EPC Contractor may consider PV Modules of power rating and efficiency as per Project Particulars of the scope of works as per the specifications provided in this document.

4.2 Unloading and Storage of Solar PV Modules as per Module Manufacturer's recommendations. Any civil works required for preparing the storage facility is in the scope of the EPC Contractor. The Contractor shall satisfy themselves of the quality of the unloaded PV Modules before storage. Unpacking of pallets, Inspection and Re-packing of PV Modules are in the scope of the EPC Contractor. Any damage to the PV Modules after taking over by EPC Contractor shall be responsibility of the EPC Contractor. The EPC Contractor shall obtain necessary insurance cover for the same. The insurance cover shall be effective from the date of delivery of the modules at site.

4.3 Module Mounting Structure (MMS) with necessary hardware suitable for mounting PV Modules.

4.4 String Monitoring Box (SMB) along with mounting structure, in case of central Inverter configuration.

4.5 Solar Cables of appropriate size and rating from PV Modules to SMB/String Inverter along with straight/Y-connectors/branch connectors, ferrules, conduits, cable ties and other materials required for cable laying and termination at both the ends.

4.6 Power Conditioning Units (Central / String Inverter) of appropriate rating.

4.7 DC Cables of appropriate size and rating from SMB to Central Inverter along with cable termination kits, ferrules / tags, conduits, cable ties and other materials required for cable laying and termination at both the ends.

4.8 Energy Management System comprising of both hardware and software, configurable for the operational modes/use cases specified in this document.

4.9 AC Combiner Box / LT Switchgear panel of appropriate rating with adequate number of inputs for pooling of power from String Inverter to Inverter transformer.

4.10 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.

4.11 Inverter duty transformers (for PCU) of appropriate rating including fire protection system.

4.12 33 kV Switchgear Panels / 33kV outdoor yard including Vacuum / SF6 Circuit Breakers, Current Transformers, Voltage Transformers, Relays, and other accessories for complete protection at the inverter stations. In case 33kV Switchgear panels are used, the same shall be placed on elevated platform with overhead canopy.

Note: Refer **SA-B: Indicative SLD.**

4.13 33 kV Over Head Transmission Line / Under Ground Cable including Poles / Towers, Conductors, Insulators, Cable Termination Kits and associated accessories from 33 kV Switchgear of inverter stations to 33/220 kV Pooling Substation including Right of Way, permits and approvals.

4.14 33/220 kV Plant Pooling Substation comprising the necessary number of Transformer Bays, Line Bays, and Bus Coupler Bays, complete with a Substation Automation System and Protective Relays. Busbars and all bay equipment shall be rated and suitable for power evacuation of up to 88 MVA.

Note: Refer **SA-B: Indicative SLD** (The **SA-B: Indicative SLD** is for reference only and not a final design. The Contractor shall carry out detailed engineering and provide all equipment, protection, metering, and control systems to ensure safe, reliable, and compliant substation operation per applicable standards and Grid Codes.)

4.15 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 CEA Metering Regulations 2006 as amended time to time and state metering code.

4.16 Any other equipment / system required to comply with the relevant Procedures / Regulations issued by CEA/ CERC/ any other statutory body for connectivity to the Grid.

4.17 220 kV Over Head Transmission Line / Under Ground Cable (suitable for evacuation of 88 MVA) including Towers, Conductors, OPGW cable, Insulators, Cable Termination Kits and associated accessories from 33/220 kV Pooling Substation to Interconnecting Substation as per CTU drawings/specifications including Right of Way, permits and approvals, CTU supervision and maintenance charges.

4.18 The Contractor shall provide provision to integrate Special Protection Scheme (SPS), if required, in case the RLDC requires the same. In that event, details of SPS and its

setting shall be worked out in consultation with RLDC & RPC.

4.19 Fibre Optic based communication system comprising of OPGW cable (having minimum 12 fibres) and hardware fittings for the transmission line and FOTE (STM-16) terminal equipment, FODP, approach cables and other associated equipment/accessories at Solar Plant Pooling Substation and interconnecting substation as per CTU specifications. The communication system shall facilitate for telemetry data communication, voice communication and tele-protection.

4.20 Phasor Measurement Units (PMU), and other associated equipment/accessories at the Solar Plant Pooling Substation as per CEA (Technical standard for construction of Electrical Plants & Electric Lines), Regulations, 2022 & amendments thereof.

4.21 Auxiliary supply system including auxiliary transformers, distribution panels, cables, and related accessories for plant internal consumption.

4.22 Uninterrupted Power Supply (UPS) including Batteries, Distribution Boards, Cables, and associated equipment.

4.23 Battery Bank, Battery Charger, Distribution Boards, Cables and associated equipment.

4.24 LT Power and Control Cables including end terminations and other required accessories.

4.25 Communication cables including end terminations and other required accessories.

4.26 Supervisory Control and Data Acquisition (SCADA) and Power Plant Controller (PPC) for remote monitoring/control of plant facilities.

4.27 Data Acquisition System and communication infrastructure to transfer real time data to SLDC / RLDC.

Note: Next Generation Firewall (NGFW) shall be provided as per specifications mentioned in “Firewall Specifications for ISTS stations” at CTU website.

4.28 Earthing system including earth strip/cables, earth electrodes, earth enhancing compound and all other associated materials for complete earthing of the plant.

4.29 Lightning Protection System for entire plant area.

4.30 LED luminaries with diffuser for illumination, lighting poles, distribution boxes and power supply cables along with required conduits, fittings, etc.

4.31 Weather monitoring station shall include but not be limited to the following and shall be spatially distributed throughout the plant areas:

Sensor Details	**Minimum Sensors Required for 88 MW Solar Plant**

Pyranometers in Horizontal Plane	3 nos.
Pyranometers in Inclined plane	3 nos.
Ultrasonic Anemometer (wind speed and direction)	3 nos.
Temperature Sensor with shielding case (ambient)	3 nos.
Temperature Sensor (module surface)	9 nos.
Rainfall (mm) Sensor	3 nos.
Relative Humidity (% RH) Sensor	1 No.
Power source to all sensors wherever required	1 No.
Data Logger	1 No.

4.32 Supply and procurement of all necessary equipment for installation of an Automatic Weather Station (AWS) in accordance with CEA Guidelines for Automatic Weather Stations (AWS) for Solar and Wind Power Plants.

4.33 CCTV cameras with monitoring station along with mounting poles, power supply cables, communication cables, network switches, conduits, fittings, etc.

4.34 Fire detection and fire protection system in buildings/containers, inverter / transformer yard and switchyard.

4.35 Testing instruments as specified.

4.36 Mandatory spares as specified in General Annexure-D.

4.37 Supply of site office (Portable Cabin type) for Owner during construction.

4.38 Any other equipment / material not mentioned but required to complete the Solar Power Plant facilities in all respect.

5 Installation, Testing and Commissioning

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

5.1 Installation of PV Modules on Module Mounting Structure and interconnection of PV Modules.

5.2 Installation, Testing and Commissioning of String Monitoring Box in case of Central Inverter configuration.

5.3 Installation, Testing and Commissioning of Power Conditioning Units (Central / String Inverter).

5.4 Laying of Solar cables from PV Modules to SMB / String inverter along with termination

at both the ends.

5.5 Installation, Testing and Commissioning of AC Combiner Box / LT Switchgear panel in case of String Inverter configuration.

5.6 Laying of DC cables from SMB to Central inverter along with termination at both the ends in case of Central Inverter configuration.

5.7 Laying of AC LT cables from String Inverter to Inverter transformer along with termination at both the ends in case of String Inverter configuration.

5.8 Laying of AC LT cables along cable trays from Power Conditioning Unit to Inverter transformer along with termination at both the ends in case of Central Inverter Configuration.

5.9 Installation, Testing and Commissioning of Inverter transformers including fire protection system (NIFPS for transformers with oil quantity > 2000 Litre).

5.10 Installation, Testing and Commissioning of 33 kV Switchgear panels in PV array field.

5.11 Laying of AC cables from Inverter transformer to 33 kV Switchgear panels in PV array field along with termination at both the ends.

5.12 Installation, Testing and Commissioning of 33 kV Over Head Transmission Line / Underground Cable from 33 kV Switchgear panels in PV array field to 33 kV CMCS Pooling Switchgear along with termination at both the ends including Right of Way, permits and approvals

5.13 Installation, Testing and Commissioning of 33 kV CMCS Pooling Switchgear.

5.14 33/220 kV Plant Pooling Substation comprising the necessary number of Transformer Bays, Line Bays, and Bus Coupler Bays, complete with a Substation Automation System and Protective Relays. Busbars and all bay equipment shall be rated and suitable for power evacuation of up to 88 MVA.

Note: Refer **SA-B: Indicative SLD**

5.15 Installation, Testing and Commissioning of ABT meters with all necessary metering rated CTs and PTs at the plant take-off point as per CEA Metering Regulations 2006 as amended time to time and state metering code.

5.16 Installation, Testing and Commissioning of 220 kV Over Head Transmission Line / Underground Cable from 33/220 kV Plant Pooling Substation to Interconnecting Substation as per CTU drawings/specifications including Right of Way, permits and approvals, CTU supervision and maintenance charges.

Note: The BoS Contractor shall coordinate with PGCIL/CTU for bay readiness and ensure line termination and energisation is aligned with PGCIL's commissioning schedule.

5.17 Installation, Testing and Commissioning of Fibre Optic based communication system comprising of OPGW cable (having minimum 12 fibers) and hardware fittings for the transmission line and FOTE (STM-16) terminal equipment, FODP, approach cables and other associated equipment/accessories at Solar Plant Pooling Substation and interconnecting substation as per CTU specifications. The communication system shall facilitate for telemetry data communication, voice communication and tele-protection.

5.18 Installation, Testing and Commissioning of Phasor Measurement Units (PMU) and other associated equipment/accessories at the Plant Pooling Substation as per CEA (Technical standard for construction of Electrical Plants & Electric Lines), Regulations, 2022 & amendments thereof.

5.19 Installation, Testing and Commissioning of auxiliary power supply system consisting of auxiliary transformers, AC distribution boards, AC LT cables and related accessories.

5.20 Installation, Testing and Commissioning of Uninterrupted Power Supply (UPS), Distribution boards, Cables, and related accessories.

5.21 Installation, Testing and Commissioning of Battery Bank, Battery Charger, Distribution boards, Cables, and related accessories.

5.22 Laying of LT Power and Control Cables along with termination at both the ends.

5.23 Installation, Testing and Commissioning of SCADA and Power Plant Controller along with suitable communication system for interfacing PCU, Inverter Transformers, 33 kV Switchgear Panels, Power Transformers, Control and Relay Panel, UPS, Fire alarm panel, WMS and other equipment with SCADA, remote monitoring capabilities and internet facility equipped with functionality as per Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019.

5.24 Installation, testing, and commissioning of Automatic Weather Station (AWS) in accordance with CEA Guidelines for Automatic Weather Stations (AWS) for Solar and Wind Power Plants

5.25 Installation, Testing and Commissioning of Telemetry System for communication of Plant Data to SLDC / RLDC.

5.26 Earthing of PV Modules, Module Mounting Structures, PCU, Switchgear panels, Transformers, and all other electrical equipment.

5.27 Installation of lightning protection system for entire plant facilities.

5.28 Installation of illumination system including all required accessories and laying of power supply cables.

5.29 Installation, Testing and Commissioning of Weather Monitoring Station along with laying of required power supply and communication cables.

5.30 Installation of CCTV cameras on strategic locations including all required accessories, laying of power/communication cables and installation of monitoring station.

5.31 Installation of fire detection and fire protection system for buildings/containers, transformer yard and switchyard.

5.32 Pre-commissioning checks and tests for all equipment.

5.33 Synchronization and Commissioning of plant.

5.34 Any other works related to installation, testing and commissioning not mentioned but required to complete the Solar Power Plant facilities in all respect.

5.35 Contractor will ensure the compliance of requirements mentioned in procedure of First Time Charging (FTC) as applicable for other power system elements. The consolidated FTC procedure is available in public domain.

6 Civil Works

The scope of civil works for the plant facilities shall include, but not limited, to the following.

6.1 Conducting topographical survey of the plant area is in the scope of the Contractor. Contour map attached in Specific Annexure – A is only for reference and general information of the bidder. No warranty is expressed or implied that such information, given in good faith, will represent a complete or accurate picture of the whole of the site. The Employer/Owner shall not be responsible for any variation in topography, if observed, during detailed topographical survey to be carried out by the Contractor during contract execution and there shall be no compensation what so ever in the contract price on this account.

6.2 Conducting geotechnical investigation of the plant area

6.3 Conducting wind tunnel studies for the design and analysis of complete MMS from any one of the reputed institutes having suitable wind tunnel facilities (IITs, SERC Chennai or equivalent level institute in India) as per SUB-SECTION C: TECHNICAL SPECIFICATIONS (TS)- CIVIL, MECHANICAL & PLUMBING WORKS. It must be vetted by the wind domain expert at any of the IITs or SERC or equivalent level institute in India.

6.4 Clearing plant site and transmission line corridor by cutting of trees, bushes and shrubs including disposal of waste material.

6.5 Earthwork for site grading, cutting, filling, levelling and compaction of land.

6.6 Construction of foundation for Module Mounting Structure (MMS) and erection of MMS.

6.7 Construction of foundation and / or mounting structure for String Monitoring Box, String

Isolator Box, AC Combiner Box / LT Switchgear panel, Power Conditioning Unit, Inverter Transformer, Auxiliary Transformer, 33 kV Switchgear panel, Power Transformer, Substation / Switchyard Equipment, lighting mast, watch tower, lightening arrestor and other electrical equipment.

6.8 Construction of Inverter Stations, and Main Control Room

6.9 Construction of outdoor storage shed of area sufficient enough to store spares.

6.10 For modules to be provided by the Owner, the Contractor shall provide storage areas in multiple locations within the plant area to receive and store them till installation. The storage areas shall be levelled hard ground free from water logging.

6.11 Construction of covered storage area (minimum 450 m^2) for storage of spare modules and other spares.

6.12 Construction of one security room at main gate and watch towers at every land parcel / one for every 200 acres of land parcel inside the boundary of the plant.

6.13 Construction of fence for transformer yard, switchyard and 33/220 kV Solar Park Substation.

6.14 Construction of foundation and / or mounting structure for Weather Monitoring Station and associated civil works.

6.15 Construction of foundation for Lighting poles, CCTV poles and other equipment.

6.16 Construction of approach roads, access roads, internal roads, and peripheral roads, as applicable.

6.17 Construction of storm water drainage network for smooth disposal of storm water from the plant to the nearest available drainage outlet.

6.18 Construction of wet type module cleaning system.

6.19 Suitable arrangement of water shall be ensured 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.

6.20 Erection of site office (portable cabin type) for Owner during construction.

6.21 Any other civil works not mentioned but required to complete the Solar Power Plant facilities in all respect.

7 Statutory Approvals

7.1 Obtaining statutory approvals /clearances/ compliances on behalf of the Employer/Owner 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 approval as and when, as necessary for setting up of the solar power plant including CEIG/ CEA, power evacuation, etc. as per the suggested guidelines.

7.2 All statutory approvals / permissions and/or No Objection Certificates (NoC) etc. from DISCOM / STU / CTU for interconnection of solar power plant at the substation.

7.3 All royalties and taxes as required to be paid for excavation of earth / rocks / sand shall be borne by the Contractor.

7.4 The Contractor shall comply all provisions of the following regulations and amendments thereof.

(i) CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007
(ii) CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022
(iii) CEA (Grid Standard) Regulations, 2010
(iv) CEA (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations, 2011
(v) CEA (Measures relating to Safety and Electric Supply) Regulations, 2010
(vi) CEA (Installation and Operation of Meters) Regulations, 2006
(vii) CEA (Technical Standards for Communication System in Power System Operations) Regulations, 2020
(viii) CERC (Communication System for inter-State transmission of electricity) Regulations, 2017
(ix) CERC (Indian Electricity Grid Code) Regulations, 2023
(x) CEA (Cyber Security in Power Sector) Guidelines, 2021
(xi) CEA (Manual of communication planning in Power System Operation), 2022
(xii) Any other applicable Standards/Regulations/Procedures/Guidelines etc.

7.5 The Contractor shall comply with Section-2 (Procedure for Integration of Solar, Wind or Hybrid Power Plant/Wind or Solar Power Parks, WPD/SPD/HPD those are regional entities) of NLDC's Procedure for First Time Charging/Energization (FTC) and Integration of New or Modified Power System Element dated 3rd June, 2020 and amendments thereof.

7.6 The Contractor shall comply with 'Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators' and amendments thereof.

7.7 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.

7.8 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/Owner.

7.9 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.

8 Operation and Maintenance

8.1 Total Operation & Maintenance of the SPV Plant shall be with the Contractor under an O&M Contract as per the terms and conditions of O&M Agreement (Section – VII Sub-Section-F: Operation & Maintenance Agreement), after successful operational acceptance of the Solar PV plant till culmination of the O&M period and shall include deployment of engineering personnel, technicians and security personnel.

8.2 To provide a detailed training plan for all O&M procedures to Employer's/Owner's nominated staff, which shall have prior approval from the Employer/Owner.

8.3 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.

8.4 Discharge obligations relating to retirement/ Superannuating benefits to employees or any other benefit accruing to them in the nature of compensation, profit in lieu / in addition to salary, etc. for the period of service with the contractor, irrespective continuance of employees with the project as employees of Contractor, after conclusion of O&M period.

8.5 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/Owner in electronic form, compatible in CSV format. The right to use the data shall remain with the Employer/Owner.

8.6 The Contractor shall establish forecasting tools for submitting schedule and comply with respective CERC/SERC Regulations on Forecasting, Scheduling and Deviation

settlement of generation. The scope under this Clause shall also include establishing and maintaining forecasting tools and appointment of QCA/Aggregator, if required. % 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.

8.7 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.

8.8 To upkeep all administrative offices, roads, tool room, stores room, equipment in clean, green and workable conditions.

8.9 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.

8.10 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.

8.11 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 CTU/other statutory organizations as per the requirement on behalf of Employer/owner for Joint Metering Report (JMR), furnishing generations schedules as per requirement, revising schedules as necessary and complying with grid requirements.
- 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 to enable Employer/Owner raise commercial bills on consumers.
- Periodic cleaning of solar modules as approved by the Employer/Owner 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/Owner

8.12 Continuous monitoring the performance of the Solar Power Plant and regular maintenance of the whole system including Modules, PCU's, transformers, overhead line, outdoor/indoor panels/ kiosks etc. are necessary for extracting and maintaining the maximum energy output from the Solar Power Plant.

8.13 Preventive and corrective O&M of the Solar Photovoltaic Power Plant including supply of spares, consumables, wear and tear, overhauling, replacement of damaged modules, invertors, PCU's and insurance covering all risks (Fire & allied perils, earth quake, terrorists, burglary and others) as required.

8.14 The period of Operation and Maintenance will be deemed to commence from the date of successful completion of OTGT and successively the complete Power Plant to be handed over to the O&M contractor for operation and maintenance of the same. O&M contract shall further be extended on the mutually agreed terms and conditions for the mutually agreed period.

8.15 All the equipment required for Testing, Commissioning and O&M for the healthy operation of the Plant must be calibrated, time to time, from the NABL accredited labs and the certificate of calibration must be provided prior to its deployment.

8.16 The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his or his sub-contractor or Employer's/Owner's Workmen. This will include procurement of all safety gadgets during Construction and O&M period including but not limited to, rubber mats of appropriate grade, PPE, rubber gloves and suitable shoes etc.

9 Operation and Performance Monitoring

9.1 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. The Contractor shall ensure continuous, un-uninterrupted Plant Operation and Monitoring as per this Clause (Clause 9) and sub-clauses therein, for the period commencing from Plant Commissioning to the signing of the O&M Agreement.

Note: The Employer/Owner shall enter into an O&M Agreement with the Contractor as per Sub-Section-F: Operation & Maintenance Agreement subsequent to Operational Acceptance of the Plant.

9.2 Daily work of the operation and maintenance in the Solar Photovoltaic Power Plant involves periodic cleaning of Modules including periodic tilt angle change 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 other task of the operators is to check battery voltage-specific gravity and temperature. The operator shall record monthly energy output, down time, etc.

9.3 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.

9.4 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.

9.5 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/Owner for such preventive maintenance prior to start.

9.6 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/owner showing the circumstances under which it happened and the extent of damage and/or injury caused.

9.7 The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.

9.8 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.

10 Security Services

10.1 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 Plant for the complete

scope of works including comprehensive O&M period.

10.2 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/Owner immediately. A monthly report shall be sent to Employer/Owner on the security aspects.

10.3 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.

SECTION - VII

SUB-SECTION B

TECHNICAL SPECIFICATIONS (TS) – ELECTRICAL SYSTEM

TABLE OF CONTENTS

1 String Monitoring Box

1.1 Standards and Codes

Standard/Code	Description
IS/IEC 60529	Enclosure Ingress Protection
IEC 62262	Enclosure Impact Protection
IEC 60269-6	Fuse
IEC 61643-31 / EN 50539-11	Surge Protection Device
IS 17293 / IEC 62852	Solar cable connector
IEC 60947-3	Switch disconnector
IEC 60695-2-11	Fire hazard testing

1.2 Construction

1.2.1 SMB 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 IK 08.

1.2.2 Not more than two strings can be connected in parallel to a single input of SMB. One spare input terminal along with connector shall be provided for each SMB.

1.2.3 Every SMB 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.

1.2.4 Disconnector of suitable rating shall be provided at SMB output to disconnect both positive and negative side simultaneously.

1.2.5 Type-II surge protective device (SPD) conforming to IEC 61643-31 / EN 50539-11 shall be connected between positive/negative bus and earth.

1.2.6 Connector conforming to IS 17293 / IEC 62852 shall be provided at each SMB input. Cable gland (double compression metallic) of suitable size for DC cables shall be provided at the SMB output.

1.2.7 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.

1.2.8 Suitable communication interface shall be provided to communicate the data to SCADA. The following parameters shall be measured/ monitored and made available at SCADA.

a) String current

b) Bus voltage

c) Output current

d) Cabinet temperature

e) DC disconnector switch ON/OFF status

f) SPD operating status

1.3 Warranty

The SMB unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (two) years from the date of supply.

1.4 Tests

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

2 Solar and DC Cables

2.1 Standards and Codes

Cable	From	To	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SMB	Copper/ XLPO	1.5 kV DC	IS 17293 / IEC 62930
DC Cable	SMB	PCU	Copper or Aluminium/ XLPE	1.5 kV DC	IS 7098 Part II
* Cable used for module interconnection shall also be referred as solar cable.					

2.2 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.

2.3 DC cables shall be single core, armoured, Flame Retardant Low smoke (FRLS), PVC outer sheath conforming to IS 7098-II. DC cable with positive polarity and negative polarity shall have red and black outer sheath respectively.

2.4 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 ‘HALOGEN FREE LOW SMOKE’

(iii) Sequential marking of length of the cable

2.5 Cables shall be sized based on the following considerations:

(i) Rated current of module

(ii) In case of central inverters, average voltage drop in the cables (from PV Modules

to PCU) shall be limited to 1.5 % of the rated voltage. In case of string Inverters, average voltage drop (from PV module to string inverter) shall be limited to 0.5% of the rated voltage drop. The Contractor shall provide voltage drop calculations in excel sheet.

(iii) Short circuit withstand capability

(iv) De-rating factors according to laying pattern

2.6 Warranty

The cables (Solar and DC) shall be warranted against all material/ manufacturing defects and workmanship for minimum of 1 (one) year from the date of supply.

2.7 Tests

Type test, routine test and acceptance tests requirements shall be as per IS 17293 / IEC 62930 for solar cables and IS 7098-II for DC cables.

2.8 Installation

2.8.1 Cable installation shall be as per IS 1255.

2.8.2 Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.

2.8.3 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.

2.8.4 Solar cables or group of solar cables combined through branch connector may be laid over ground on GI or FRP cable trays / underground through Double Wall Corrugated (DWC) HDPE conduits from PV String (Series connection of PV Modules) to SMB/String Inverter. The size of the conduit or pipe shall be selected on the basis of 40% fill criteria. Solar cable terminations shall be made with connectors complying IS 16781 / IEC 62852. The connectors shall have degree of protection of IP 68.

2.8.5 Solar cables shall be aesthetically tied to Module Mounting Structure using UV resistant cable-ties suitable for outdoor application.

2.8.6 DC cables from SMB to PCU shall be laid directly buried underground as per IS 1255. DC 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.

3 Power Conditioning Unit

3.1 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.3	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed.3	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 Ed.6	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2 Ed.5	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14 Ed.6	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30 Ed.3	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	
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.	

3.2 Supplier Qualification Criteria

3.2.1 The Inverter Supplier shall be Class-I local supplier as per MNRE Order on Public Procurement (Preference to Make in India) to provide for Purchase Preference (linked with local content) in respect of Renewable Energy (RE) Sector dated 9th February, 2021 and subsequent amendments.

3.3 Technical Requirements

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	0.8 lag to 0.8 lead
European 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 20 (Indoor) / IP 54 (Outdoor), String Inverter – IP 65

3.3.1 The rated/ name plate AC capacity of the PCU shall be AC power output of the PCU at 50°C.

3.3.2 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.

3.3.3 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.

3.4 Construction

3.4.1 Power Conditioning Unit (PCU) shall consist of an electronic three phase inverter along with associated control, protection, filtering, measurement and data logging devices.

3.4.2 Every DC input terminal of PCU shall be provided with fuse / MCB / MCCB of appropriate rating. The combined DC feeder shall have suitably rated isolators for safe start up and shut down of the system. One spare DC input terminal shall be provided for each PCU. String inverters without DC fuse may be acceptable in case not more than two strings are connected to the same MPPT.

3.4.3 DC input current monitoring shall be provided at each input of the PCU.

3.4.4 Type-I+II surge protective device (SPD) conforming to IEC 61643-31 shall be connected between positive/ negative bus and earth on the DC side. Type-II SPD

conforming to IEC 61643-11 shall be provided on the AC side.

3.4.5 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.

3.4.6 Circuit Breaker or Relay of appropriate voltage and current rating shall be provided at the output to isolate the PCU from grid in case of faults.

3.4.7 The PCU shall be tropicalized and the design shall be compatible with conditions prevailing at site. Suitable number of exhaust fans 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.

3.4.8 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. Grounding on DC side of the PCU shall be as per the requirements of PV Module Manufacturer.

3.4.9 Dedicated communication interface shall be provided to monitor the PCU from SCADA.

3.4.10 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.

(i) DC input power
(ii) DC input voltage
(iii) DC input current (for each terminal)
(iv) AC output power
(v) AC output voltage (all the 3 phases and line)
(vi) AC output current (all the 3 phases and line)
(vii) Frequency
(viii) Power Factor
(ix) KWh produced during entire day
(x) Total KWh produced during its entire lifetime.
(xi) Thermal loading (percentage)

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

3.4.11 String inverter, if installed in open, shall be placed inside a canopy shed with at least 15 cm in all directions.

3.4.12 AC combiner box for string inverter configuration shall comply with Clause 8 of the Technical Specifications with exception of the following.

(i) Rated System Voltage – Inverter Output Voltage

(ii) IP Rating – IP 5X (Indoor)

(iii) Metering System – Not required

(iv) CBCT – Not applicable

3.5 Operating Modes

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.

3.5.1 Standby Mode

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

3.5.2 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.

3.5.3 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.

The Contractor shall also provide the short-circuit characteristics of the PCU (Voltage and Time dependent) as per the CTU requirements for Connectivity.

3.6 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 including but not limited to following..

(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) Anti Islanding
(viii) Over temperature
(ix) Lightning surges
(x) Cooling system failure
(xi) AC & DC surge protection

3.7 Grid Support Functions

3.7.1 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 compliance.

3.7.2 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.

3.7.3 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.

3.8 Warranty

The complete Power Conditioning Unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 5 (five) years from the date of supply.

3.9 Tests

3.9.1 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.The type test reports shall be submitted before supply of PCUs.

3.9.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer/Owner and the reports shall be submitted to Employer/Owner..

4 Inverter Transformer and Auxiliary Transformer

4.1 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 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. 317	
CEA regulations and other statutory regulations	

4.2 Technical Requirements

Parameters	**Inverter Transformer**	**Auxiliary Transformer**
Quantity	**As per system design requirement**	**As per system requirement**
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 and as per IS 2026	As per system requirement and as per IS 2026
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 IS 6600/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 c) 140% for at least five seconds. Bidder shall furnish over fluxing characteristic up to 150%	

Air Clearance	As per IS/IEC

4.3 Construction

4.3.1 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.

4.3.2 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.

4.3.3 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.

4.3.4 The transformer shall be suitable for continuous operation with a frequency variation of ± 2.5% from nominal frequency of 50 Hz without exceeding the specified temperature rise.

4.3.5 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.

4.3.6 Neutral earthing of inverter transformer shall be as per the recommendations of inverter manufacturer. Even if neutral earthing is not required, neutral bushing 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.

4.3.7 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.

4.3.8 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.

4.3.9 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.

4.3.10 Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided.

4.3.11 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.

4.3.12 Filter valve at top the tank and drain cum sampling valve at bottom of the tank shall be provided.

4.3.13 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.

4.3.14 LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.

4.3.15 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.

4.3.16 Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

4.3.17 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.

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

4.3.19 Current transformer: Bushing or turret mounted current transformers shall be provided. It shall be possible to remove the CTs from the transformer tank without removing the transformer cover. CT secondary leads shall be brought out to a weather-proof terminal box near the bushings and the wiring from terminal box to

marshalling box shall be done.

4.4 Dry Type Auxiliary Transformer

4.4.1 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/Aluminium and insulation shall be Class F or better.

4.4.2 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.

4.5 Warranty

The transformer shall be warranted against all material/ manufacturing defects and workmanship for minimum of 5 (five) years from the date of supply.

4.6 Testing and Inspection

4.6.1 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 the similar transformer by NABL accredited laboratory within last five years from the last date of bid submission.

4.6.1.1 Type Tests

(i) Lightning impulse (Full & Chopped Wave) test on windings as per IEC 60076-3

(ii) Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076-2

(iii) Tank vacuum test & pressure test as per CBIP manual

4.6.1.2 Special Tests

(i) Measurement of zero-sequence impedance as per IEC 60076-1

(ii) Measurement of harmonics of no-load current as per IEC 60076-1

(iii) Measurement of acoustic noise level as per NEMA TR-1

(iv) Short-circuit withstand test as per IEC 60076-5

In case the contractor is unable 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/Owner.

4.6.1.3 Type tests mentioned in Clause 5.6.1.1(ii) & (iii) shall be performed for auxiliary

transformers. Special tests are not required.

4.6.2 Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IEC 60076 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 on at least one equipment of each type and rating)

4.6.3 Tests at Site

After erection at site all transformer(s) shall be subjected to the following tests.

(i) Measurement of voltage ratio
(ii) Check of vector group
(iii) Magnetic balance test
(iv) Measurement of insulation resistance
(v) Breakdown voltage test on transformer oil

In case the equipment is not found as per the requirements of the Technical Specifications of NIT, all expenses incurred during site testing will be to the Contractor's account and the equipment shall be replaced by him at free of cost.

5 33 kV Switchgear Panel

5.1 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 62271-206	High-voltage Switchgear and Control gear - Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV
IEC 61869 / IS 16227	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 15086-4	Surge Arresters, Part 4: Metal-Oxide Surge Arresters Without Gaps for A.C. systems
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

5.2 Technical Parameters

Parameter	Specification
System Parameters	
Highest system voltage	36 kV

Rated system voltage	33 kV
Rated frequency	50 Hz ± 5%
Number of phases/poles	3
Power frequency withstand voltage	70 kV (r.m.s.)
Lightning impulse withstand voltage	170 kV (peak)
System fault current	As per Requirement
Internal Arc Classification	IAC-A, FLR, System Fault Current for 1s
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3 sec – CO – 3 min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C1
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2S for metering at outgoing feeder), 5P20 for protection Class PS for Differential/Unit protection with suitable knee point voltage, as applicable
Rated VA burden	As per requirement
Insulation class	Class E or better
Voltage Transformer	
Accuracy class	0.2 for metering, 3P for protection
Rated VA burden	As per requirement
Insulation class	Class E or better

5.3 Switchgear Panel

5.3.1 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.

5.3.2 The circuit breakers shall be mounted on horizontally withdrawable trucks with locking facility in SERVICE and TEST positions.

5.3.3 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.

5.3.4 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 micron.

5.3.5 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.

5.3.6 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.

5.3.7 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.

5.3.8 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 with pre-engineered building as per relevant codes/standards..

5.3.9 Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.

(i) The breaker shall be operated only if it is in SERVICE or TEST position.

(ii) Movement of the breaker truck between SERVICE and TEST positions shall be possible only if the breaker is OFF.

(iii) It shall be possible to open the door only when the breaker is in TEST position.

5.3.10 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.

5.3.11 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.

5.3.12 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.

5.3.13 Gapless, metal-oxide surge arrestors shall be provided between line and earth in cable compartment of the switchgear panel.

5.3.14 Suitable lifting hooks shall be provided for each panel.

5.3.15 Minimum 10% spare feeders of each rating shall be provided in pooling switchgear.

5.4 Circuit Breakers

5.4.1 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.

5.4.2 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.

5.4.3 The rated control voltage shall be 110 VDC/220 VDC. The closing coil and spring charging motor shall operate at all values of control voltage between 85% and 110% of rated voltage. The shunt trip coil shall operate correctly under all operating conditions of the circuit breaker up to the rated short-circuit breaking capacity and at all values of control voltage between 70% and 110% of rated voltage.

5.4.4 Each circuit breaker shall be provided with two tripping coils operated through two independent DC supplies. Each trip coil shall have its own actuating contacts.

5.4.5 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.

5.4.6 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.

5.4.7 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.

5.5 Relays

5.5.1 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.

5.5.2 Numerical relays shall be IEDs (Intelligent Electronic Devices) complying with IEC 61850, having protection, control, measurement and monitoring features.

5.5.3 Auxiliary voltage of the relays shall be 110 VDC / 220 VDC and the relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.

5.5.4 All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO). Quantities shall be finalised during detailed engineering.

5.5.5 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.

5.5.6 All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

5.5.7 Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

5.5.8 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.

(i) Definite time (DT) phase over current protection
(ii) Inverse Definite Minimum Time (IDMT) phase over current protection
(iii) Definite time (DT) earth fault current protection
(iv) Inverse Definite Minimum Time (IDMT) earth fault current protection
(v) Under Voltage protection
(vi) Over Voltage protection

5.5.9 Transformer feeder protection relay shall have provision for the following protection functions.

(i) Buchholz alarm & trip
(ii) Oil Temperature Indicator (OTI) alarm & trip
(iii) Winding Temperature Indicator (WTI) alarm & trip
(iv) Pressure Relief Valve (PRV) trip
(v) Magnetic Oil Gauge (MOG) alarm

(vi) 87 Differential Protection / Unit Protection (as applicable)

(vii) 50/51N Instantaneous and time delay over current and earth fault protection On HV as well as LV Side.

5.5.10 All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

5.5.11 The numerical relay shall be able to record faults and events in non-volatile memory.

(i) Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.

(ii) Event record – At least 200 events with date and time stamp.

Sequence of events shall have at least 1 ms resolution at device level.

5.5.12 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.

5.5.13 The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

5.5.14 The numerical relay shall have feature for time synchronization through the SCADA System / networking.

5.5.15 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.

5.5.16 Contractor shall arrange for a Laptop to be used to facilitate numerical relay configuration, DR and downloading event/fault records from relay locally. Latest version of hardware and Software for interfacing the numerical relays with laptop shall be provided. At least two sets of communication cable for Laptop to relay communication shall be provided.

5.6 Instrument Transformers

5.6.1 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.

5.6.2 Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

5.6.3 Voltage transformers shall be single phase units. Bus voltage transformers shall be

housed in a separate panel on withdrawable truck.

5.6.4 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.

5.7 Earthing

5.7.1 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.

5.7.2 The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

5.7.3 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.

5.7.4 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.

5.7.5 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.

5.7.6 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.

5.7.7 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.

5.7.8 The interlocks shall be provided to ensure the following.

(i) It is not possible to rack-in the earthing truck/close the earthing switch when the breaker truck is in SERVICE position.

(ii) It is not possible to rack-in the breaker truck into SERVICE position when

earthing truck is connected/earthing switch is in closed position.

5.8 Bus bar

5.8.1 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.

5.8.2 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.

5.8.3 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.

5.8.4 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.

5.8.5 The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

5.9 Measuring Instruments

5.9.1 All the measuring instruments shall be digital, flush mounting type with communication facility.

5.9.2 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.

5.9.3 Measuring instruments shall have provision to display the following parameters.

(i) Line and phase voltages
(ii) Line and phase currents
(iii) Active power, Reactive power, Apparent power
(iv) Frequency
(v) Power factor
(vi) Total Harmonic Distortion (THD)

5.10 Wiring and Terminal blocks

5.10.1 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.

5.10.2 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.

5.10.3 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.

5.10.4 The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

5.10.5 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.

5.10.6 CT and VT secondary circuits shall be terminated on stud type, disconnecting terminal blocks.

5.10.7 At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

5.11 Warranty

The HT panel unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (Two) years from the date of supply.

5.12 Testing and Inspection

5.12.1 Type Tests

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. Validity period of type tests conducted on the equipment shall be as per 'CEA Guidelines for the Validity Period of Type Test(s) conducted on Major Electrical Equipment in Power Transmission'.

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 circuit	IEC 62271-200	6.4.1
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 (M1 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	
Communication requirements	IEC 61850	
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
Short-circuit withstand capability test	IEC 61869-3	7.2.301

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/Owner.

5.12.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer/Owner and reports shall be submitted to Owner..

6 AC Cables

6.1 Standards and Codes

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

IS 7098-I	Crosslinked Polyethylene Insulated Thermoplastic Sheathed Cables, Part 1: For Working Voltages up to and including 1100 V
IS 7098-II	Crosslinked Polyethylene Insulated Thermoplastics Sheathed Cables Part 2: For Working Voltages from 3.3 kV up to and including 33 kV

6.2 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.

6.3 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/Owner's approval.

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

(i) Cable size and voltage grade
(ii) Word 'FRLS' at every metre
(iii) Sequential marking of length of the cable in metres at every metre
(iv) 600 MW GAIL (India) Limited

6.5 Cables shall be sized based on the following considerations:

(i) Rated current the equipment
(ii) In case of Central inverters, average voltage drop in LT cable (from PCU to inverter transformer) shall be limited to 0.5% of the rated voltage. In case of String inverters, average voltage drop (from string inverter to LT combiner panel and from LT combiner panel to Inverter duty transformer) shall be limited to 1.5%. For HT cables (from inverter transformer to Pooling Substation), average voltage drop shall be limited to 1% of the rated voltage. The Contactor shall provide voltage

drop calculations in excel sheet.

(iii) Short circuit withstand capability as per design

(iv) De-rating factors according to laying pattern

6.6 Warranty

All cables shall be warranted for minimum of 1 (one) year against all material/ manufacturing defects and workmanship from the date of supply.

6.7 Testing

Type, routine and acceptance tests requirements shall be as per relevant standards/ Final Quality Assurance Plan for all cable sizes and reports shall be submitted to Owner.

6.8 Installation

6.8.1 Cable installation shall be as per IS 1255.

6.8.2 In case of central inverter configuration, AC cables from inverter to transformer shall be laid above ground on horizontal GI cable trays of required width. The cable trays shall be supported on concrete foundations. Minimum clear height of the cable tray shall be 350 mm above FGL.

6.8.3 Cables within plant pooling substation shall be laid through RCC cable trench with supports.

6.8.4 AC Cables from Inverter Transformer to 33 kV Switchgear Panel in Local Control Room shall be laid directly buried underground. AC cables from 33 kV Switchgear Panel in Local Control Room to 33 kV Switchgear Panel/33 kV outdoor Switchyard in Plant Pooling Substation may be laid overground on GI cable trays / directly buried underground / on overground transmission lines.

6.8.5 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.

6.8.6 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.

7 Auxiliary Supply System

7.1 Scheme for auxiliary supply system shall be submitted by contractor during detailed engineering for the approval by Employer/Owner.

7.2 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.

7.3 Auxiliary system of Pooling Substation shall incorporate redundant source of power supply for increased reliability.

7.4 Following consideration shall be taken into account while sizing the auxiliary transformer:

(i) 20% future load margin

(ii) Total connected load at 0.8 power factor

8 LT Switchgear

The LT switchgear specifications mentioned in this section are applicable for auxiliary supply distribution panel, AC combiner box and LT switchgear panel in case of string inverter configuration.

8.1 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
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
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

8.2 Technical Parameters

System Details	
Rated system voltage	415 V ± 10%, 3 Phase, 50Hz, 4 wire, Neutral Solidly Earthed
Rated frequency	50 Hz ± 5%
System fault current	As per system requirement
Moulded case circuit breaker (MCCB)	
Rated voltage	415 V
Rated current	As per system requirement
Rated insulation level	690 V
Rated ultimate short-circuit breaking capacity and Rated service short-circuit breaking capacity	As per system fault current
Rated short-circuit making capacity	2.1 × Rated ultimate short-circuit breaking capacity
Rated short-time withstand current duration	1 s
Utilization category	A
Current transformer (CT)	
Type	Cast Resin Bar Primary
Voltage class and frequency	650 V, 50 Hz
CT Secondary Current	1 A
Class of insulation	Class E or better
Accuracy class & burden	
a) For Protection	5P20, 5VA
b) For Metering	Class 0.5, 5VA (min)
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
Digital Multifunctional Meter (MFM)	
Accuracy class	0.5
Communication with SCADA	RS485 communication with Modbus RTU

8.3 Constructional Details

8.3.1 The panel shall be metal enclosed, free standing, floor mounted, modular type with compartmentalized construction having degree of protection of IP 5X (Indoor) and IP 55 (Outdoor) as per IS/IEC 60529. All doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust.

8.3.2 All switches, push buttons etc. shall be operated front and shall be flush/semi-flush mounted.

8.3.3 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.

8.3.4 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.

8.3.5 Earthing bus bar of suitable cross section shall be provided throughout the length of panel.

8.3.6 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.

8.3.7 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.

8.3.8 The panel shall be of dead front construction suitable for front operated and back maintained functioning.

8.3.9 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.

8.3.10 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.

8.3.11 Suitable lifting hooks shall be provided for each panel.

8.3.12 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.

8.3.13 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.

8.4 Warranty

LT switchgear shall be warranted against all material/ manufacturing defects and workmanship for minimum of 1 (one) year from the date of supply.

8.5 Testing

Routine test and acceptance tests requirements shall be as per relevant standards/ Final Quality Assurance Plan for all cable sizes.

9 Uninterrupted Power Supply

9.1 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

9.2 General Requirements

9.2.1 Main Control Room and all the Inverter Control Rooms shall be provided with a UPS to cater to critical loads.

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

(i) Data logger / SCADA
(ii) Fire Detection/ Alarm Panel
(iii) HMI of SCADA
(iv) Emergency Lighting
(v) Inverter's Auxiliary supply (if applicable)
(vi) HT panel auxiliary
(vii) CCTV (Closed Circuit Television System)

9.2.3 Pooling Substation UPS system shall comprise of two nos. of UPS of 100% capacity, i.e., two inverters, batteries and UPSDB connected by bus coupler.

9.2.4 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.

9.2.5 The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.1 & depth of discharge of 80%.

9.3 System Description

9.3.1 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.

(i) 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

9.3.2 The UPS shall meet the following minimum specifications.

Parameter	**Specification**
Topology	Online double conversion UPS
Overall efficiency	> 90%
Input	
Voltage	230 V ± 10% AC for UPS rating of less than 5 kVA 415 V ± 10% AC for UPS rating of 5 kVA and above
Frequency	50 ± 5%
Power factor	0.95
Output	
Voltage	230V ± 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 Indication	Yes
Local Display	LCD / LED
SCADA communication	RS-485 Interface Port

9.3.3 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.

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

9.4 Warranty

UPS shall be warranted for minimum of 5 (five) years and batteries shall be warranted for a minimum of 2 (two) years against all material/ manufacturing defects and workmanship from the date of supply.

9.5 Tests

9.5.1 Routine tests and acceptance tests on final product shall be done as per QAP approved by the Employer/Owner.

9.5.2 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.

10 Battery and Battery Charger

10.1 Standards and Codes

Standard/Code	Description
IEC 60896-21:2004	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IEC 60896-22:2004	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements

IS 15549	Stationary Regulated Lead Acid Batteries

10.2 General

10.2.1 110 V / 220 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) Float cum Boost Charger (FCBC)

(iii) DC Distribution Board (DCDB)

10.2.2 Pooling Substation DC system shall comprise of two nos. of battery system, battery charger and DCDB connected by bus coupler.

10.2.3 Battery shall be used to supply the following loads with back up of two hours in case of complete power failure:

(i) Trip and closing coil of 33 kV circuit breaker

(ii) Spring charging motors for 33 kV circuit breaker

(iii) Annunciator and Indication circuit of 33 kV switchgear panel

(iv) Auxiliary supply to protection relays

(v) Pooling Substation protection and control supply

(vi) PLCC equipment

10.2.4 The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.1 & depth of discharge of 80%.

10.2.5 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.

10.3 Battery

The battery shall be VRLA type complying with IEC 60896-21 & IEC 60896-22 / IS 15549. The Contractor shall submit type test reports as per IEC 60896-21 & IEC 60896-22 / IS 15549.

10.4 Battery Charger

10.4.1 The Battery Charger as well as its automatic regulator shall be of static type and shall be compatible with offered batteries. The Battery Charger shall be capable of continuous operation at the respective rated load in float charging mode. The charger shall also be capable of boost charging the associated battery at the desired rate.

10.4.2 The battery charger shall regulate the float/boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid

thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback control.

10.4.3 The battery charger shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. When on automatic control mode during float charging, the charger output voltage shall remain within ±1% of the set value for AC input voltage variation of ±10%, frequency variation of ±5%, combined voltage and frequency variation of ±10%, and DC load variation from zero to full load.

10.4.4 The battery charger shall have a constant voltage characteristics throughout the range (from zero to full load) at the floating value of the voltage so as to keep the battery fully charged but without harmful overcharge.

10.4.5 The battery charger shall have load limiters having drooping characteristic, which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the charger. The load-limiter characteristics shall be such that any sustained overload or short circuit in DC system shall not damage the charger, nor shall it cause blowing of any of the charger fuses. The charger shall not trip on overload or external short circuit.

10.4.6 Uniform and step less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Step less adjustment of the load limiter setting shall also be possible from 80% to 100% of the rated output current for float charging mode.

10.4.7 During boost charging, the battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100% of the rated output current for boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode.

10.4.8 Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1%, irrespective of DC load level, even

when they are not connected to battery.

10.4.9 Digital Outputs shall be configured for connection to the SCADA to monitor the outputs like charger output current, output voltage, float/boost mode, etc.

10.4.10 The battery charger shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. A thermal overload relay incorporating a distinct single phasing protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

10.4.11 The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger.

10.4.12 Digital or analog indicating instruments to indicate DC current, DC voltage & AC voltage shall be provided.

10.4.13 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.

10.4.14 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 (Indoor) / IP 55 (Outdoor).

10.4.15 The instruments, switches and indicating lamps shall be flush mounted on the front panel.

10.4.16 DCDB shall have adequate number of outgoing feeders with double pole, DC MCBs. At least 20% feeders shall be provided as spare.

10.5 Warranty

Batteries and battery charger shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship from the date of supply.

10.6 Tests

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

11 Earthing

11.1 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
CEA Regulations and other statutory regulations	

11.2 General Requirements

11.2.1 The contractor shall submit to the Employer the design calculations for the Earthing System and other relevant information during detailed engineering.

11.2.2 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.

11.2.3 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. For Plant Pooling Substation earthing, mild steel rod may be used as earth electrode.

11.2.4 Earth conductors shall be made of copper bonded steel, galvanized steel or galvanised iron of sufficient cross section to carry the fault current and withstand corrosion.

11.2.5 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.

11.2.6 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.

11.2.7 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.

11.2.8 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.

For other areas in the solar plant such as transformer yard, switchgear room the earthing system shall consist of minimum two parallel conductors interconnected together. All non-current carrying metal parts, metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system in compliance to Rule 11 and 61 Indian Electricity Rule 1956 (as amended upto date), IS3043 and IEE80-2000 .

11.3 Earthing of PV array field

11.3.1 All PV Modules, Module Mounting Structures (MMS) and String Combiner Box (SMB) structures in the PV array field shall be bonded to the earthing system by two distinct connections.

11.3.2 Earthing of PV Modules shall be as per the requirements of the PV Module Manufacturer.

11.3.3 VOID.

11.3.4 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.

11.3.5 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.

11.3.6 SMB 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.

11.4 PCU Earthing

Grounding on DC side of the PCU shall be as per the requirements of PCU Manufacturer. PCU earth bus shall be connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by PCU manufacturer. The interconnection of PCU earth electrodes with DC earth grid shall be as per PCU manufacturer recommendation.

11.5 Transformer Earthing

11.5.1 Inverter transformer neutral earthing shall be as per the recommendation of inverter manufacturer.

11.5.2 Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.

11.5.3 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.

11.5.4 Neutral and body of the auxiliary transformer shall be earthed.

11.6 Inverter Room and Main Control Room Earthing

11.6.1 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.

11.6.2 Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.

11.6.3 SCADA and other related electronic devices shall be earthed separately using minimum two no. of earth electrodes.

11.7 SCADA Earthing

11.7.1 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.

11.7.2 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.

11.8 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 over-head shield wire or earth wire or spikes(masts) or a combination there of as per CEA regulations 2010 (Technical standards)- 42(2)(C).

11.9 Tests

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.

12 Lightning Protection System

12.1 Lightning Protection System (LPS) for the entire plant except buildings and plant pooling substation against direct lighting strokes shall be provided as per IS/IEC 62305:2010 or NFC 17-102. Lightning Protection System for buildings shall be provided as per IS/IEC 62305:2010.

12.2 Protection level for the entire plant shall be Level-III.

12.3 Air terminals, down conductors and earth termination system shall be designed as per relevant parts of IS/IEC 62305:2010 or NFC 17-102.

12.4 Necessary foundation/anchoring for holding the air terminal in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

12.5 Type test reports as per IS/IEC 62305:2010 or NFC 17-102 shall be submitted during detailed engineering for approval.

12.6 The contractor shall submit to the Employer the design calculations for the Lightning Protection System and other relevant during detailed engineering.

12.7 Lightning Protection System for Plant Pooling Substation

12.7.1 Direct Stroke Lightning Protection (DSLP) for Plant Pooling Substation shall be provided by Lightning Mast and Shield Wires.

12.7.2 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

12.7.3 Down conductors shall not be connected to other conductors above ground level. Down conductors shall be cleated on the structures at 2000 mm interval.

12.7.4 Every down conductor shall be provided with a test joint at about 1000 mm above ground level. The test joint shall be directly connected to the earthing system.

13 Communication Cables

13.1 Optical Fibre Cables

13.1.1 Optic Fibre cable shall be 8/12 core, galvanized corrugated steel taped armoured, fully water blocked, for outdoor/ indoor application so as to prevent any physical damage.

13.1.2 The cable shall have multiple single-mode or multimode fibres on as required basis so as to avoid the usage of any repeaters.

13.1.3 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.

13.1.4 The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling.

13.1.5 All testing of the optic fibre cable being supplied shall be as per the relevant IEC, EIA and other international standards.

13.1.6 The Contractor shall ensure that minimum 50% cores (not less than 4) are kept as spare in all types of optical fibre cables.

13.1.7 Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.

13.1.8 Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standard.

13.2 RS-485 Cable

RS-485 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.

13.3 Communication Cable Laying

13.3.1 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.

13.3.2 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.

13.3.3 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.

13.3.4 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.

14 SCADA

14.1 General Requirements

14.1.1 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.

14.1.2 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.

14.1.3 SCADA System shall have the provision to perform the following features and/or functions:

(i) 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 parameter.

(ii) 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.

(iii) Fault and System Diagnostics with time stamped event logging.

(iv) AI/ML-based data analytics tools to enable detailed performance tracking, predictive maintenance and analysis of renewable energy assets over time. This will include identifying trends, patterns, and areas for lost generation and assessment of potential improvement Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.

(v) Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.

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

14.1.4 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.

14.1.5 The SCADA System shall comply with CEA (Cyber Security in Power Systems) Guidelines, 2021, amended from time to time, and the technical standards for communication system in Power Sector laid down by the relevant Authority.

14.2 Architecture

14.2.1 The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database.

14.2.2 Data acquisition shall be distributed across MCR and LCRs while plant level data

aggregation shall be done in plant servers.

14.2.3 Analog and Digital IO modules shall have integrated processor for distributed IO processing and control.

14.2.4 Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth IEC 61850/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.

14.2.5 Plant SCADA Server shall have Industrial Grade server hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.

Note: One redundant server shall be provided along with separate SMPS power supply.

14.2.6 Plant data for monitoring and control operations should be accessible without dependence on external network.

14.2.7 Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant. 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.

14.2.8 Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps 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.

14.2.9 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. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.

14.2.10 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.

14.3 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 SCADA Servers. The IIoT Controllers shall meet the following minimum requirements:

14.3.1 The IIoT Controllers shall be distributed in nature and work independently of other IIoT Controllers or any central controller in the system.

14.3.2 Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, MQTTS,HTTPS,SFTP,IEC 60870-5-104,DNP3.0 etc.)

14.3.3 Shall have provision for local storage in case of network failure in the database format like SQL lite or FTP (.csv) with minimum 2GB SD card.

14.3.4 Provide web-based interface to configure the controller for various equipment in the field.

14.3.5 IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT & Transformer panels through distributed DI/AI modules.

14.3.6 Controls: Shall be capable of Controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.

14.3.7 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.

14.3.8 Controllers shall be capable of sending data over Internet connections by using secure communication via TLS Over MQTTs, HTTPS, OPC UA, IEC 60870-5-104 etc.

14.3.9 IIoT device should have integrated firewall with VPN functionality.

14.3.10 IIoT device should have security certification acc. to IEC 62443-4-2

14.3.11 IIoT device should be rugged & tested from ILAC accredited/NABL laboratory for magnetic field as per IEC 60870-2-1.

14.3.12 IIoT Controller shall support Higher level language for programming and support Docker functionality.

14.4 Network Switches

14.4.1 Industrial-grade, managed, DIN-rail mounted with temperature rating suitable for site.

14.4.2 Switches shall offer MRP or RSTP protocol support (50-200ms recovery) and Port-

level monitoring capability

14.5 System Spare Capacity

Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site:

(i) 10 % spare channels in input/output modules fully wired up to cabinets TB.

(ii) Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.

(iii) Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.

(iv) Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.

(v) Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.

(vi) The Data communication system shall have the capacity to handle the additions mentioned above.

(vii) Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.

(viii) The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

14.6 Functionalities

14.6.1 The SCADA system shall monitor instantaneous and cumulative electrical

parameters from all DC & AC Equipment including but not limited to inverters, weather station, MFM, Transformer and Switchgear (LT & HT Panels), UPS at regular intervals not greater than one minute.

14.6.2 The SCADA system shall monitor instantaneous and cumulative environment parameters from weather sensors or data loggers at same interval as electrical parameters and provide PR, CUF on the fly.

14.6.3 Data Archival

14.6.3.1 The IIoT/SCADA controller shall record all operational parameters at a 1-minute logging interval and shall maintain adequate local buffering to support backfilling in case of communication outages.

14.6.3.2 The SCADA server shall implement the permanent data archival function for a period of 2 years. Under normal operating conditions, the server database shall archive data at a 15-minute interval by applying appropriate aggregation or down-sampling rules. No permanent data reduction shall be performed at the controller level.

14.6.3.3 Upon detection of any anomalous conditions (for e.g. alarms, threshold violations, etc.), the server shall automatically retain full 1-minute resolution data for the entire duration of the event, including configurable pre-event and post-event buffers.

14.6.4 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.

14.6.5 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.

14.6.6 In the event of a communication loss between the controller and the SCADA server, the controller shall locally buffer 1-minute logged data. Upon restoration of connectivity, the server shall perform time-synchronised backfilling to ensure continuity and completeness of the historical data set without duplication.

14.6.7 All logged and archived data shall utilise controller-generated timestamps to maintain accuracy and traceability across the system.

14.6.8 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.

14.6.9 Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.

14.6.10 Data Communication to SLDC/RLDC: SCADA system shall provide required interface to integrate with SLDC/RLDC, in compliance with grid code, to send any parameters specified by SLDC/RLDC.

Note: The methodology and specification of SLDC/RLDC interface will be provided separately by SLDC/RLDC and it shall be the responsibility of the Contractor to determine the same.

14.6.11 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 IEC61850/ Modbus TCP/IP.

14.6.12 All programming functionalities shall be password protected to avoid unauthorized modification.

14.6.13 The Contractor shall provide software locks and passwords to Employer/Owner for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer/Owner to carry out modification at a later date.

14.7 Control Cabinets / Panels / Desks at Main Control Room

14.7.1 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.

14.7.2 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.

14.8 Software Licences

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.

14.9 Hardware at Main Control Room

14.9.1 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.

14.9.2 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 (2 Nos. - Main & Redundant)	
Server Hardware	Hex/Octal Core Xeon, 64 GB RAM (expandable to 128 GB RAM), 4 × 2 TB SSD hard discs in RAID 5 configuration, 2 TB external USB SSD hard disc (for backup), dual power supplies, 2 LAN ports, LED console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System (OS) and Database (DB) shall be of enterprise scale (OS - RedHat Linux/equivalent Linux/Windows Server OS; Database - Oracle/MySQL/equivalent DB), with required AMC for 5 years
Accessories	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 (OWS) – 2 Nos.	
Hardware	i9 CPU running at base speed 3.0 GHz or faster with 32 GB RAM or higher, 2 TB SSD hard disk, 28” LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. UPS of required capacity with 2-hour battery backup. Common for the Operator Workstations: 1. Screen Display Unit: Min 60” LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer.
PPC Workstation – 1 No.	
Hardware	i9 CPU running at base speed 3.0 GHz or faster with 32 GB RAM or higher, 2 TB SSD hard disk, 28” LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.

Accessories	1. UPS of required capacity with 2-hour battery backup.

14.9.3 All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

14.10 Factory Acceptance Test (FAT)

FAT 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.

15 Power Plant Controller

15.1 Power Plant Controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

15.2 SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual solar inverter. Provisions shall be enabled for the PPC to take voltage and current of POI as a reference to Power Plant Controller for giving command to individual PCUs. Detailed control logic in the PPC shall be finalized during detailed engineering stage. The control logic and setting of the PPC shall be in line with latest CEA (Technical Standards for Connectivity to Grid) and as per RLDC requirement.

15.3 Memory of PPC controller system shall be sufficient for the complete system operation and have a capability for at least 25% expansion in the future.

15.4 Suitable PQ meters (class-A type) at plant final output for measurement of required electrical parameters (active power, reactive power, power factor, voltage, current, frequency, etc.) shall also be provided for this purpose.

15.5 The PPC shall comply with cyber security guidelines issued by the Central Government, from time to time, and the technical standards for communication system in Power Sector laid down by the Authority.

15.6 The Contractor shall provide the UPS/ DC Power supply of suitable rating to cater all

the load requirements of PPC and its auxiliaries.

16 **Power Transformer**

As specified in Section VII: Sub Section - A (Scope of Works), Power Transformer of 33/220 kV ONAN/ONAF with OLTC Power Transformer shall be provided in line with "Standard Technical Specifications of Transformer(s) for Solar Park pooling station" issued by Central Electricity Authority (CEA). The transformer shall be capable of being overloaded to 110% for four hours in a 24-hour cycle.

17 **Nitrogen Injection Fire Protection System**

Nitrogen Injection Fire Protection System (NIFPS) shall use nitrogen as fire quenching medium. The protection system shall prevent transformer oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fire, fire from surrounding equipment etc., it shall act as a fast and effective fire extinguisher without any manual intervention.

17.1 Standards and Codes

All the equipment of NIFPS shall comply with the latest edition of the following standards and codes including amendments.

Standard	**Description**
IS 10028-2	Code of practice for selection, installation and maintenance of transformers; Part 2: Installation
IS 7285-2	Refillable Seamless Steel Gas Cylinders - Specification Part 2: Quenched and Tempered Steel Cylinders With Tensile Strength Less Than 1100 MPa (112 kgf/mm^2)
CEA Technical Standards for Construction of Electrical Plants and Electric Lines Regulations, 2010 with 2015 amendment	
CEA Measures relating to Safety and Electric Supply Regulations, 2010 with 2015 amendment	
CBIP Manual on Transformers, Publication No. 317	

17.2 Technical Requirements

Parameter	**Specification**
Fire extinction period from commencement of nitrogen injection	30 second (maximum)
Total time duration to bring oil temperature below flash point	30 minute (maximum)
Fire detector heat sensing temperature	141°C

TCIV setting for normal operation to ensure no obstacle for transformer breathing	40 litre per minute
TCIV setting for operation during abnormal flow of oil	60 litre per minute
Capacity of nitrogen gas cylinder	10 m^3 gas at pressure of 150 kg/cm^2 for up to 60,000 litre of oil 20 m^3 gas at pressure of 150 kg/cm^2 for above 60,000 litre of oil

17.3 System Components

NIFPS shall broadly consists of the following components. However, all other components which are necessary for fast, reliable and effective working of the fire protection system shall be deemed to be included in the scope of supply. The NIFPS shall have provision for SCADA connectivity.

17.3.1 Fire Extinguishing Cubicle

The Fire Extinguishing Cubicle (FEC) shall be made of CRCA sheet of minimum 3 mm thick with Polyurethane painting. The degree of protection shall be IP 55 or better. It shall have hinged split doors fitted with high-quality tamper-proof lock. The following components shall be provided in the FEC.

(i) Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer. The nitrogen gas cylinder should have been certified by Bureau of Indian Standards and approved by Chief Controller of Explosives, Government of India.
(ii) Oil drain pipe with mechanical quick drain valve
(iii) Control equipment for draining of oil and injecting nitrogen gas
(iv) Pressure monitoring switch for backup protection for nitrogen release
(v) Limit switches for monitoring of the system
(vi) Valve with flanges on top of the cubicle for connecting oil drain pipe and nitrogen injection pipe
(vii) Panel lighting
(viii) Oil drain pipe extension of suitable sizes for connecting pipes to oil pit

17.3.2 Control Box

Control box shall be placed in the Master Control Room (MCR) for monitoring, automatic control and remote control. The rated control voltage of the control box shall be 110 VDC. The control box shall have suitable indications, alarms, switches

and push buttons for complete monitoring and control of the system.

17.3.3 Transformer Conservator Isolation Valve

Transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipe line between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling. Locking plates shall be provided with handle for pad locking. It shall have proximity switch for remote alarm and indication glass window for visual inspection for physical checking of the status of valve. The TCIV shall be of the best quality and proven design as malfunctioning of TCIV could lead to serious consequences.

17.3.4 Fire Detector

Adequate number of fire detectors shall be fitted on top cover of the transformer and OLTC with brackets. Heat sensing temperature of the fire detectors shall be 141°C.

17.3.5 Signal Box

Signal box shall be mounted way from the transformer preferably near the marshalling box for terminating the cables from TCIV & fire detectors and to further connection to control box at the MCR. The degree of protection of the signal box shall be IP 55 or better.

17.3.6 Cables

The interconnecting cables shall be Fire Retardant Low Smoke (FRLS) type. Cables passing along the top of the transformer shall be Fire Survival type.

17.3.7 Pipes

Heavy duty pipe connecting the transformer tank for oil drain and for nitrogen injection shall be provided. Pipes, complete with supports, connections, flanges, bends and tees etc. shall be supplied along with the system.

17.3.8 Other Items

(i) Doors and covers of all the panels (FEC, Control box, Signal box, etc.) shall be provided with neoprene gaskets.

(ii) All the panels and piping system shall be painted with enamelled paint.

17.4 Operation

17.4.1 On receipt of signals, e.g. Differential protection parallel with fire detector,

Buchholz (surge) parallel with PRV and transformer isolation signals, a pre-determined quantity of oil drain shall commence and simultaneously nitrogen shall be injected at a pre-determined flow rate to create stirring action and to bring down temperature of top oil surface below ignition point and shall extinguish fire within short possible time. TCIV shall block oil passage and isolate conservator tank oil and shall prevent escalation of fire.

17.4.2 The system shall operate in automatic, remote and manual mode in the event of power failure.

17.4.3 The system shall have provision of testing on live transformers to ensure healthiness at all times.

17.4.4 The system shall have interlock to ensure operation of system only after transformer electrical isolation to avoid nitrogen in energised transformer.

17.4.5 The system shall have mechanical locking arrangement for nitrogen release system as well as oil drain to avoid unnecessary operation during maintenance and/or testing of the transformer and/or system.

17.4.6 The system shall have provision to monitor nitrogen injection pressure as well as cylinder pressure.

17.4.7 Pressure monitoring switch for back-up protection for nitrogen release as redundancy to first signal of oil draining commencement for nitrogen release shall preferably be provided.

17.4.8 The system shall have individual mechanical release devices and provision for oil drain and nitrogen release to operate manually in case of operation of DC supply failure.

17.4.9 Nitrogen release scheme shall be designed in such a way that the nitrogen gas shall not enter the energised transformer even in case of passing/leakage of valve.

18 Control and Relay Panel

18.1 Standards and Codes

All equipment provided under Control and Relay Panel shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the C&R Panel shall comply with the following standards and codes.

Standard/Code	Description
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 15086-4	Surge Arresters, Part 4: Metal-Oxide Surge Arresters Without Gaps for A.C. systems
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

18.2 Construction

18.2.1 The control and relay panel shall be free standing, floor mounted, simplex type, metal enclosed construction. The panel enclosure shall be made of CRCA steel sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.

18.2.2 All external surface shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 micron.

18.2.3 Controls, indications, relays, meters and other instruments shall be flush mounted on the front of the panel. Door shall be provided at the rear of the panel. All doors and removable covers shall be provided with neoprene or synthetic rubber gasket.

18.2.4 The panel shall be dust, moisture and vermin proof with degree of protection not less than IP 4X as per IEC 60529.

18.2.5 Cable entry shall be through the bottom of the panel. Gland plate of thickness not less than 3 mm shall be provided.

18.3 Relays

18.3.1 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.

18.3.2 Auxiliary voltage of the relays shall be 110 VDC / 220 VDC and the relays shall be

capable of operating continuously between 80 – 120% of auxiliary voltage.

18.3.3 All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO). All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

18.3.4 All numerical relays shall have sufficient number of current and voltage inputs required for all the required protection functions.

18.3.5 The numerical relay shall provide choice of ANSI/IEC/IEEE relay characteristic curves with wide protection setting ranges through a minimum of two protection setting groups.

18.3.6 Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

18.3.7 All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

18.3.8 The numerical relay shall be able to record faults and events in non-volatile memory.

(iii) Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.

(iv) Event record – At least 200 events with date and time stamp.

18.3.9 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.

18.3.10 The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

18.3.11 The numerical relay shall have two serial communication ports, one on front side for local communication with PC and another on rear side for remote communication with SCADA system as per IEC 61850.

18.3.12 The numerical relay shall have feature for time synchronization through the SCADA System / networking.

18.3.13 The numerical relay shall be provided with backlit alphanumeric LCD or LED to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

18.3.14 Necessary software and hardware to up/down load the data to/from the relay from/to the PC shall also be provided.

18.3.15 Each feeder shall have two lock out relays powered through independent DC

supplies. Each lock out relay shall send signals to the respective independent trip coils through separate potential free output contacts.

18.4 Protection Scheme

18.4.1 The following protection schemes shall be implemented for the protection of power transformer and its feeder.

(i) Biased Differential Protection with Second Harmonic Restraint
(ii) Non-directional Over Current and Earth Fault Protection
(iii) Restricted Earth Fault Protection
(iv) Under Voltage and Over Voltage Protection
(iii) Buchholz Alarm and Trip
(iv) OTI Alarm and Trip
(v) WTI Alarm and Trip
(vi) PRV Trip
(vii) MOG Alarm
(viii) OSR Trip

The above-mentioned protection schemes are indicative only. All the protection schemes required for safe and reliable operation of power transformer and the feeder shall be provided.

18.4.2 Protection philosophy for the protection of line feeders shall be as per remote end substation requirements.

18.5 Measuring Instruments

18.5.1 All measuring instruments shall be enclosed in dust proof, moisture resistant cases and flush mounted on the panel.

18.5.2 Analog Ammeter and Voltmeter with selector switch shall be provided. Accuracy class shall be 0.5 or better. Instrument dial shall be with white scale, black pointer and black numerals.

18.5.3 Digital Multi-Function Meter (MFM) of accuracy class 0.2 or better shall be provided. It shall have communication capability for integration with SCADA. MFM shall be able to measure line & phase voltages, line & phase currents, active power, reactive power, apparent power, power factor and frequency.

18.6 Control Switches

All control switches shall be rotary operated type with adequate making, carrying and breaking current ratings. The control switches shall be pistol grip type, lockable with

spring return to normal position. They shall be flush mounted on the panel with shrouded terminals.

18.7 Indications

All indicating lamps shall be flush mounted LED type with supply voltage of 110 VDC / 220 VDC. Lamp covers shall preferably be screwed type and moulded from heat resisting material. Indicating lamps shall be provided for R, Y, B PT supply, Breaker ON & OFF, Auto trip, Spring charged, Trip circuit healthy, etc.

18.8 Annunciation

Flush mounted static type annunciator with sufficient number of windows to accommodate all trip and alarm signals shall be provided. Separate audible annunciation for alarm and trip shall be provided by means of buzzer and hooter. Visual annunciation shall be by flickering of facia. Push buttons for test, accept and reset shall also be provided.

18.9 Earthing

18.9.1 An earth bus made of copper or aluminium shall be provided throughout the length of the panel and bolted to the framework of the panel. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

18.9.2 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 earth grid.

18.9.3 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.

18.9.4 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.

18.10 Mimic Diagram

Coloured mimic diagram made of metal or plastic with symbols to facilitate exact representation of the system shall be fixed on the front of control panel. Semaphore indicators shall be incorporated in the mimic diagram for indicating position of circuit breakers, isolators and earthing switches. The rated control voltage of semaphore

indicator shall be 110 / 220 VDC.

18.11 Wiring and Terminal Blocks

18.11.1 All internal wiring shall be done with 1100 V grade, 2.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 4 sq.mm copper wire shall be used.

18.11.2 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.

18.11.3 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.

18.11.4 The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

18.11.5 All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 1100 V, 10 A and made of non-inflammable material.

18.11.6 CT and VT secondary circuits shall be terminated on stud type, non-disconnecting terminal blocks.

18.11.7 At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

18.11.8 Screw driver operated stud type test terminal block shall be provided.

18.12 Accessories

(ix) Thermostatically controlled space heater with switch for isolation

(x) 240 V, 15 A industrial socket with ON/OFF switch

(xi) LED lamp controlled by door switch

18.13 Warranty

The control and relay panel unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship from the date of supply.

18.14 Testing and Inspection

18.14.1 Type Tests

The Contractor shall submit type test report of the panel for degree of protection as required by the Technical Specifications as per IEC 60529. The test should have been conducted by NABL accredited laboratory.

18.14.2 Routine Tests

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

19 Plant Pooling Substation Equipment

19.1 Standards and Codes

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

Standard/Code	Description
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IEC 60376, IS 13072	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IEC 61869	Instrument Transformers
IS 2099	Bushings for alternating voltages above 1000 Volts
IS/IEC 60168	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass for Systems with Nominal Voltages Greater than 1000 V
IS 16683, IEC TS 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 335, IEC 60296	Insulating oil
IS/IEC 60034	Rotating electrical machines
IS 996	Single-phase AC industrial motors for general purpose
IS 15086-4, IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
CEA (Technical Standards for Construction of Electrical Plants & Electric Lines) Regulations, 2022	
Indian Electricity Act, CBIP manual	

19.2 General Technical Parameters

System Parameters	Specification
Highest system voltage	245 kV

Rated system voltage	220 kV
Rated frequency	50 Hz
Number of phases	3
One minute power frequency withstand voltage	460 kV (rms)
Full wave impulse withstand voltage (1.2 / 50 μs)	1050 kV (peak)
Rated short-time withstand current	50 kA for 1 s
Rated peak withstand current	100 kAp
System neutral earthing	Effectively earthed
Minimum creepage distance	As per site pollution level
Minimum clearance (i) Phase to phase clearance (ii) Phase to earth clearance (iii) Sectional clearance (iv) Ground clearance	 2100 mm 2100 mm 5000 mm 5500 mm

19.3 Supplier Qualification Criteria

Only PGCIL approved components shall be used for construction of 220 kV substation.

19.4 Circuit breaker

19.4.1 Technical Parameters

Parameters	**Specification**
Type	Outdoor SF6, single pressure
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	1000 μV at 156 kV rms
Minimum corona extinction voltage	156 kV rms
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Rated break time	60 ms
Total break time	65 ms
Total closing time	Not more than 150 ms
Re-strike performance class	C2
Mechanical endurance class	M2
First pole to clear factor	1.3

Reclosing	Single phase & three phase high speed auto reclosing
Rated terminal load	Adequate to withstand 100 kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity
Noise level	Maximum 140 dB at 50 m distance from base of circuit breaker
Seismic level	0.5 g horizontal for the site location under Zone-V as per IS 1893 0.3 g horizontal for the site location under other than Zone-V as per IS 1893
Auxiliary contacts	
No. of contacts	As required plus 10 NO and 10 NC contacts per pole as spare
Thermal rating	10 A at 220 V DC
Breaking capacity	2 A DC with circuit time constant not less than 20 ms

19.4.2 Duty Requirements

19.4.2.1 The circuit breaker shall be shall be capable of performing their duties without opening resistors. The circuit breaker shall meet the duty requirements for any type of fault or fault location and shall be suitable for line charging and dropping when used on effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.

19.4.2.2 The circuit breaker shall be capable of breaking the steady and transient magnetizing current corresponding to power transformers of applicable rating. It shall be capable of breaking line charging currents as per IEC 62271-100 with a voltage factor of 1.4. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC 62271-100.

19.4.2.3 The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic/hydraulic pressure and arc extinguishing medium pressure, etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles shall be brought out to establish the guaranteed total break time. While furnishing particulars regarding the D.C. component of the circuit breaker, the Contractor shall note that IEC 62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.

19.4.3 Construction

19.4.3.1 Circuit breakers shall be SF6 insulated, single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

19.4.3.2 Each pole shall form an enclosure filled with SF6 gas independent of two other poles and the SF6 density of each pole shall be monitored individually.

19.4.3.3 The SF6 gas density monitor shall be adequately temperature compensated to model the density changes due to variations in ambient temperature within the body of circuit breaker as a whole. It shall be possible to dismantle the monitor without removal of gas. Temperature compensated SF6 pressure gauge shall be provided which will be visible from ground level.

19.4.3.4 Sufficient SF6 gas shall be supplied to fill all the circuit breakers installed plus an additional 20% of the quantity as spare.

19.4.3.5 All making and breaking contacts shall be sealed and free from atmospheric effect. In the event of leakage of extinguishing medium to a value, which cannot withstand the dielectric stresses specified in the open position, the contacts shall preferably self-close. Main contacts shall be easily accessible for inspection and replacement. If there are no separately mounted arcing contacts, then the main contacts shall be easily accessible for inspection and replacement. Main contacts shall have ample area and contact pressure for carrying the rated current under all conditions.

19.4.3.6 All the three poles of the breaker shall be linked together either electrically/pneumatically or electro hydraulically.

19.4.3.7 Circuit breakers shall be provided with two (2) independent trip coils, suitable for trip circuit supervision. The trip circuit supervision relay would also be provided. Necessary terminals shall be provided in the central control cabinet of the circuit breaker.

19.4.4 Operating Mechanism and Control

19.4.4.1 Circuit breaker shall be operated by pneumatic mechanism or electrically spring charged mechanism or electro-hydraulic mechanism or a combination of these. It shall be gang operated for 3-phase reclosing operation.

19.4.4.2 The pneumatically operated mechanism shall offer unit compressor with each circuit breaker with the breaker local air receivers having a capacity for two ‘CO’ operations of the breaker at the lowest pressure for reclose duty without refilling.

19.4.4.3 The spring-operated mechanism shall be complete with motor, opening spring & closing spring with limit switch for automatic charging and other necessary

accessories to make the mechanism a complete operating unit. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty. After failure of power supply to the motor, one close-open operation shall be possible with the energy contained in the operating mechanism. Motor ratings shall be such that it requires not more than 30 seconds for fully charging the closing spring.

19.4.4.4 The hydraulic mechanism shall be suitable for at least two close open operations after failure of ac supply to the motor starting at pressure equal to lowest pressure of auto-reclose duty. All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

19.5 Disconnector

19.5.1 Technical Parameters

System Parameters	**Specification**
Service	Outdoor
Type	Gang operated, Double break type
Rated short-time withstand current for isolator & earth switch	50 kA for 1 s
Rated peak withstand current for isolator & earth switch	100 kAp
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	1000 µV at 156 kV rms
Minimum corona extinction voltage	156 kV rms
Operating Mechanism	AC / DC / Universal motor operated
Maximum operating time	12 s
Control Voltage	110 / 220 V DC
Auxiliary contacts	
No. of contacts for isolator	As required plus 8 NO and 8 NC contacts per pole as spare
No. of contacts for earth switch	Total 6 NO and 6 NC
Thermal rating	10 A at 220 V DC
Breaking capacity	2 A DC with circuit time constant not less than 20 ms

Mechanical endurance class a) Isolator b) Earth switch	 M2 M0

19.5.2 Duty Requirements

19.5.2.1 Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the system in their closed position. They shall be constructed such that they do not open under influence of short circuit current and wind pressure together.

19.5.2.2 The earth switches, wherever provided, shall be interlocked so that the earth switches can be operated only when the isolator is open and vice versa. In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail-safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within stipulated variation range. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for DC control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

19.5.2.3 The earthing switches shall be capable of discharging trapped charges of the associated lines. Isolators and earth switches shall be able to bear on the terminals the total forces including wind loading and electrodynamic forces on the attached conductor without impairing reliability or current carrying capacity.

19.5.2.4 The isolator shall be capable for making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of the isolator on account of making/breaking operation.

19.5.3 Construction

19.5.3.1 Contacts

(i) The contacts shall be self-aligning and self-cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

(ii) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that

full pressure is maintained on all contacts at all time.

(iii) Contact springs shall not carry any current and shall not lose their characteristics due to heating effects.

(iv) The moving contact of double break isolator shall preferably be turn-and-twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

(v) Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

19.5.3.2 Base

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structure.

19.5.3.3 Blades

(i) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

(ii) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces. Where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

(iii) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

(iv) The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e., after every 1000 operations or after 5 years whichever is earlier.

19.5.3.4 Insulator

(i) The insulator shall conform to IS / IEC 60168 and IS 16683 / IEC TS 60815.

(ii) In addition to all type, routine and acceptance tests, as per IS / IEC 60168, the following additional routine/ acceptance tests shall also be carried out.

(a) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as routine test

(b) Bending load test in four directions at 100% of minimum bending load guaranteed as a sample test on each lot

(c) Torsional test on sample insulator of a lot

(d) Ultrasonic test as a routine test

(iii) The porcelain of the insulator shall have minimum cantilever strength of 1000 kg.

(iv) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

19.5.3.5 Earthing Switches

(i) Where earthing switches are specified, these shall include the complete operating mechanism and auxiliary contacts. The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

(ii) Earthing switches shall only be locally operated.

(iii) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

19.5.4 Operating Mechanism and Control

19.5.4.1 The Contractor shall offer motor operated switches having padlock arrangement for both ON and OFF positions.

19.5.4.2 Limit switches for control shall be fitted on the isolator / earth switch shaft within the cabinet to sense the open and close positions of the isolators and earth switches.

19.5.4.3 It shall not be possible, after final adjustment has been made, for any part of the mechanism to be displaced at any point in the travel sufficient enough to allow improper functioning of the isolator when the isolator is opened or closed at any speed.

19.5.4.4 Control cabinet / operating mechanism box shall conform to requirements stipulated

elsewhere in the document and IS/IEC 61439 as applicable.

19.5.5 Operation

19.5.5.1 Isolator shall be electrically/mechanically gang operated for main blades and earth switches. The operation of all the three poles shall be well synchronized and interlocked.

19.5.5.2 The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments.

19.5.5.3 The isolator and earth switches shall be provided with 'dead centre mechanism' to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

19.5.5.4 The design of linkages and gears be such so as to allow one man to operate the handle with ease for isolator and earth.

19.6 Surge Arrester

19.6.1 Technical Parameters

Parameter	**Specification**
Arrester Classification	Station Medium (SM)
Nominal discharge current (8/20 µs)	10 kA
Repetitive charge transfer rating	1.6 coulomb
Rated thermal energy rating	7 kJ/kV
Rated arrester voltage	216 kV
Continuous operating voltage at 50°C	168 kV
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	500 µV at 156 kV rms
Maximum Residual Voltage (i) At 30/60 µs, 1 kA current (ii) At 8/20 µs, 5 kA current (iii) At 8/20 µs, 10 kA current	 500 kVp 560 kVp 600 kVp
High-current short duration test value (4/10 µs)	100 kAp
Current for pressure relief test	40 kA
Partial discharge at 1.05 times the continuous operating voltage	≤ 10 pC

19.6.2 Duty Requirements

19.6.2.1 The Surge Arresters shall be capable of discharging over-voltages occurring due to

switching of unloaded transformers, reactors and long lines.

19.6.2.2 The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

19.6.2.3 The Surge Arresters shall be capable of withstanding meteorological and short circuit forces under site conditions.

19.6.2.4 The SAs shall protect power transformers, circuit breakers, disconnecting switches, instrument transformers, etc. with insulation levels specified in this specification.

19.6.3 Construction

19.6.3.1 Each surge arrester shall be hermetically sealed single-phase unit. The non-linear blocks shall be made of sintered metal oxide material. The surge arrester construction shall be robust with excellent mechanical and electrical properties.

19.6.3.2 Surge Arresters shall be fitted with pressure relief devices and arc diverting ports suitable for preventing shattering of polymer housing and to provide path for flow of rated fault current in the event of SA failure.

19.6.3.3 Outer insulator of surge arrester shall be made of porcelain/polymer. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester. Arresters shall not fail due to insulator contamination.

19.6.3.4 Seals shall be provided in such a way that they are always effectively maintained even when discharging rated lightning current.

19.6.3.5 The cantilever strength of the insulator shall be minimum 150 kg.

19.6.3.6 The following details shall be furnished for quality checks.

(i) The heat treatment cycle details along with necessary quality checks used for individual blocks and insulation layer formed across each block.

(ii) Metalizing coating thickness for reduced resistance between adjacent discs.

19.6.4 Fittings and Accessories

19.6.4.1 Surge arrester shall be complete with insulating base having provision for mounting to structure.

19.6.4.2 Grading/corona rings shall be provided on each surge arrester unit, as required.

19.6.4.3 The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

19.6.4.4 Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection arrangement. Suitable leakage current meters shall also be provided in the same enclosure. The reading of ammeter and counter

shall be visible through an inspection glass panel to maintenance personnel standing on ground. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 V DC which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

19.7 Instrument Transformer

19.7.1 Technical Parameters

Parameter	**Specification**
Current Transformer	
Accuracy class	Metering – 0.2S Protection – PS / 5P20
Rated VA burden	As per requirement
Insulation class	Class A
One minute power frequency withstand voltage between secondary terminals & earth	5 kV
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	1000 µV at 156 kV rms
Rated short time thermal withstand current	50 kA for 1 s
Rated dynamic current	100 kAp
Partial discharge level	10 pico Coulomb (max)
No. of terminals	All terminals of control circuits wired up to marshalling box plus 20% spare
Capacitive Voltage Transformer	
Accuracy class	Metering – 0.2 Protection – PS / 3P
Rated VA burden	As per requirement
Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance
Equivalent series resistance over entire carrier frequency range	< 40 ohm

One minute power frequency withstand voltage between secondary terminals & earth	
(i) Between LV (HF) terminal and earth terminal	10 kV for exposed terminals 4 kV for terminals enclosed in a weather proof box
(ii) For secondary winding	3 kV
Partial discharge level	10 pico Coulomb (max)
Rated voltage factor	1.2 continuous and 1.5 for 30 sec.
No. of terminals	All terminals of control circuits wired up to marshalling box plus 20% spare

19.7.2 General Requirements

19.7.2.1 Instrument transformers shall be hermetically sealed single-phase units, oil immersed, self-cooled suitable for outdoor installations and shall be supplied with common marshalling box for a set of three single phase units.

19.7.2.2 The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted with colour shade as decided by the Employer during detailed engineering.

19.7.2.3 Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS 335 / IEC-60296. Non–PCB based synthetic insulating oil conforming to IEC 60867 shall be used in the capacitor units of CVT.

19.7.2.4 Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

19.7.2.5 The insulators shall have cantilever strength of more than 350 kg.

19.7.2.6 Marshaling box shall conform to all requirements given elsewhere in the document. The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.

19.7.3 Current Transformer

19.7.3.1 Current transformer shall have single primary of either ring type or hair pin type or bar type. Wound type primary is acceptable only for metering CTs of ratio less than 400/1. In case of inverted type/live tank CT, the following requirements shall be met.

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) The insulator shall be one piece without any metallic flange joint.

19.7.3.2 Core lamination shall be of cold rolled grain-oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.

19.7.3.3 The CT shall be provided with oil filling plug, drain plug, and oil sight glass which should be clearly visible to maintenance personnel standing on ground.

19.7.3.4 The secondary terminals of CT shall be terminated to suitable number of stud type non-disconnecting and disconnecting terminal blocks as required inside the terminal box of degree of protection IP 55 at the bottom of CT.

19.7.3.5 Different ratios shall be achieved by secondary taps only; primary reconnection shall not be accepted.

19.7.3.6 The Instrument Security Factor (ISF) at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactors are used, then all parameters specified shall be met treating auxiliary CTs as an integral part of the CT. The auxiliary CTs/reactors shall preferably be in-built construction of the CT. In case these are to be mounted separately, these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

19.7.3.7 Current transformers shall be suitable for high-speed auto reclosing.

19.7.4 Capacitor Voltage Transformer

19.7.4.1 Capacitor Voltage Transformer shall consist of a capacitor divider and an electromagnetic unit housed in independent, non-oil communicating hermitically sealed compartments.

19.7.4.2 The capacitor divider shall consist of primary and secondary capacitance housed in high quality porcelain insulators filled with oil. The electromagnetic unit shall comprise of compensating reactor, intermediate transformer, protective and damping devices.

19.7.4.3 Suitable damping device shall be permanently connected to one of the secondary windings and shall be capable of suppressing ferro-resonance oscillations.

19.7.4.4 All the secondary windings of the CVT shall be protected by HRC cartridge type fuses or MCBs. In addition, fuses/MCBs shall also be provided for protection and

metering windings for connection to fuse monitoring scheme.

19.7.4.5 The secondary terminals of the CVT shall be terminated to stud type non-disconnecting terminal blocks via fuses/MCBs inside the terminal box of degree of protection IP 55. It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

19.7.4.6 CVTs shall be suitable for High Frequency (HF) coupling required for Power Line Carrier Communication (PLCC). Carrier signals must be prevented from flowing into EMU circuit by means of RF choke/reactor over the entire frequency range of 40 to 500 kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. Further, earthing link with fastener to be provided for HF terminal.

19.7.4.7 A protective surge arrester/spark gap shall preferably be provided to prevent break down of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Contractor for Employer's review.

19.7.4.8 The accuracy of metering core shall be maintained through the entire burden range up to rated value without any adjustments during operations.

19.7.4.9 The protection cores shall not saturate at about 1.5 times the rated voltage for a minimum duration of 30s.

19.8 Bus Post Insulator

19.8.1 Technical Parameters

Parameters	**Specification**
Type	Solid Core
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	500 µV at 156 kV rms
Minimum corona extinction voltage	156 kV rms
Minimum cantilever strength	800 kgf

19.8.2 Post insulators shall conform to IS/IEC 60168, IEC 60273 and IS 16683 / IEC 60815.

19.8.3 Post insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core

insulators will be acceptable.

19.9 Warranty

All substation equipment shall be warranted for minimum of 2 (Two) years against all material/ manufacturing defects and workmanship from the date of supply.

19.10 Testing and Inspection

19.10.1 Type Tests

All substation equipment shall be of type tested design. Type test reports as per the relevant IEC/IS standards shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory. Validity period of type tests conducted on the equipment shall be as per 'CEA Guidelines for the Validity Period of Type Test(s) conducted on Major Electrical Equipment in Power Transmission'. 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.

19.10.2 Routine Tests

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

20 Illumination

20.1 Standards and Codes

LED luminaires shall be tested at independent laboratory as per the following test standards and test reports shall be submitted to Owner.

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

20.2 General Specification

20.2.1 This specification covers design, supply and installation of uniformly Illumination system along the peripheral corridor, access & internal roads, main control room & inverter rooms, switchyard and other facilities including entry points/gate(s) inside the plant area.

20.2.2 The Contractor shall furnish Guaranteed Technical Particulars of the LED

luminaires, from renowned brands available in the market for approval of Employer/Owner.

20.2.3 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.

20.3 Lighting Levels

20.3.1 The lighting system 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	150
Internal / Access Roads	4
Transformer yard/Switchyard	20
H – pole and metering point	10

20.3.2 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.

20.4 LED Luminaire for Outdoor Applications

20.4.1 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 / Aluminum.
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)

20.4.2 LED luminaire of minimum 50 W mounted at a pole height of 4 m shall be provided at every 100 m interval for plant boundary.

20.4.3 The LED luminaire (outdoor) housing, heat sink, pole mounting bracket, individual LED reflectors and front heat resistant tempered glass should be provided.

20.4.4 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.

20.4.5 The luminaire should be provided with in-built power unit and electronic driver.

20.4.6 The luminaire should be suitable for standard street light poles and should be suitable for side entry and bottom entry (post top).

20.4.7 GI Lighting pole of suitable diameter capable of withstanding system and wind load, shall be provided with average Zn coating thickness of 80 micron. The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.

20.4.8 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.

20.4.9 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.

20.4.10 Junction box for lighting shall be made of fire-retardant material. The degree of protection shall be IP 55 for outdoor JB.

20.4.11 Lighting cables, wherever exposed to direct sunlight, shall be laid through Double

Wall Corrugated (DWC) HDPE conduits.

20.5 LED Luminaire/Lamps for Indoor Applications

All indoor LED luminaire/lamps shall be supplied with proper diffuser to avoid direct visibility of LED and suitable heat sink for longer life.

20.6 Warranty

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

21 **Weather Monitoring System**

As a part of weather monitoring system, the Contractor shall provide the following measuring instruments with all necessary software and hardware required to integrate with SCADA

The locations of these sensors shall be finalised and approved during detailed engineering

21.1 Pyranometer

21.1.1 The Contractor shall provide spectrally flat Class-A pyranometers (ISO 9060:2018 classification) along with necessary accessories for measuring incidental solar radiation at horizontal and inclined plane of array.

21.1.2 Specification of the pyranometer 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: RS485

21.1.3 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.

21.1.4 VOID

21.2 Temperature Sensor

21.2.1 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.

21.2.2 VOID.

21.3 Anemometer

Contractor shall provide minimum five nos. ultrasonic wind sensors (no moving parts), spatially distributed throughout the Plant Area for wind speed and direction monitoring.

Parameter	**Specification**
Velocity range with accuracy limit	0-60m/s with +/-2% accuracy @12 m/s; Resolution: 0.01m/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

21.4 VOID.

21.5 Data logger and Data Acquisition System

Data logger for the weather monitoring station should have the following features:

21.5.1 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 from telecom time or server time

(viii) Data Storage: Provision for at least 2 MB internal Flash Memory and at least 8 GB Micro SD card (expandable)

(ix) Protection level: IP 65

22 CCTV Camera

22.1 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: Any strategic location in the Plant Area required to be monitored.

(iii) Main Control Room: Covering Entry/Exit and Equipment Rooms

(iv) Inverter Station & Inverter Transformer Yard

(v) Plant Pooling Substation

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

22.3 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.

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

22.5 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.

22.6 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.

23 Fire Alarm System

23.1 Standards and Codes

Standard/Code	Description
IS 2189	Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System - Code of Practice
IS 15683	Portable Fire Extinguishers - Performance and Construction - Specification
IS 2546	Specification for galvanized mild steel fire bucket
National Building code 2016	

23.2 The 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.

23.3 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 (CO_2 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.

23.4 Minimum two numbers of fire extinguishers (CO_2 and Foam type each, of capacity 9 kg having BIS certification marking as per IS 15683) 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.

23.5 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.

23.6 Digital output from the fire detection system shall be integrated with SCADA.

23.7 The Contractor shall submit the plan for fire and smoke detection system for the Employer's/Owner's approval.

24 Testing Instruments

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

24.1 Earth resistance tester

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

24.2 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	

24.3 Insulation tester

Parameter	**Specification**
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	

24.4 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 Standard 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	

24.5 Clamp meter

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

24.6 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 ≤ 0.1 K at 30 °C
Geometric resolution	640 x 480 pixels
Absolute error of measurement	< ± 2 K
Adjustable parameters	Emissivity, Reflected 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 thermographic camera has to be traceably calibrated at least every two years. The calibration has to be documented. If the camera is not compliant (absolute temperature and/or temperature differences), it has to be readjusted by the manufacturer.
Documentation	Storing of the infrared picture with the radiometric data to be able to determine absolute temperatures

24.7 Digital lux meter

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

24.8 All testing equipment shall possess valid calibration certificate issued from approved NABL labs.

24.9 Instruments of superior rating is allowed after seeking consent of the Employer/Owner.

24.10 Maintenance, calibration, up keeping, repair & replacement of these tools will be in the scope of the Contractor during O&M.

24.11 It is Contractor's responsibility to arrange for tools, tackles, logistics, test kits, manpower, experts etc. required for trouble free operation of Plant.

25 Power Evacuation System

25.1 The Contractor shall design and construct the power evacuation system to and with the designated interconnection point (as mentioned in Sub Section A: Scope of Works) via either overhead transmission line or underground cables at specified grid voltage with all necessary infrastructure such as protection switchgears and metering systems as per the requirement of the CTU/STU.

25.2 The Contractor shall get the route approval from the Employer/Owner prior to start of the construction. Any changes in the route or scheme due to ROW issues at any point of the time prior to commissioning shall be complied without any additional cost to the Employer/Owner.

25.3 The ROW for the TL/UG cable shall be obtained prior to the construction of the line from the concerned authorities.

25.4 Overhead Transmission Line

In case the power evacuation is planned with overhead transmission line for plant external evacuation, the design of tower/pole and its accessories shall be as per the CTU's requirement and the design shall be submitted to Employer/Owner for approval/ accord.

25.5 Underground cable

In case the power evacuation is planned with underground cable for plant internal evacuation, the cable shall be approved by the Employer/Owner. However, in case of external power evacuation, the evacuation plan shall be as per CTU's requirement and the same shall be submitted to Employer/Owner for approval/ accord.

26 Substation Automation System

26.1 General Requirements

26.1.1 The Substation Automation System (SAS) shall be based on the communication protocol IEC61850 and meet the requirements stipulated herein as a minimum.

For major information exchange, following gateways (stand-alone/in-built network controller), as specified elsewhere in the specification shall be provided:

(i) RLDC/SLDC & Owner's Cloud Server

(ii) Solar SCADA

It is the Contractor responsibility to send all required data of solar plant and switchyard

to SLDC/RLDC. All required hardware's, software's, communication links and modification as per requirement shall be in the Contractor scope.

26.1.2 The point-to-point testing of all signals for the 220 kV Substation Network at the plant end, protection equipment end and the terminal end (Substation Controller and Operator Workstations) at the substation shall be the responsibility of the contractor.

26.1.3 The contractor shall be responsible for all the works on switchyard SAS.

26.1.4 The architecture for the SAS shall be finalized during detailed engineering stage.

26.1.5 The SAS shall be a computer-based system that shall integrate independently operating subsystems, such as Bay Control Units, Bay Protection Units, Metering and alarm annunciation into a unified data acquisition, monitoring, protection and control system in the substation.

26.1.6 Contractor shall offer the Bay Level Units for the 220 kV Substation system (each circuit breaker with associated dis-connector, Earth switches and instrument transformer shall comprise one bay) complete with Bay Control Units (BCUs) and Bay Protection Units (BPUs) as per the Substation Scheme. Bay Level Units, common panels like bus bar protection/ metering panels, Station HMI, LVS and other work-stations/gateways etc. shall be installed in the Control and Relay Panel located in Main Control Room.

26.1.7 Dedicated Bay Control Unit and Bay Protection Units shall be provided for each bay in the Contractor's scope of work as per Pooling Substation Bay configurations

26.1.8 The SAS architecture shall be flexible to allow future extensions in switchyard. Only IEC 61850 protocols shall be used for inter-device communication

26.1.9 The SAS at substation level and the communication network(s) shall be designed in a dual redundancy configuration. No single failure of any component/module of the SAS, including the communication links, shall cause loss of functionality of the SAS of more than a single bay.

26.1.10 Each component/module of SAS, including all the communication links, shall be provided with built-in supervision and self-diagnostic features and any failures shall be alarmed to the operator.

26.1.11 The SAS shall be designed such that no periodic testing and maintenance is required for various subsystems comprising SAS. On-line testing routines for various subsystems of SAS shall be provided.

26.1.12 SAS shall be designed such that maintenance, modification or extension of its components/modules shall not cause shutdown of the complete SAS.

26.1.13 The SAS and all its components shall be synchronized from a GPS time referenced clock receiver. The Time Synchronization Equipment shall also be in Contractor's scope of supply.

26.1.14 Time synchronisation Units for SAS and PMU shall be provided separately

26.1.15 The Contractor shall provide all the documentation required during project implementation and during the life cycle of SAS for operation and maintenance. A list of such documentation shall be reviewed and approved by the Owner during detailed engineering.

26.1.16 Owner intends to ensure interoperability of any third party IEC61850 compatible IEDs to be incorporated in future with the offered SAS. Contractor to provide all necessary data, configuration files, information in this regard.

26.1.17 The SAS supplied as per this specification shall be designed and constructed to meet all specification requirements for 15 years. Further, the Contractor should guarantee for hardware and software support for 15 (fifteen) years to guard against obsolescence. All requirements / devices of the SAS that are not listed under recommended spares shall have a normal life expectancy exceeding the specified expected life of the SAS.

26.2 Software Licenses and Upgrades

26.2.1 The contractor shall provide all software licenses for all the software being used in SAS system. The license shall be provided on a site license basis and shall be valid for the plant / equipment life cycle. The license shall not be hardware / machine specific i.e. if any hardware / machine is changed / upgraded, the same software license shall be valid and the Owner shall not have to seek fresh license or renewal of license. The contractor shall provide the license considering sufficient number of I/O s catering to the complete switchyard. In the case of anti-virus software, the license shall include regular updates until the end of warranty. The Contractor shall guarantee that all software are defect free and meet the system specifications, and undertake to fix any defects which may arise during the life of the system at no cost to the Owner.

26.2.2 All software versions in components of the SAS shall be the latest official releases as on the date of shipment from works and shall include all software updates etc. released till that date. A certificate to this effect shall be furnished by the contractor at the time of pre-dispatch inspection for each software package. All new software revisions and/or patch updates that are released before the end of the warranty period which addresses system defects shall be implemented on site and the

system re-tested to validate system integrity by the contractor at no cost to the Owner (This excludes new revisions which provides additional functionality). The contractor shall periodically inform the designated officer of the Owner about software updates / new releases that would be taking place after the system is commissioned.

26.3 Design and Operating Requirements of SAS

26.3.1 The control hierarchy and control levels of the SAS shall be based on the logical structure of the SAS, which is as follows:

Control Level 3	Remote Control Centre
↑ ↓	↑ ↓
Control Level 2	Substation Level (HMI)
↑ ↓	↑ ↓
Control Level 1	CRP (BCU)
↑ ↓	↑ ↓
Control Level 0	Switchyard Equipment

26.3.2 The data exchange between Control Level 3 and Control Level 2 shall take place via suitable communication links for remote telemetry and control of the substation using the IEC60870-5-101/104/OPC protocol.

26.3.3 The data exchange between Control Level 2 and Control Level 1 shall take place via the inter-bay/ Station communication bus using the IEC 61850 protocol. The inter-bay communication bus shall support peer-to-peer communications capability.

26.3.4 The data exchange between Control Level 1 and Control Level 0 shall be by means of hard-wired status / control signals between Switchgear Equipment and Bay Control /Protection Units and analog signals from CTs / CVTs.

26.4 Substation Level Functionality

26.4.1 Control Functions:

(i) The SAS shall perform control functions on various switchyard equipment based on the status, analog and logical inputs acquired by SAS from various bay control units.

(ii) It shall be possible to monitor and control all the switchyard bays in the Bidder's scope and the status of the plant (status and analog signals such as MW, MVAR, information, etc.) from any of the Operator Workstations at Control Level 2 i.e. from switchyard Control Room. However, in the case of maintenance, failure or emergency, it shall be possible to control the individual bays from the Bay Control Units at Control Level 1.

(iii) Clear control priorities shall ensure that operation of particular bay equipment (Circuit Breaker or Isolator) cannot be initiated simultaneously from more than one of the control levels. The priority shall always be on the lowest enabled control level. The selected control level shall be indicated at all the levels so that the operator is aware of his control capabilities.

(iv) The SAS shall have provision of Device Tagging for all the substation devices. This function is to block the control of any substation device in such a manner that its command is prevented from Operator's Workstations.

(v) Interlocking shall be implemented and shall ensure that no illegal switch operation can be performed by any control initiated from Control Level 3, Control Level 2 or Control Level 1. Interlocking shall be implemented on bay level as specified in relevant section of this specification.

26.4.2 Sequence of Events and Alarm Management:

(i) The SAS shall be capable of reporting on all Operator Workstation and printers, the time sequenced record of events occurring in the substation. Separate logs shall be created for alarms and events and both the logs shall be time-tagged. Suitable filters, based on date and time, bay number, device number, function etc. shall be provided for both alarm as well as event logs for ease of viewing.

(ii) The SAS shall record in non-volatile memory all changes of alarms and plant statuses of switchyard equipment, including the alarms generated by Bay Control and Bay Protection units. It shall be possible to print historic events and real-time (unacknowledged and non-cleared) alarms after a system failure or reset with no loss of information.

(iii) All the alarms and events shall be time tagged at the Bay Controller or Bay Protection unit with a time resolution of 1 ms.

(iv) The SAS shall include all the alarms and changes of plant statuses of the 220 kV substation networks.

(v) The SAS shall acquire the alarm signals from Bay Control Units and Bay Protection Units with preset priorities and on receipt of an alarm shall generate an audible

signal and report it either upon request or automatically to the respective printer.

(vi) The Owner shall approve the list of alarms and plant statuses to be wired for Sequence of Events log and Alarm Management, during detailed engineering stage.

26.4.3 Historical Data Management:

(i) The SAS shall maintain historical data in bulk non-volatile memory. The historical data shall be available for review and editing by authorized user.

(ii) The SAS shall monitor specified incoming information for historical data base, perform calculations on some of the incoming data and store incoming and calculated data in the non-volatile memory as historical data.

(iii) The historical data shall include Digital Fault Records and Sequence of Event logs received from bay protection units and bay control units.

(iv) It shall be possible to trend any measurement signal or summation of signals available in real time or data available in the historical database, in the shape of trend curves.

26.4.4 Operations Log

It shall be possible to create a daily operations log, in a user-defined format, about the substation operations as well as any failures / tripping therein. It shall also be possible to include on daily basis all the information required to keep a historical record of equipment behaviour.

26.4.5 Reports

The SAS should be capable of generating different types of reports, which can be presented in the operator interface screens upon request or programmed for automatic presentation in printers. It shall be possible to generate reports with information from both historical data base and real time information.

26.4.6 System Security

(i) Security features shall be provided at each level for safeguarding against unauthorized access. An alarm message will be displayed at the Control Centre and recorded in the logs for any unauthorized access attempts. The contractor shall provide software locks and passwords to the Owner's engineers at site for all operating and application software at all levels.

(ii) The system shall maintain a SYSTEM CHANGE log, recording all system changes made along with the identification of the person making the change, date, time and area of the system modified. The format and details of this log shall be finalized

during detailed engineering.

(iii) No single failure either of equipment or power source shall result in rendering any part/subsystem of SAS inoperative, except that the information related to failed part/component is not available.

(iv) To ensure system security, the complete functionality of SAS shall be divided into various system security levels, to be decided by Owner during detailed engineering. Each security level shall offer certain functionality of the SAS to users e.g.

a. Security Level 0 – Display only of Graphics, Real Time data and Historical Data and trend curves.
b. Security Level 1 – Normal Control Operations, Access to acknowledge alarm logs
c. Security Level 2 – Restricted Control Operations; access to edit / defeat bay interlocks
d. Security Level 3 – Complete access, engineering and maintenance of configurations and databases.

(v) The users shall be grouped into various user-groups with each user having a user-name and password. The level of accessibility to each user group shall be pre-defined.

(vi) The system administrator group shall have complete access to SAS and shall be able to add / remove users and redefine access rights.

(vii) The various system security levels and various user groups shall be defined by the Owner during detailed engineering.

(viii) SAS and all associated equipment shall comply with the CEA Cybersecurity Regulations and associated amendments.

26.4.7 Remote Interface with RLDC/SLDC

26.4.7.1 The SAS shall interface with remote RLDC and SLDC through suitable communication gateways with adequate number of ports. The exact number of ports, communication channels, and interface requirements shall be finalized during detailed engineering in coordination with the concerned RLDC/SLDC.

26.4.7.2 The primary communication medium shall be Optical Fiber Communication through FOTE (Fiber Optic Terminal Equipment). The SAS gateway shall connect directly to the FOTE terminal equipment through Ethernet interface, and shall support **IEC 60870-5-104/101.**

26.4.7.3 Only selected information such as bus voltage, frequency, active / reactive power through various feeders, status of OLTC, open / close status of circuit breakers, isolators etc is required to be shared with SLDC/RLDC. However, actual list of information to be shared shall be finalized during detailed engineering.

26.4.7.4 Necessary hardware/software (both end) to ensure Remote Interface with SLDC/RLDC shall also be provided by the contractor. All required communication with SLDC/RLDC shall be in the scope of the contractor.

26.4.7.5 Adequate provisions shall be given to interface the SAS with the Cloud Server via OPC, MQTT or other relevant protocols.

(a) Timestamp of when the measurement was acquired at source (IED/device level) shall be used in the Cloud Server. Server shall not use the server system time as timestamp of the measured signal.

(b) Vendor to indicate the latency between measurement and availability in OPC server.

(c) All substation data including MW, MVAR, MWh, MVArh, voltage, current, frequency, CB/isolator status, relay trip signals, alarms, events, and all metering data shall be communicated through this Server. The number of tags to be licensed for the Server as well as the maximum number of tags the OPC server can support shall be finalized and approved during detailed engineering.

26.5 Communication Network Bus

26.5.1 The data communication network (substation/ inter-bay bus) shall have bus configuration with either ring or star topology. The dual redundant buses, in case of star topology, shall be physically separate and shall be routed separately.

26.5.2 The contractor shall submit details regarding the communication system like communication protocol, bus utilization calculations etc. during detailed engineering.

26.5.3 Built-in diagnostics shall be provided for easy fault detection and to alarm any single bus failures. The design and installation of the main communication bus shall take care of the environmental conditions and hazardous area classification as applicable to similar services.

26.5.4 The system architecture shall allow a number of application protocols to co-exist on the application layer of the LAN stack.

26.5.5 Substation Network Bus

26.5.5.1 The substation network LAN shall be an Ethernet LAN based on IEEE802.3 Ethernet standard using the IP protocol. It shall allow inter-operability with LANs

from other vendors or with IEDs (Intelligent Electronic Devices) from other vendors in future, supporting IEC 61850.

26.5.5.2 CAT6 or better UTP cables or fibre optic cables shall be employed for all Ethernet data communication bus. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure. The communication shall be made in 1+1 mode, excluding the links between individual bay IEDs to switch, such that failure of one set of fibre shall not affect the normal operation of the SAS.

26.5.5.3 Each fibre optic cable shall have four (4) spare fibres.

26.5.5.4 Fibre optic cables shall be used wherever the Ethernet connection is in excess of 50 m, or where the connection extends between rooms/ buildings.

26.5.5.5 The Contractor shall ensure that structured cabling philosophy and good engineering practices as per internationally accepted standards are followed, for ease of maintenance and traceability, and that fibre-optic cables are adequately protected. Armored Fibre Optic cables shall be used in all cable routes containing other armored electrical cables. The armoured fibre optic cables shall be run in G.I. conduit wherever laid underground or without trays.

26.5.5.6 The LAN shall have a data communication speed of minimum 1 GBPS. It shall be sufficient to meet the responses of the system in terms of displays, monitoring and control commands according to the design.

26.5.5.7 Suitable hardware and software interface shall be provided to link solar plant SCADA bus.

26.5.6 Inter bay Network Bus

26.5.6.1 An Inter Bay Communication bus shall be provided for the 220 kV network, which shall support peer-to-peer communication, and communication to the Substation Controller.

26.5.6.2 The communication protocol used for all devices including Bay Control Units and Bay Protection Units shall be the IEC61850 protocol. No hardwiring of alarms shall be permitted between Bay Protection Units and Bay Control Units. As a minimum, all Bay Controller Units and primary relays i.e. Distance, Differential, Bus-Bar protection and multi-functional Over current and Earth fault protection relays, etc. offered shall support the IEC61850 protocol.

26.5.6.3 Fibre optic cables shall be used for Inter bay/Station Level Communication Bus. Contractor shall ensure that structured cabling philosophy and good engineering practices as per internationally accepted standards are followed, for ease of maintenance and traceability. Electrical data connections may only be used within a cubicle of the same bay.

26.6 Bay Level Functionality

26.6.1 All the Bay Level Functionality shall be built into Bay Control Units (BCUs) and Bay Protection Units (BPUs), which are built into the Plant's Control and Relay Panels. These are provided at Control Level 1.

26.6.2 Different BCU & BPU shall be mounted in different panels.

26.6.3 Specifications of Control and Relay Panels have been described elsewhere in this technical specifications.

26.7 SAS Hardware Specifications

26.7.1 Contractor shall provide the compatible Engineering, DR and Operator workstations and other components (HMI Monitor, A4 Colour Printer, Extenders, Station and Bay Level Ethernet Switches, Switches for PMU Connectivity, Firewall, Time Display Unit etc.) in line with the below specifications as a minimum.

Operator Workstations (Industrial Grade)		
S. No	**Feature**	**Specifications**
1	Processor	64 bit (i5 or Equivalent)
2	Memory	8 GB RAM upgradable to 16 GB
3	Hard Disk	4 × 4 TB SSD hard discs in RAID 5 configuration
4	Monitor (color)	Min. 24" TFT flat Monitor with non interfaced refresh rate min. 75 Hz. Communication port: 2 Serial bus , one parallel Dual 10/100/1000 Mbps. Ethernet Graphic Memory:16 MB Expansion slot: 3
5	Removable bulk storage drive	32 GB (minimum)
6	Network Connectivity	4 Nos. Built-in Ethernet Network Port
7	Portable Bulk Storage Media	2 TB (2 nos.) SSD
8	Keyboard	ASCII
9	Pointing Device	Mouse
10	Additional general purpose software (for using over network by servers/workstations /PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.

11	Other Features	• Power Fail Auto Restart (PFAR) facility, with automatic time synchronization to GPS time • All relay associated software
12	Software	MS Windows latest, MS Office Editor (EXCEL, WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, etc.

Engineering cum DR Workstations (Industrial Grade)		
S. No	**Feature**	**Specifications**
1	Processor	64 bit Server Grade (Xeon or Equivalent), Octa core minimum with latest Generation
2	Memory	32 GB RAM upgradable to 64 GB
3	Hard Disk	4 × 4 TB SSD hard discs in RAID 5 configuration
4	Monitor (color)	Min. 24" TFT flat Monitor with non-interfaced refresh rate min. 75 Hz. Communication port: 2 Serial bus , one parallel Dual 10/100/1000 Mbps. Ethernet Graphic Memory:16 MB Expansion slot: 3
5	Removable bulk storage drive	6 GB (minimum)
6	Portable Bulk Storage Media	2 TB (2 nos.)
7	Network Connectivity	2 Nos. Built-in Ethernet Network Port
8	Keyboard	ASCII
9	Pointing Device	Mouse
10	Additional general Purpose software (for using over network by servers/workstations/PCs)	Comprehensive disk maintenance utility for disk clean sweep / crash guard / antivirus, etc.
11	Software	MS. Windows latest, MS Office Editor (EXCEL,WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.
12	Power Supply	Dual Power Supply suitable for 110-240V AC and 125V - 220V DC

LED Display		
S. No	**Feature**	**Specifications**
1	LED Display	50 Inch LED Display, Display Resolution: 1920 x 1080, Wall Mounted, Reputed make

26.7.2 Technical Requirements for Standalone Network Firewall (Minimum)

Next Generation Firewall (NGFW) shall be provided as per specifications mentioned in "Firewall Specifications for ISTS stations" at CTU website.

26.7.3 Technical Requirements for Substation and Bay Level Switches (Minimum)

SUBSTATION AND BAY LEVEL SWITCHES	
Relevant Standards	Compliance with **IEC-61850-3** requirements for substation networking)
Switch Type	Managed Industrial Ethernet Switch (Layer-2 minimum)
Network Protocols	VLAN (802.1Q), RSTP, SNMP v1/v2/v3, NTP/SNTP etc.
Redundancy Protocols	Ring redundancy
Port Types	Combination of RJ45 copper ports and fiber optic ports
Port Speed	100 Mbps minimum
Port Configuration	Number and type of ports (fiber FX / copper TX) shall be as per approved communication architecture and number of connected devices.
Spare Capacity	Minimum ~ 10% spare ports for future expansion
Mounting	19-inch rack mount or DIN rail industrial mounting
Power Supply	100–300 VDC and/or 100–240 VAC
Accessories	Patch cords (Cat-6 or fiber), rack kit, configuration software etc.

26.7.4 Technical Requirements for SAS and PMU Time Synchronization Equipment (Minimum)

TIME SYNCHRONISATION EQUIPMENT		
	SAS	**PMU**
Application	Protection relays, BCUs, SCADA, PMU, workstations, disturbance recorders, automation controllers etc	PMU
Time Source	UTC time from satellite-based positioning systems (GPS or equivalent GNSS)	
Accuracy	≤ 1 ms	15 ns or lower
Satellite Tracking	Receiver shall track multiple satellites simultaneously to ensure continuous time synchronisation.	
Output Protocols	NTP/SNTP Ethernet outputs, IRIG-B (TTL/modulated), programmable pulse outputs, and other outputs as required by SAS architecture.	IRIG-B, NTP
Output Flexibility	Number and type of output ports shall be finalised during detailed engineering based on connected equipment requirements.	
Alarm Outputs	Potential-free contact outputs for system health, GPS failure, and synchronisation status.	

Antenna System	Complete antenna, mounting accessories, surge protection devices, and cables shall be included.
Display & Monitoring	Local display showing time, synchronisation status, satellite lock, and system health; provision for remote monitoring preferred.

26.7.5 Minimum quantity requirement of the equipment is specified below:

LED Display		
S. No	**Description**	**Quantity**
1	Engineering/DR Workstation (PC with min. 22" LED Monitor)	01 Set
2	Operator Workstation (OWS) (PC with min. 22" LED Monitor)	02 Set
3	Portable (laptop) based EWS (same specification as EWS)	01 No
4	50 Inch LED display (connect with both OWS)	01 No
5	Gateways	Based on Requirement
6	Time Synchronization equipment (SAS)	01 No
7	Time Synchronization equipment (PMU)	01 No
8	Time Display Unit	01 No
9	Firewall	02 nos.
10	Control Desk	Based on Requirement
11	Chairs for Control Desk	
12	Networked Color Laser Printer	01 No

26.8 Factory and Site Acceptance Test

26.9 FAT and SAT checks shall be finalised during detailed engineering.

SECTION - VII

SUB-SECTION C

TECHNICAL SPECIFICATIONS (TS)- CIVIL, MECHANICAL & PLUMBING WORKS

TABLE OF CONTENTS

1 General Requirement

1.1 This section of Technical Specifications describes detailed technical and functional requirements of all civil, structural, mechanical & plumbing works included in the scope as detailed under Section IV, Scope of Works.

1.2 This specification does not cover design of transmission line poles, towers, tower extensions and accessories. They shall be designed as per latest CTU/STU/DISCOM guidelines and relevant IS standards. Poles at corner with angle > 10° shall be provided with 4-pole structure or lattice tower. Use of Pre-stressed cement concrete spun poles is not acceptable. Copies of released for construction (RFC) designs & drawings for transmission line poles, towers, tower extensions and accessories approved by CTU/STU/DISCOM shall be submitted to the employer for reference and record.

1.3 Earthing mat shall be provided around buildings and structures as per design requirements / approved drawings.

1.4 Standards & Codes

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

1.4.2 Design of steel structures shall conform to IS: 800, 801 or 802 as applicable. Ductile design and detailing as per IS 13920 shall be followed in concrete structures except in case of concrete support structure up to plinth level supporting open installations of inverter transformers, control panels at ICR/LCR etc. wherein the detailing shall conform to IS 456 and SP 34. 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.

1.4.3 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.

1.4.4 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.

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

in the bid price.

1.5 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 programme 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 submission of design documents and drawings shall be as per the details listed under Section VII(A), Scope of Works.

1.6 The methodology for construction of MMS foundation, Road & drainage works and Standard Operating Procedure for MMS Installation shall also be submitted for prior approval of Engineer before start of these works.

2 Topographical Survey

2.1 The contractor shall be responsible for detailed Topographical Survey of the proposed project site. The work shall be carried out through an agency with relevant experience and qualified survey team.

2.2 The Topographical survey shall be conducted in 5m x 5m grid, or as directed by the Engineer, with the help of digital surveying instruments like Total Station/ Auto level/ DGPS.

2.3 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 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 as directed by the Engineer. 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.

2.4 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 (corresponding to Geographical North or Plant North) as directed by the Engineer.

2.5 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.

2.6 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.

3 Geotechnical Investigations

3.1 The contractor 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.

3.2 The scope of work includes execution of complete soil exploration including boring and drilling with rotary drilling rig (DTH in case of rocky strata), 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.

3.3 The field investigations shall mainly include drilling of min. 5 m deep BHs, 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, ICR and Switchyard shall be 10m deep. There shall be minimum 1 no. of BH per 12.5 acres of the area, 1 no(each). of Trial pit, CBR test, ERT & Ground water samples for laboratory investigations for every 25 acres of area. 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 into number of discrete blocks (< 25 acres) separated from each other, there shall be min. 3 nos. of bore holes, 2 nos. of trial pits, 2 nos. of CBR test & ERT, 2 nos. of Ground water samples for laboratory investigations per such block.

3.4 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.

3.5 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), permeability test (in-situ, to be conducted at a depth of 750 mm), Slake Durability etc. Laboratory CBR test on soaked samples shall also be conducted 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.

3.6 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 & Open installations (as applicable), Switch Yard structures & Sub-Station (as applicable), Transformer foundation, HT lines (as applicable), MMS foundation etc. corresponding to settlement of 25mm.

3.7 The report shall include the study for "Liquefaction potential assessment of the ground and suggestions for any ground improvement measures" as required.

3.8 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.**Error! Reference source not found.** 'Concrete Works'.

3.9 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 piles in rock, the safe pile capacity shall be calculated as per IS:14593. 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.

3.9.1 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).

3.9.2 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.

3.9.3 The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area and as per the provisions of IS 2911 Part 4. 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.

3.9.4 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.

3.9.5 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.

3.9.6 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.

3.9.7 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. For reference, the standard pile test procedures for compression & pull out and lateral

load test given Annexure-G of this section. 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.

3.10 All buildings and Plinth for Open installations (MCR, ICR etc.), Transformer yard, Switchyard and Sub-station area shall have levelled ground as detailed under Clause No. 5.

4 Other Investigations

4.1 The contractor 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.

4.2 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 (3^{o} to the horizontal) 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.

4.3 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 (M25 and above) before start of construction. However, for piling M25 concrete with nominal mix of (1:1:2) may be used. For grades of concrete less than M25 to be used in PPC works, nominal mix as specified in IS:456 may be used. The concrete mix shall be designed for each source of cement and aggregates as per provisions of IS:10262 Standard and confirmed through 28 days compressive strength of concrete trial mix samples. Target mean strength of concrete for mix design shall be based on σ (standard deviation) = 5. The concrete mix design shall be carried out through NABL accredited laboratory or any Govt. agency approved by the Engineer. 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).

5 Area Grading and Land Development

5.1 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 10m beyond external wall/ area including access road & parking whichever is minimum) all buildings/ plinth for open installations (MCR, ICR, etc.), transformer yard and switchyard 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.

5.2 A detailed drawing for site levelling and grading (if envisaged) shall be submitted by the contractor before commencement of construction of all buildings, plinth for open installation and transformer/switchyard works. The levelling and grading drawing shall provide finished grade levels of different grading zones over original ground contours as background. All the coordinates of the grading zones shall be clearly mentioned on the drawing. 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.

5.3 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. 100mm outside pile cap all around and remaining area may be filled up with local soil properly compacted.

5.4 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 (clayey) 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.

5.5 It shall be ensured that the land 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.

5.6 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.

6 Roads

6.1 Suitable approach road (as applicable) from nearest public road up to plant Main gate, Access road from Main gate to Main control cum office room (MCR), Internal roads connecting MCR and other facilities/ buildings/ open installations like Local control room(s) (LCR)/ 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.

6.2 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 MCR and internal service road(s) connecting MCR 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 200 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 T4 (10 HCV per day) and critical field CBR value of the subgrade.

6.3 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.

(iii) Base course WBM (CBR>100%) conforming to Cl. 405 of MORD specs: 75mm compacted thick, Grade III

(iv) Base course WBM (CBR>100%) conforming to Cl. 405 of MORD specs: 75 mm compacted thick, Grade II

(v) 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

(vi) Compacted subgrade: 300mm thick below sub-base (non-expansive soil with max. dry density > 1.65 kN/m^3) 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.

(vii) Gravel Shoulders conforming to Cl 407 of MORD specs: 150mm compacted thick, compacted to 100 % of max. dry density

6.4 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.

6.5 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.

6.6 The construction of road shall conform to MORD specifications for Rural roads published by IRC.

6.7 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.

6.8 Minimum dia. of casing pipe to be used at any facility like electric cable, water pipe line etc. shall be 150mm.

6.9 Maintenance pathways of min. 1.0m 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 granular 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.

6.10 2.5m wide corridor compacted to a depth of 300mm 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.

6.11 The design and drawings for approach road, all internal roads and culverts shall be submitted to the Engineer for approval before execution.

7 Surface/ Area drainage

7.1 The contractor shall design and construct storm water drainage network for smooth disposal of storm water from the plant to the nearest available drainage outlet.

7.2 The storm water drainage system shall be designed and planned to ensure no water stagnation in the plant.

7.3 The plant drainage system shall be designed for maximum hourly rainfall intensity and relevant time of concentration.

7.4 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).

7.5 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.

7.6 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.

7.7 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.

7.8 Suitable size plant peripheral drain as per design and requirement (min. 450mm wide x 450mm 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 300mm (bottom width) x 300mm (depth).

7.9 All trapezoidal drains shall have side slopes not steeper than 1:1. Unlined drains may be provided depending upon the geotechnical characteristics and drainage design in the view of the stability and erosion of drain walls. However, the drain segments near outfalls and drain crossings shall be lined. Thickness of the lining shall be minimum 115mm for brick masonry, 75mm for concrete slabs, 100mm for RR masonry and 50mm 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.

7.10 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 ‘Design Loads’. However, the min. wall thickness shall be 230mm, 300mm and 125mm respectively for brick masonry, RR masonry and 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.

7.11 The structural design of drains shall be as per provisions of relevant BIS standards and good industry practice.

7.12 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.

7.13 The proposed drainage scheme along with design calculations and drawings shall be submitted to the Engineer for review/ approval before start of construction.

7.14 The contractor shall provide percolation/recharge pit for harvesting of water in the MCR area. For the remaining plant facilities, the Contractor shall explore provisions for 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. at major drainage outfalls. The scheme for rain water harvesting along with design calculations shall be submitted for approval.

8 Peripheral Fence & Main Gate

8.1 The plant peripheral boundary shall be provided with chain link fence as per the tender drawing titled ‘Chain link fence Drawing’ attached in Annexure-D (Tender Drawings).

8.2 The fence shall be provided with Main Gate as per the tender drawing titled ‘Main Gate Drawing’ attached in Annexure-D (Tender Drawings).

9 Plant Layout

9.1 The contractor shall submit drawing showing proposed Project Plant and SPV module Layout.

9.2 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 and peripheral 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, Lightening arrester, UG/Over ground water Tank(s), Storm water drains, Corridor for buried cables etc.

9.3 The cable corridor shall be laid through clear gap between arrays and shall not be laid below modules for easy maintenance.

9.4 All the facilities and buildings shall be presented with suitable Legend.

9.5 The drawing shall be in suitable scale to have proper representation of the information.

9.6 The Plant & SPV module layout drawing shall be submitted by the contractor for review/ approval by the Engineer.

10 Design Loads

10.1 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.

10.2 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 (accessible and inaccessible)	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, Chequred 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 chequred plate cover over cable trench	4.00 kN/ Sqm
8	Roads	As per IRC SP 72 corresponding to vehicular traffic of T4 (10 HCV per day) and critical in-field CBR

10.3 Primary Loads

(i) Dead Load (DL)

(ii) Live Load (LL)

(iii) Wind Load (WL) – Both along ±X & ±Z horizontal direction

(iv) Seismic Load (EL) – Both along ±X & ±Z horizontal direction

10.4 Basic wind speed (V_b) at project site shall be taken as per IS 875 (part-3) unless otherwise specified elsewhere.

~~10.5~~ 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). Terrain category shall be taken as category 2.

10.6 Topography factor 'k_3' shall be taken as 1.0 upto upwards slope of 3°. For topography with upward slope greater than 3°, the value of 'k_3' shall be calculated as per Annexure-C of IS 875 (Part-3).

10.7 Importance factor k_4 shall be taken as 1.0. However, in case of plant site within 60 km of sea coast, the importance factor for cyclonic region, 'k_4' shall be taken as 1.15.

10.8 To calculate the design wind pressure 'p_d', factors 'k_a' (area averaging factor) and 'k_c' (combination factor) shall be taken as 1.0. However, the factor 'k_d' shall be taken as 1.0 in case of plant site within 60km of sea coast.

10.9 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 design and detailing as per IS 13920 shall be followed in all RCC framed structures except for plinth for open installations.

10.10 <u>Module Mounting Structure (MMS) (additional requirements):</u>

10.10.1 The bidder shall conduct wind tunnel studies for the evaluation of wind loads on PV modules to be adopted for the analysis and design of MMS, and the following shall be ensured:

1. It must be done from an institute of repute having suitable wind tunnel facilities (IITs, SERC Chennai or equivalent level institute in India.)
2. If the studies done by any reputed international facility, the study results must be vetted by the wind domain expert at any of the IITs or SERC or equivalent level institute in India.
3. Design wind speed shall be as per the requirements specified under Clause 10: Design Loads.
4. The wind tunnel studies shall be conducted with appropriate scale (however, in general not less than 1:50) model.

10.10.2 WL on the Module canopy shall be based on the findings of Wind Tunnel studies. Load due to wind action on exposed face of respective MMS members shall be as per IS 875 Part-3. WL shall be considered as detailed below:

(i) WLx (downward, Cp+), WLz (downward, Cp+): Load due to positive pressure on

PV modules at design tilt angle for wind acting in both (±X, ±Z) directions.

(ii) WLx (upward, Cp-), WLz (upward, Cp-): Load due to negative pressure on PV modules at design tilt angle for wind acting in both (±X, ±Z) directions.

(iii) WLx (member load), WLz (member load): Load due to wind action on side (exposed) face of respective MMS members for wind acting in both (±X, ±Z) directions.

- ±WLx (member load, transverse to MMS table): Load due to wind action on column, front and back bracing, longitudinal bracing, tie-member or any other members.
- ±WLz (member load, along length of MMS table): Load due to wind action on column, rafter, front and back bracing, longitudinal bracing, tie-member or any other members.

10.11 Design Load combinations

10.11.1 Concrete structures shall be designed as per limit state method of design with appropriate load factors as per IS:456. Cold formed light gauge steel structures including MMS shall be designed by working stress method as per IS:801 with appropriate factor of safety. All other steel structures shall be designed by working stress method as per IS:800 with appropriate factor of safety.

10.11.2 Following load combinations shall be considered in design:

- For MMS Design:

  (i) DL

  (ii) DL + WLx + WLx (member load)

  (iii) DL - WLx - WLx (member load)

  (iv) DL + WLz + WLz (member load)

  (v) DL - WLz - WLz (member load)

  (vi) DL ± ELx

  (vii) DL ± ELz

  Note - No increase in permissible stress is permitted in design of MMS.

- For RCC and Steel structures except MMS:

  (i) DL

  (ii) DL + LL

  (iii) DL ± WLx

  (iv) DL ± WLz

  (v) DL ± ELx

  (vi) DL ± ELz

(vii) DL + LL ± WLx

(viii) DL + LL ± WLz

(ix) DL + LL ± ELx

(x) DL + LL ± ELz

10.11.3 All buildings, structures and foundations shall be designed to withstand loads corresponding to worst design load combination.

11 Foundations (General)

11.1 The Contractor shall design all foundations for buildings, equipment, Transmission line towers, In-plant sub-station (switch-yard) structures, Transformer, MMS & other structures as per recommendations of Geotechnical investigation report and relevant BIS standards.

11.2 No foundation for MMS, buildings, switchyard equipment and structures, sub-stations, Transmission 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.

11.3 Min. depth of foundation for all buildings and plinth for open installations shall be 1.5 m below NGL. Min. depth of foundation for steps in brick and concrete masonry shall be min. 450mm below FGL. For all other structures, min. depth of foundation shall be 1.0 m unless specified otherwise.

11.4 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. The foundations of all buildings and plinths for open installation platforms shall be constructed after grading the area to the design FGL.

11.5 All design & drawings for foundations shall be submitted to the Engineer for approval before execution.

12 MMS Foundation

12.1 Module mounting structure (MMS) may be supported on isolated/ strip footing or pile foundation.

12.2 <u>Bored cast-in situ, Driven precast or under reamed Concrete pile</u>

12.2.1 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 and 1500 mm 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 1200 mm below cut-off level. A minimum clear cover of 50 mm shall be provided to the steel section or reinforcement in the pile.

12.2.2 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 two stage construction.

12.2.3 In two stage construction, 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 projection above FGL.

12.2.4 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.

12.2.5 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.

12.2.6 The design & installation of piles shall conform to IS: 2911 and IS:14593.

12.2.7 The bore shall be free from water before poring of pile concrete. For under water concreting tremie shall be used.

12.3 Helical/ Screw Pile

12.3.1 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)"

12.3.2 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.

12.3.3 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.

12.3.4 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 All materials shall be hot dip galvanized conforming to relevant BIS standard with min. thickness of galvanization 80 microns.

12.3.6 Wherever the pile shaft is required to be infilled with concrete grout, the same shall be of min. grade M30 (anti shrink).

12.3.7 The allowable axial design load (Direct compression & Pull out), Pa, of helical piles shall be the least of the following values:

(i) Sum of the areas of the helical bearing plates times the bearing capacity of the soil or rock comprising the bearing stratum.

(ii) Capacity determined from well-documented correlations with installation torque.

(iii) Load capacity determined from initial load tests.

(iv) Axial capacity of pile shaft.

(v) Axial capacity of pile shaft couplings.

(vi) Sum of the axial capacity of helical bearing plates affixed to pile.

12.3.8 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 (i) the total lateral load producing max. lateral deflection of 5mm and (ii) 50% of the total lateral load at which the lateral displacement increases to 12mm.

12.3.9 Dimensions of the central shaft and the number, size and thickness of helical bearing plates shall be sufficient to support the design loads.

12.3.10 The Design Report shall include following details.

(i) Design loads

(ii) Geotechnical Strength Reduction Factors and supporting methodology

(iii) List of design standards

(iv) Design methodology and how specific loads such as seismic, lateral and settlement are addressed

(v) Founding stratum

(vi) Estimated length

(vii) Connection design and details between pile shaft & pile cap plate and Col base plate

(viii) Pre-production and production load testing to support design including acceptance criteria.

12.3.11 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

12.3.12 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.

12.3.13 The installation of piles shall be done by an agency having adequate experience in helical pile construction.

12.3.14 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:

12.3.14.1 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):

- Programme of the testing, detailing the timing and sequence of each load test including any additional investigations proposed
- The general arrangement of the equipment
- A method for measuring the displacement at the head and toe of each test pile
- Template for the Pile load test report
- Confirming the criteria for determining the acceptability of the compression, tension and lateral load tests
- A contingency plan in the event that a load test is deemed not acceptable
- 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
- 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.

12.3.14.2 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):

- Programme of the works, detailing the timing and sequence of individual portions of the works
- Full details of the installation plant to be used, including manufacturer's information and proof of servicing/recent upkeep and calibration
- Proposed phasing of excavation/filling operations such that the design stresses in the piles (and any supporting frames) are not exceeded
- The contingency plan to be adopted, to minimize disruption and delay, in the event of encountering obstructions
- Anticipated noise levels (measured in dB) and vibration levels (measured in mm/sec) arising from piling operations (if applicable)

12.4 The Piling Contractor shall nominate a suitably experienced, professionally qualified engineer, as the "Piling Supervisor".

12.5 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. The no. and location of such tests shall be as per the provisions stipulated under Cl. No. 3.9.3.

12.6 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.

13 Module Mounting Structure (MMS)

13.1 The top of the table on each canopy slope shall be in one plane.

13.2 The module mounting structure design shall generally follow the existing land profile.

13.3 In MMS analysis the column support shall be assumed at EGL/NGL.

13.4 In case of topographical variations more than 3°, the contractor shall carry out detailed study of its effect on array layout, shadow analysis and structural stability of MMS.

13.5 The structure shall be designed to allow easy replacement of any module and shall be in line with site requirements.

13.6 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
- IS 15961 - Hot-dip Aluminium-Zinc alloy metallic coated steel strip and sheet
- IS 18513 - Hot-Dip Zinc-Aluminium-Magnesium Alloy Coated Steel Sheets, Plates and Strips

13.7 Material specifications & coating for structural steel works:

A. Hot-rolled/Cold -formed steel sections

Members	Reference code	Min. Yield Strength (in MPa)	Coating reference code	Min. Thickness (mm)
Column/ Vertical Post	IS 2062	350	90 microns minimum (IS 4759/ IS 4736/ IS 2629)	2
Bracing/ Rafter/ Beam/ Purlin				2
Steel tubes in all sections	IS 1161	310		2
Hollow steel in all sections	IS 4923	310		2
Coupler/ Plate/ Cleat Splice/ Sag Angle	IS 2062	350		2
NOTE:	1. Min. elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Min. coating requirement is mentioned in the above table. 4. No negative tolerance shall be permitted on Base Metal Thickness (BMT). 5. The galvanization of all members shall be done after fabrication of members and cutting of holes to ensure galvanization of all cut/ exposed edges.			

B. Hot-dip Aluminium- Zinc Alloy Coated Steel Strips and Sheets

Members	Reference Code	Yield Strength (in MPa)	Min. Coating Class Designation	Min. Thickness (mm)
Rafter	IS 15961	350-550	AZ 200 (IS 15961)	1.5
Purlin	IS 15961	350-550	AZ 200 (IS 15961)	1.2
NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement is mentioned in the above table. 4. No negative tolerances shall be permitted on Base Metal Thickness (BMT). 5. All the sections of the base metal exposed after cutting of members and punching of holes shall be provided with sprayed aluminium-zinc alloy coating corresponding to Grade - A (service life >20 years) conforming to IS:5905 suitable to corrosion class at project site environment.			

C. Hot-dip Zinc-Aluminium-Magnesium Alloy Coated Steel Sheets, Plates and Strips				
Members	**Reference Code**	**Min. grade of steel**	**Min. Coating Class Designation**	**Min. Thickness (mm)**
Rafter	IS 18513	IZMC420S or IZMH450S	ZM 310 (IS 18513)	1.5
Purlin	IS 18513	IZMC420S or IZMH450S	ZM 310 (IS 18513)	1.2
NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement is mentioned in the above table. 4. No negative tolerances shall be permitted on Base Metal Thickness (BMT). 5. All the sections of the base metal exposed after cutting of members and punching of holes shall be provided with sprayed aluminium-zinc alloy coating corresponding to Grade - A (service life >20 years) conforming to IS:5905 suitable to corrosion class at project site environment. 6. The steel shall be of structural quality steel conforming to IS 18513.			

13.8 The primary loads and load combinations for design of MMS structure shall be as specified under Clause No. 10. The design shall be done by Working stress method and no increase in allowable stress shall be permitted.

13.9 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

13.10 In case of fundamental natural frequency (first mode frequency) of MMS structure is 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.

13.11 The purlins shall be provided with min. following tie/sag rods or angles or channels:

- 1 no., in the mid of each span and shall connect all the purlin members
- 1 no., diagonal, at each corner in end spans

Note: This requirement shall not be applicable for the modules provided with steel back rails.

13.12 In double sloped free-standing canopy, at all frames columns supporting the opposite slopes of the canopy shall be connected using a tie-member.

13.13 Lateral restraint to compression flange if any due to PV panels including back rails of the module is not permitted in purlin design.

13.14 The vertical diagonal bracing shall be provided in end span for all rows of columns of each unit (table) of MMS. The bracing arrangement shall be centre line symmetric.

13.15 MMS shall support SPV modules at a given orientation & tilt and shall absorb and transfer the mechanical loads to the ground properly.

13.16 Welding of structure at site shall not be allowed and only bolted connections shall be

used.

13.17 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.

13.18 The bidder shall ensure that inner side of tube or hollow section is also provided with galvanization coating by proper dipping in hot zinc molten mass.

13.19 The galvanization of all members shall be done after fabrication of members and cutting of holes to ensure galvanization of all cut/ exposed edges.

13.20 In case the proposed section is made up of Aluminium, anodized coating shall be min. Gr. AC25 and shall conform to IS: 1868.

13.21 The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels at the same time.

13.22 Two numbers of anti-theft fasteners of stainless steel on two diagonally opposite corners for each module shall be provided. All fasteners and washers (2 round + 1 spring) both for MMS connections and fixing of PV Module.

13.23 Fasteners and washers to be used for fixing the module shall be of stainless-steel grade SS 304, with property class A2-70 conforming to relevant ISO standard. Fasteners and washers to be used for the erection of module mounting structure shall be HDG and of grade 8.8 conforming to IS 1367 and must sustain the adverse climatic conditions to ensure the life of the structure for 25 years.

13.24 Min. diameter of bolt for MMS connections shall be 10mm (12 mm in case of single bolt connection) except at column-rafter connection, where it shall not be less than 12mm (not less than 16mm in case of single bolt connection).

13.25 Modules shall be clamped or bolted with the structure properly. The material of clamps shall be Al / SS having weather resistant properties. Clamp shall be designed in such a way so as not to cast any shadow on the active part of a module.

13.26 The MMS foundation shall be designed as per Cl. No. 12.

13.27 MMS column post supported with base plate secured to 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. The underside of base plate shall be provided with anti- shrink grout.

13.28 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, projecting min. 50 mm beyond the face, to be welded at the bottom of column leg or an angle section of minimum 2mm thick to be bolted on either face of the column web at bottom end of the column (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 as per Cl. No. 13.27 and no embedment of column leg in foundation is permitted).

13.29 The array structure shall be grounded properly using maintenance free earthing kit.

13.30 The bidder/manufacturer shall specify installation details of the PV modules and the support structures with appropriate diagram on the construction and assembly drawings.

13.31 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.

13.32 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.

13.33 The length of any cold formed section (CFS) generally shall not be more than 5.5 m.

13.34 In case of seasonal tilt, the front and back bracing members (subject to seasonal rotation) shall be connected to the column through gusset/ connecting plate and shall not be connected directly to the column.

13.35 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.

13.36 The purlin splice shall meet the structural design considerations and its design shall conform to Annexure-F of BIS:800. There shall be min. four number of bolts on either sides of joints in web zones and one number of bolt on either side of joint in flange zones.

14 Concrete Works

14.1 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.

14.2 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).

14.3 Cement higher than 43 Grade shall not be used in construction.

14.4 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 levelling course which shall be of grade M7.5 (nominal mix 1:4:8).

14.5 Reinforcement steel shall be of high strength thermo mechanically treated (TMT) bars of grade Fe500D conforming to IS: 1786.

14.6 All pockets, block-outs, sleeves and the openings around the embedment, inserts, bolts etc. and under pinning below the base/sole plate shall be grouted. Grouting shall be with anti-shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound. The grout shall be high strength grout having min. characteristic strength of 35 N/mm^2 at 28 days.

14.7 MS Angles of minimum size 50 x 50 x 6 mm with 8 mm dia - 150mm long MS lugs @ 150mm c / c shall be provided for edge protection around all cutouts / openings in RCC floor slabs / walls, edges of drains supporting grating / pre-cast covers, edges of manhole supporting covers, around periphery of all removable pre-cast covers and any other place where breakage of corners of concrete is expected.

15 Miscellaneous Steel Works

15.1 Structural steel hot rolled sections, flats and plates shall conform IS: 2062. Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects. Structural steel shall be of tested quality and shall be of Mild steel of Grade ‘A’ up to 20mm thickness and of Grade 'B' normalised for thickness above 20 mm conforming to IS 2062: 2011.

15.2 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. Pipes for hand rail shall conform to medium grade IS: 1161.

15.3 All gratings shall be pressure locked/ electro forged. Minimum thickness of the grating shall be 40mm. The opening size shall not be more than 30mm x 100mm.The minimum thickness of the main bearing bar shall be 3mm. All gratings shall be hot double dip galvanized at the rate of 610 g / Sqm.

15.4 Minimum 900 mm high hand railing shall be provided around all floor/ roof openings, projections/ balconies, platforms, walkways etc. All handrails and ladder pipes shall be

32 mm nominal bore MS pipes (medium class) conforming to IS: 1161 and shall be galvanized as per IS: 4736 and IS: 1239. All rungs and ladders shall also be galvanized unless otherwise specified. Minimum weight of galvanizing shall be 610g/ sqm.

16 Buildings and Plinth (Support Structure) for Open Installations

16.1 General Requirement

16.1.1 Plant buildings and plinth for open installations as required as per the plant design and approved layout shall be constructed for housing the electrical equipment/ panel (Local Control Room - LCR) and Control room cum office cum store (Main Control Room Building - MCR) etc. for operation and maintenance of Photovoltaic Solar Power Plant. Security room at main gate & Security cabin(s) (at strategic locations) shall also be provided to secure the plant from any theft/ burglary/unauthorized entry.

16.1.2 Unless otherwise specified elsewhere, all buildings and plinth (support structure) 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 size of the plinth (framed structure) for open installations and equipment area shall as per OEM requirements. The security room/ cabin(s) shall be of prefabricated structure.

16.1.3 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).

16.1.4 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 the external walls with 230 THK brick 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.

16.2 Functional requirements

16.2.1 MCR Buildings

For operation & maintenance of SPV Plant, unless otherwise specified elsewhere, Control room cum office area of MCR building shall provide following facilities:

- Air-conditioned area (with provision of split A/C unit of adequate capacity) for

SCADA room (min. carpet area 32m2), Conference room (min. carpet area 32 m2) & Supervisor cabin (15 m2) and office area (min. carpet area 25 m2)

- Switchgear, equipment room(s) as per OEM requirements (can be in a separate building adjacent to the MCR)
- Tool room (12.5 m2)
- Store cum record room (min. carpet area 15 m2)
- Battery room as per requirement (can be in a separate building adjacent to the MCR)
- Toilet block with separate gents and ladies wash room facilities (min. total carpet area 12 m2)
- Pantry with service platform and utensil washing facilities (min. carpet area 5 m2)
- Suitable provision for passage (for smooth movement of O & M personnel), cable trenches, operating area etc. (min. clear width 1500mm)
- GI Ladder with hand rail for roof access
- MCR Building shall be RCC Framed Structure.

16.2.2 LCR/ ICR

- Inverter and associated equipment shall be installed on plinth (support structure) as open installations. They shall generally comprise of data loggers, battery, inverter, electrical panels, etc. as per requirements and as per approved system drawings.
- There shall be suitable provision for easy/smooth passage of O&M personnel, cable trench, operating area, etc.
- The plinth supporting the ICR/LCR equipment shall have RCC framed structure up to plinth level (equipment support level) with foundations, columns, beams and RCC floor slab. The RCC floor slab shall be provided with PVC pipe sleeves of required size for cable entry which shall be sealed with fire sealant after cable installation.
- The size and clear head room (below soffit of floor beam) above FGL for LCR/ICR shall be provided as per system/O&M requirements with min of 750mm.
- When LCR/ICR and MCR building facilities are clubbed in one single building, the Equipment area (inverter room) and Office cum Control room area shall be separated by a 345mm thick brick wall with provision of internal fire proof entry door.
- MCR building shall have separate main entry to office area.

- The size of inverter/HT panel area shall be provided as per system requirements.
- ICR/ LCR with open installation shall be provided with metal canopy for protection of O & M staff from weather. This weather protection canopy shall be an open steel shed structure designed and constructed with columns/ stanchions, rafters and purlins using hot rolled steel sections. The canopy shall be provided with suitable bracing system including roof (plan) and vertical bracings. The columns/ stanchions shall be fixed with base plate and foundation bolt assembly to the columns of support frame structure. The roof shall be of Al-Zn alloy coated high tensile steel troughed metal panels (BMT- 0.45mm, Al-Zn alloy coating -150 GSM total on both sides). The roof shall be provided with suitable slope, not less than 10° to the horizontal for proper drainage of rain water and shall project 300mm beyond the plinth or support platform. The make and (colour) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of colour coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.
- 150 mm thick gravel layer shall be provided on the finished ground level over the whole foot print of the support framed structure after application of anti-weed treatment on the ground.

16.2.3 Storage cabin for plant Spare

16.2.3.1 Contractor shall provide storage cabin having area adequate for storage of plant spares including PV Modules, cables, MMS spares, etc.

16.2.3.2 Storage cabin shall be of PEB (Pre-engineered building) type with RCC framed structure up to plinth level with foundations, columns, beams and RCC grade slab (if applicable).

16.2.3.3 Structural members for the superstructure shall be as detailed under PEB specifications under Cl. 38.

16.2.3.4 The walls and roof shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.45mm, Al-Zn alloy coating -150 GSM total on both sides). The insulation shall be of PUF with min. density 40 kg/ cum and adequate thickness. Roof shall be provided with suitable slope, not less than 10° to the horizontal (approx. 1V:6H) and shall project 300 mm beyond the walls. The make and (color) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.

16.2.3.5 The doors and windows shall have AL frame with glazing and shall be provided with all necessary fitting and fixtures like handles, tower bolts, mortise lock for door, stays, door stopper etc. All glazing shall be of clear float glass with thickness of 4mm for window and 6 mm for door panel. All AL sections for doors and windows shall be anodized (min. average thickness 25 microns) or polyester powder coated (min. DFT 50 microns) with approved color shade for protection against weather. Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used for all connections.

16.2.3.6 Doors shall be of adequate size to facilitate movement of O & M personnel and spares. There shall also be provision of Ramp and rolling shutter for the storage cabin.

16.2.3.7 Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

16.2.3.8 Alternatively, prefabricated storage containers conforming to ISO 668 may be used for housing the plant spares. The containers shall have sufficient area for storage and handling of spares during O&M phase. The containers shall be provided with the necessary lighting, HVAC and safety arrangements, etc. Further, the containers shall also be structurally adequate to cater for the applicable design loads and shall be supported on suitable RCC Foundation.

16.2.4 Security Room/ Cabin

16.2.4.1 Contractor shall provide required number of pre-fabricated security cabins at strategic locations & at corners of the plot and 1 nos. security room at Main entry gate.

16.2.4.2 The Security room shall be of min. size 3m x 3m x 2.75m height. The Security cabin shall be of min. size 1.2 x 1.8m x 2.5m height.

16.2.4.3 Security room/ cabin shall be a pre-engineered & pre-fabricated structure. The walls and roof of the building shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.45mm, Al-Zn alloy coating -150 GSM total on both sides). The insulation shall be of PUF with min. density 40 kg/ cum and adequate thickness. Roof shall be provided with suitable slope, not less than 10° to the horizontal (approx. 1V:6H) for proper drainage of rain water and shall project 300mm beyond the walls. The make and (color) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.

16.2.4.4 The Main security room shall be provided with one Aluminum (AL) glazed door

(0.75m wide x 2.1m height) on one face and AL glazed sliding windows (1.2m width x 1.0 m height) with AL grill on remaining three sides. Security cabin shall have one AL glazed door (0.75m widex2.1m height) and 1 no. AL sliding window (0.8m width x 1.0 m height) with AL (anodized) grill on one side. All glazing shall be of clear float glass with thickness of 4mm for window and 6 mm for door panel.

16.2.4.5 The door and windows shall be provided with all necessary fitting and fixtures like handles, tower bolts, mortise lock for door, stays, door stopper etc. All AL sections for doors and windows shall be anodized (min. average thickness 25 microns) or polyester powder coated (min. DFT 50 microns) with approved color shade for protection against weather.

16.2.4.6 Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used for all connections.

16.2.4.7 Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

16.2.4.8 The Security Cabin may be installed on concrete M20 skid platform (min. 250 mm thick, over 250 mm thick compacted rubble soling with interstices filled with sand). The top of skid shall be 200 mm above FGL. The concrete skid shall be provided with shrinkage reinforcement (8 dia @ 200 c/c both ways) near top surface. The concrete skid shall project 200mm beyond the walls.

16.2.4.9 The Security Room shall be supported on RCC framed structure with columns supported on foundations. The Finished Floor Level shall be 450mm high above FGL.

16.2.5 Watch Tower

Watch towers shall comprise of galvanized steel support structure with galvanized steel ladder for access. Minimum height of the watch tower shall be 10m above ground level. Cabin provided at the top of watch tower shall be as per the provisions of Clause 16.2.3.

16.3 The Design and drawings shall be submitted for approval prior to fabrication and installation.

17 Flooring, Skirting and Dado

17.1 Min. 40 mm thick floor finish shall be provided for all buildings.

17.2 Store area, Equipment Area

40 mm thick Cement concrete (IPS) flooring (1:2:4), aggregate size 10 mm down, conforming to IS 2571 with 2mm thick Heavy-duty epoxy coating (Industrial grade) of approved make on top as per manufacturer specifications and 10mm thick matching

skirting of 100mm height.

17.3 SCADA Room, Control cum Office Room, Supervisor Room and Lobby

1200 mm X 1200 mm Heavy duty vitrified tile (8mm thick or more) flooring with matching skirting of 100mm height.

17.4 Battery Area/Room

Acid/ Alkali resistant tile flooring and 2100 mm height dado, Floor and dado tiles – min 20mm and 12 mm thick respectively. However, in case of maintenance free batteries/dry batteries, Acid/ Alkali resistant tile (min 10mm thick) flooring and dado shall be provided.

17.5 Toilet

- Vitrified anti-skid floor tiles of size 600x600 mm laid on 20mm thick bed of cement mortar 1:4 with 2100 mm height dado.
- 20mm thick Granite stone finish over platform for wash basin.

17.6 Pantry

Heavy duty vitrified tile (8 mm thick) flooring and glazed tile (6mm thick) 2100 mm height dado, 20mm thick Granite stone finish over service platform.

17.7 Passage/ Corridor

Heavy duty vitrified tile (8mm thick) flooring with matching skirting of 100mm height.

17.8 Steps

Kota stone (20 thick) or 50 thick mosaic tiled flooring in white cement for the MCR

17.9 All items shall be of reputed make. Only Items with approved samples by the Engineer shall be used.

18 Doors and Windows

18.1 Doors, windows, louvers and ventilators shall be made of AL sections (minimum average thickness 2.5mm), industrial grade, anodized (grade AC25, min. thickness 25 micron conforming to IS: 1868) or with polyester powder coating (Total DFT 50 microns conforming to IS: 13871) and shall be of approved make & colour shade. All sections, fittings and fixtures shall be anodized (min. thickness of coating 20 micron). The window and door shutters shall be of clear float/ wired/ ground glass as per design/ functional requirements. The doors in toile area shall be of steel frame with solid core (MDF) flush shutter, 35mm thick, with laminated finish on both sides conforming to IS: 2202.

18.2 AL Louvers, duct/ ventilation openings shall be provided as per functional requirement.

18.3 All doors, windows and ventilators shall be provided with all necessary fittings and fixtures like handles, tower bolts, wind stays, hinges etc. of heavy-duty anodized AL. All doors shall be provided with hydraulic door closure of required capacity.

18.4 All windows shall be provided with suitable AL grill of anodized sections with adequate thickness for security purposes.

18.5 Clear float glass for window and door shutter shall be of min 4mm and 6mm thickness respectively. Wired/ ground glass where provided shall be of min thickness 6mm.

18.6 Entrance door and door in passage shall be min. 1.5m wide (double leaf) x 2.1 m height while door for Conference room and Store room shall be min. 1.2m wide x 2.1m height. All other doors shall be min. 1.0m widex2.1m height except for WC which may be of 0.8m width.

18.7 Rolling shutters shall be of required size and shall be made of cold rolled steel strips with adequate gauge thickness (min. 18 gauge) and shall conform to IS 6248. Rolling shutter shall be provided with all fixture, accessories, paintings etc. all complete and shall be mechanically operated type.

19 Roofing

19.1 The roof of all buildings shall be provided with min. slope of 1:100 for effective drainage of rain water. The slope shall be achieved either by application of screed concrete of grade 1:2:4 (with 12.5mm down coarse aggregate) with min. 25mm thick CM 1:4 layer on top to achieve smooth surface to facilitate application of water proofing treatment.

19.2 The water proofing treatment shall be in situ five course water proofing treatment with APP (Atactic Polypropylene) modified Polymeric membrane over roof consisting of first coat of bitumen primer @ 0.40Kg per sqm, 2nd & 4th courses of bonding material @ 1.20 kg/sqm, which shall consist of blown type bitumen of grade 85/25 conforming to IS : 702, 3rd layer of roofing membrane APP modified Polymeric membrane 2.0 mm thick of 3.00 Kg/sqm weight consisting of five layers prefabricated with centre core as 100 micron HMHDPE film sandwiched on both sides with polymeric mix and the polymeric mix is protected on both sides with 20 micron HMHDPE film. The top most layer (5^{th} layer) shall be finished with brick tiles of class designation 10 grouted with cement mortar 1:3 (1 cement: 3 fine sand) mixed with 2% integral water proofing compound by weight of cement over a 12 mm layer of cement mortar 1:3 (1 cement: 3 fine sand) and finished neat. The water proofing treatment shall be extended over golla/ fillet and inner face of the parapet up to 450mm height. The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final

test.

19.3 The corners at parapet wall and slab shall be provided with 50 thick fillet/ golla in CM 1:3 with neat finish.

19.4 Required no. of rain water down take pipes min. 100mm dia. PVC pipes (UV resistant), with 450x450mmx15mm deep khurra and MS grill at inlet shall be provided for rain water disposal.

20 Plinth protection and drain

20.1 750mm wide plinth protection with min. 75mm thickness of PCC (1:3:6) over 75 mm thick bed of dry brick ballast, 40mm nominal size well rammed and consolidated and grouted with fine sand, shall be provided around all the buildings.

20.2 A peripheral drain (except for Security room/ cabin) of min. internal size 250mm x 250mm with brick walls in CM 1:6 over 75mm thick PCC (1:3:6) bedding with 12mm thick plaster in CM 1:5 and 25thk PCC (1:3:6) coping at top shall be provided along the periphery of the plinth protection for collection and disposal of rain water from building roof.

21 Plinth filling for buildings

Plinth beam, when provided, shall be taken minimum 200mm below FGL. The plinth filling below Ground floor (GF) for all buildings shall be provided with following specifications.

(i) Well compacted sub-grade

(ii) Well compacted boulder soling with interstices filled with sand over compacted sub-grade.

(iii) 75mm thick PCC 1:3:6 over (ii)

(iv) 100mm thick PCC 1:2:4 over (iii)

(v) 40mm thick floor finish over (iv)

22 Anti- termite Treatment

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.

23 Plumbing & Sanitary Works

23.1 Toilet block shall have following min. fittings:

- Wall mounted WC (Western type) 390 mm high with toilet paper roll holder, low height flushing tank and all fittings

- A set of 2 wall mounted Urinals (430 x 260 x 350 mm size) with flushing tank and all fittings (Gent's wash room only)
- Wash basin (550 x 400 mm) over concrete platform with all fittings including 2-pillar cocks
- Wall mirror (600 x 450 x 6 mm thick clear float glass) with hard board backing
- CP brass towel rail (600 x 20 mm) with C.P. brass brackets – one each in common area and bathroom (bathroom if applicable)
- Soap holder and liquid soap dispenser one each in common area and bathroom (bathroom if applicable)
- Shower and mixer for hot and cold water in bathroom (if applicable)
- Ventilators – Mechanical exhaust facility of adequate capacity
- Overhead PVC water storage tank – Capacity 1000 litres (common for both wash rooms) (2000 litres in case bathroom is to be provided)

23.2 Pantry room shall be provided with kitchen sink cum drain board and provision for installation of Water Cooler.

23.3 One toilet room with provision of WC and Wash basin shall be provided at Security Room near main gate.

23.4 Necessary plumbing lines for MCR building and Security Room near main gate.

23.5 All sanitary ware, fittings and fixtures shall be of reputed Make and Type and approved by the Engineer. All fittings, fastener, grating shall be of CP brass conforming to relevant BIS standards.

24 Painting & Other Finishes

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.

Internal Walls except toilets & battery room	Acrylic emulsion (for MCR) & Oil bound distemper (for LCR/ Security Room)
Battery room	Acid/ Alkali resistant tiled dado of 2100 mm height & Acid resistant resin-based epoxy paint above dado (Vitrified tile flooring and dado with oil bound distemper in case of maintenance free batteries)
Toilet	Oil bound distemper
External Walls	All weather proof cement based acrylic emulsion paint, exterior grade

MMS foundations/ Earth pit Enclosure	Cement paint
Underside of roof slab, Plinth (support structure) for open installation	White wash
Air-conditioned areas	Underside of roof slab- Under deck insulation with 50mm thick mineral wool, min. density 45 kg/ m3 and Gypsum board false ceiling with GI grid/ Gypsum tile (600x600 mm x 12 thick) false ceiling with AL grid as per manufacturer's details
Structural steel work	2 coats of synthetic enamel paint over 2 coats of suitable primer

25 Air conditioning & Ventilation for MCR and Other Buildings

25.1 All buildings shall be equipped with appropriate numbers of fans for effective heat dissipation.

25.2 In MCR building, the supervisor room, Conference room and SCADA room shall have split type air conditioning units.

26 Fire Extinguishers

26.1 All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. Liquefied CO_2 / foam / DCP type fire extinguisher shall be upright type of capacity 9 kg conforming to IS 15683 / IS 2878.

26.2 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.

27 Sand buckets

27.1 Sand buckets shall be wall mounted made from at least 24SWG sheet with bracket fixing on wall conforming to IS 2546.

27.2 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.

28 Sign Boards and Danger Boards

28.1 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.

28.2 The Signboard shall be made of steel plate of not less than 3 mm. Letters on the board

shall be with appropriate illumination arrangements.

28.3 Safety signs, building evacuation plan and direction signs, assembly points shall also be placed at strategic locations.

28.4 The Contractor shall provide to the Engineer, detailed specifications of the sign boards.

29 Masonry Work

29.1 The masonry work shall be of bricks, laterite blocks (as per site conditions) or concrete blocks.

29.2 All external walls of buildings shall be 230mm and internal walls shall be 230mm or 115mm as per requirements.

29.3 All concrete block masonry walls shall be min. 200mm thick.

29.4 Brick work shall be in cement mortar (CM) 1:6 & 1:4 for 230 mm and 115 mm thick brick wall respectively unless specified.

29.5 Unless otherwise specified elsewhere, Bricks shall be of class designation 7.5 conforming to IS: 1077, IS: 2212 & IS: 3495.

29.6 All concrete blocks shall be of min. compressive strength of 7.5 N/mm^2 and shall be of Grade-A conforming to IS: 2185.

29.7 The laterite blocks shall conform to IS: 3620.

29.8 All buildings shall be provided with suitable damp-proof course (DPC). The DPC shall be with PCC (1:2:4) using 6 down coarse aggregate and water proofing admixture. The min. thickness of DPC shall be 40mm.

29.9 The construction of brick masonry shall conform to IS: 2212. Construction of Concrete block masonry shall conform to IS: 2572.

30 Plastering, Pointing & Coping Works

30.1 All brick masonry work shall be provided with plaster.

30.2 Wall and ceiling plaster shall be in cement mortar (CM) 1:6 and 1:3 respectively.

30.3 Thickness of plaster shall be 18mm and 12mm respectively for rough and smooth surface of the masonry wall. The ceiling plaster shall be 6mm thick.

30.4 All joints in stone masonry shall be raked and pointed in cement mortar (CM) 1:3 except specified otherwise.

30.5 Exposed top surface of brick or stone masonry shall be provided with 25 mm thick plain cement concrete (PCC) coping (1:2:4) with trawl finish. All exposed coping shall be provided with suitable slope and projection for easy drainage of water.

30.6 All door and window chajja shall be provided with 10mm wide drip course.

31 Building Water Supply & Plumbing Works

31.1 C-PVC pipes shall be used for all internal building water supply works while all external water supply pipes shall be UPVC conforming to relevant BIS standard.

31.2 Rain water pipe shall be of PVC conforming to relevant BIS standard.

31.3 All sewerage, waste water and ventilation pipes shall be of HDPE conforming to relevant BIS standard.

31.4 MCR building and Security room shall be connected to Sewage treatment facility including all associated works like Manholes etc.

32 **Sewage Treatment facility**

The Contractor shall design & provide soak pit and septic tank for treatment of sewage and waste water from MCR building and Security room. The design of the septic tank shall conform to IS 2470 (Part 1). However, in case of ground water within 1.5m of finished grade level or the soil strata being of low permeability (permeability ≤ 10-6 m/s) where septic tank and soak pit arrangement is not effective, suitable packaged sewage treatment plant of reputed make/manufacture shall be provided. The sewage treatment facility shall be of required capacity and of proven design suitable for total of 15 people.

33 **Pipe & Cable Trenches**

33.1 All trenches inside the building and transformer area shall be of RCC. The min. wall and base slab thickness shall be 100mm for depth ≤ 850mm and 150mm for depths > 850mm.

33.2 The trench shall be designed for loads as specified under 'Design Loads'. External trenches shall be kept min. 150 mm above FGL to avoid entry of rain water. In case of straight length of the trench being more than 40m, suitable expansion joints with PVC water stop shall be provided.

33.3 Internal trenches (inside buildings) shall be provided with chequered plate (min. 8mm thick with stiffening angle ISA 50x50x6 @ 750 mm c/c for trench width greater than 800 mm) covers while external trench shall have precast concrete covers.

33.4 Min. thickness of precast cover shall be 50mm. Both bearing edges of the cable trench and all edges of pre-cast concrete covers shall be provided with min. 50x50x6 mm edge protection angle with MS lugs.

33.5 The trench cover (chequered or pre – cast both) shall be provided with suitable lifting hooks.

33.6 As required, suitable MS insert plates shall be provided on trench wall to support the cable rack/ pipe.

33.7 The trench bed shall have a slope of approx. 1(V):250(H) along and 1(V):50(H) across

the length of the trench. The cable trench shall have a dewatering sump(s) of size 450x450x450 mm depth at suitable location to facilitate collection & pumping out of rain water from the trench.

33.8 The external buried cables shall be laid in excavated trench as specified under specifications for Electrical works.

34 Transformer Yard Civil Works

34.1 Transformer and equipment foundations shall be founded on piles/isolated spread footings or block foundation depending on the final geotechnical investigation report and functional requirements.

34.2 Requirement of Soak Pit and Oil collecting pit shall be as per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations.

34.3 Both, the transformer soak pit 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 burnt oil 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 burnt oil pit shall be plastered with 6 mm thick CM 1:6 and painted with 2 coats of epoxy paint over 2 coats of primer.

34.4 The area around the transformer and equipment shall be covered with uniformly graded granite stone gravel of size 40mm.

34.5 The area shall be provided with galvanized chain link fence with min. height 1.8m and a main gate of 3.5m width.

34.5.1 The fencing shall be of galvanized iron chain link mesh fabric with internal, corner and stay posts of hot dipped GI angle (min. ISA 55x55x5 mm). MS angle posts shall conform to IS 2062. The fence post shall have split end of length 75 mm, for proper anchorage into the foundation concrete.

34.5.2 All GI posts shall be supported with min. 300 mm dia. and 750 mm deep (below GL) piles in M20 (Nominal Mix 1:1.5:3) grade concrete. The pile shall project 100 mm above GL. The column posts shall be extended into the pile up to 800 mm with 50mm cover at the bottom. The intermediate, corner and stay posts shall be supported by angle struts that shall have the same foundation as that of the main posts.

34.5.3 Spacing of intermediate posts shall not be more than 3.0 m. Every 10th

intermediate post shall be provided with a stay post while every corner post shall be provided with two stay posts on either side.

34.5.4 The GI chain link mesh fabric (75x75 mm with min. wire gauge 3.15 mm, both ends twisted) and fencing shall conform to IS: 2721.

34.5.5 Each fence panel shall be provided with strain wires (Min 4 mm Dia HTSS) at top, mid and bottom. The mesh fabric and strain wires shall be firmly secured to the fence posts using GI flats.

34.5.6 All MS sections, mesh fabric, strain wires, flats, fasteners, etc. shall be galvanized (Min 85 Microns).

34.5.7 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.

34.5.8 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 also be provided for man entry for maintenance purpose.

34.5.9 The transformer yard fencing work shall conform to CEIG requirements.

34.6 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.

35 PV Module Cleaning System

35.1 The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at least once in two weeks or at a closer frequency as per the soiling conditions prevailing at site. Also, the contractor is required to plan the water storage accordingly with provision of a tank of suitable capacity for this purpose. However, min. consumption of 2 Ltr / Sqm of surface area of SPV module shall be considered in estimation of required quantity of water storage.

35.2 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.

35.3 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.

35.4 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.

35.5 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.

35.6 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.

35.7 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.

35.8 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.

35.9 Module cleaning procedure and pressure requirement at discharge point shall be as per the recommendation of PV module manufacturer. However, discharge pressure at tapping points (outlets for connecting flexible hose pipes) shall not be less than 5kgf/cm2 (0.5 MPa).

35.10 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.

36 Underground Liquid Retaining RCC Structures

36.1 The top of the UG tank shall be 250 mm above FGL.

36.2 The tank shall have clear free board of 300mm above MWL.

36.3 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.

36.4 The underground RCC tank shall be designed for following load conditions:

- 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.
- Tank full up to MWL and no external loads

36.5 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.

36.6 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.

37 In-plant Sub-Station/ Switch-Yard Civil Works

37.1 The specifications cover levelling and grading, construction of all sub-station/ switchyard structures and facilities including gantry towers & beams, lightning mast, equipment supporting structures, transformer foundations including oil pit, rail track, fire wall, cable trenches, roads, culvert, drains, sewers, water supply, fencing with gates, gravel filling & anti-weed treatment etc. and other related works in switch yard area as per the scope.

37.2 <u>Gantry towers & beams, lightning mast, equipment supporting structures</u>

37.2.1 Gantry towers and beams, equipment support structures shall be latticed steel structures. Height & type of towers and beams shall be established based on electrical requirements.

37.2.2 Loads and Loading Conditions:

Switchyard structures shall be designed for the worst combinations of following loads.

Structures shall be checked for safe design under Reliability (normal) and Security (short circuit) conditions:

- Dead loads (load of wires/conductors, insulator, electrical equipment and structural members)
- Imposed loads – These are vertical loads. Load of 1500 N considered acting at each cross arm, as a provision of weight of lineman with tools. Load of 3500 N considered acting at the tip of cross arms up to 220 kV and 5000 N for 400 kV and higher voltage for design of cross arms. All bracing and redundant members of the towers which are horizontal or inclined up to 15° from horizontal shall be designed to withstand ultimate vertical loads of 1500 N considered acting at centre independent of all other loads.
- Wind load on bus bars, shield wires, insulator strings, electrical equipment, structural members, etc.
- Seismic loads
- Conductor sag tension
- Loads due to line deviation (gantries shall be checked for ± 30^0 deviation in horizontal plane and ± 30^0 deviation in vertical plane.
- Temperature effects
- Erection loads – Erection loads at lifting points for 400 kV and higher voltage shall be taken as per Cl. No. 12.2.3 (d) of IS:802-part 1 (section-1)
- Short circuit forces including snap in case of bundled conductors, etc.

37.2.3 Wind load on Gantry structure (tower and beam), equipment, conductor, ground wire and insulator strings shall be calculated as per IS:802-part 4, IS:802-part 1 (section-1). Terrain roughness coefficient k2 in calculation of design wind speed Vd shall be min. 1.0 (terrain category 2). However, for site with hills/ ridges the value of k2 shall be taken as 1.08 corresponding to the next higher value (k2 corresponding to terrain category 1).

37.2.4 Temperature effects shall be considered as per IS:802-part 4.

- The average everyday temperature shall be 32°C anywhere in the country, except in regions experiencing minimum temperature of –5°C or lower, where everyday temperature may be taken as 15°C or as specified elsewhere.
- The beam/column may generally be designed to suit the conductor temperature of 85°C (Max) for Aluminium Conductor Steel Reinforced (ACSR) and 95°C for All Aluminium Alloy Conductor (AAAC). The maximum temperature of ground wire

exposed to sun may be taken as 53°C. If the new generation conductors such as AL-59, Aluminium Conductor Steel Supported (ACSS) Trapezoid Wire (TW), gap conductor, Aluminium Composite Core Conductor (ACCC) etc, are deployed, maximum allowable temperature of the conductor based on the permissible/designed ampacity, shall be considered.

- The minimum every day and maximum temperature of the conductors shall be as per electrical considerations.

37.2.5 Sag tension calculation for conductor and ground wire shall be made in accordance with the relevant provisions of IS 5613 (Part 2/Sec 1) for the following conditions:

(a) 100 percent design wind pressure at everyday temperature or 36 percent design wind pressure at minimum temperature after accounting for drag co-efficient and gust response factor (design wind pressure = P_d * C_{dc} * G_c).

(b) The values of sag and tension on conductor shall be corrected to account for the weight tension and wind effect on the droppers.

(c) Effect of insulator weight, spacer weight, dropper weight and weight of other hardware to be considered suitably in the sag tension calculations.

37.2.6 Transverse loads due to line deviation shall be the component of 100 percent mechanical tension of conductor and ground wire/OPGW.

37.2.7 The mechanical tension of conductor/ground wire is the tension corresponding to (a) 100 percent of design wind pressure at everyday temperature or (b) 36 percent of design pressure at minimum temperature after accounting for drag co-efficient and gust response factor. Mechanical tension shall be considered as a longitudinal load for reliability condition and security condition.

37.2.8 Design load cases, load combinations and design criteria for gantry structure (beam and column/tower) and equipment support structures shall be as per IS:802-part 4.

37.2.9 Following factor of safety/overload factor shall be provided in the design of members:

- *Normal Condition (Reliability Condition)* — In normal condition, factor of safety/overload factor shall be taken as 2.0 in the design of members and the bolts.
- *Short Circuit Condition (Security Condition)* — In short circuit condition, factor of safety/overload factor shall be taken as 1.5 in the design of members and bolts.

37.2.10 The equipment support structures shall be designed for the weight of the equipment, self-weight of the structure, tensions of strung conductor, wind on strung conductor or pipe, wind on equipment and the support structure. Short circuit forces shall also be considered as acting on the equipment and getting it transferred to the structure

along the strung conductor or pipe.

37.2.11 Other structures like, lightning mast, lighting mast watch and ward towers etc. shall be designed for wind loads and self–weight.

37.2.12 Special design considerations for equipment support structures:

- The supporting structure for B.P.I., LA, CVT and Isolator equipment shall be comprised of GI (ERW) pipe of grade YST:210 or of higher grade conforming to IS: 1161 & shall be designed as per IS:806. Minimum diameter of the pipe type support for structures shall be 200NB.For higher voltage levels, relevant standard shall be followed.
- The supporting structure for CT equipment shall be comprised of lattice structural steel conforming to IS 2026 and shall be designed as per IS: 802.
- Common raft foundation shall be provided for each pole of isolator.

37.2.13 Special design considerations for Lightning mast (as applicable):

Diagonal wind condition shall be considered for Lightning Mast. Diagonal wind shall be taken as 1.2 times the wind calculated on longitudinal/transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and an internal ladder for climbing purpose shall be provided up to the platforms. Top of platform shall have grating, railing and two guard plates. The minimum width of platform shall be 900mm. Live load of 300kg/m2 above platforms shall be considered for design of Lightning Mast. The fabrication and erection of the switchyard works shall be carried out generally in accordance with IS: 802 and IS: 800. All materials shall be completely shop fabricated and galvanized.

37.2.14 Materials:

- Gantry structure, which consists of open web towers connected by girders, shall be made of structural steel conforming to Grade IS:2062 or IS:8500 and duly galvanized conforming to IS: 2629 and IS: 4759.
- Minimum thickness of Leg members, ground wire peak members and lower members of cross arms in compression shall be 5 mm and min thickness of gusset plates shall be 6 mm. Minimum section thickness for other members shall be 4 mm.
- All joints shall be bolted connections.
- All bolts for connections shall be of 16mm dia. conforming to IS: 12427, property class 5.6 as specified in IS: 1367 (Part 3). Nuts shall conform to I.S 14394 (Part 3) of property class 5. Foundation bolts shall conform to IS: 5624, property class

4.6 as specified in IS: 1367 (Part 3).

- Butt splice shall be used for splicing the main members and splice shall be located away from the node point.
- Washers shall conform to IS 2016 with thickness as required based on connection details. Spring washers shall conform to type B of IS 3063. Heavy washers shall conform to IS 6610.
- Washers to be used with high strength bolts and nuts shall conform to IS 6649.
- All gratings shall be blast cleaned to Sa 2½ finish of Swedish standard SIS–05-5900 and shall be hot dip galvanised at the rate of 610 GSM.
- All handrails and ladders shall be galvanised at the rate of 610 GSM as per IS: 4736.
- Other material used in the construction of switch yard structures shall conform to appropriate Indian Standards, wherever available.

37.2.15 Galvanization:

- All steel sed in construction of switchyard structures such as Towers & Beams, Lightning mast and equipment supporting structures shall be galvanized in accordance with the provisions of IS 4759. Weight of zinc coating shall be at least 0.610 kg/m2 and foundation bolts shall have heavier zinc coating of at least 0.80 kg/m2.
- Threaded fasteners shall be galvanized to conform to the requirements of IS 1367 (Part 13).
- Spring washers shall be electro galvanized as per grade B of IS 1573 as and plain washers shall be hot dip galvanized as per service Grade 4 of IS 4759 or electro galvanized as per service Grade 3 of IS 1573.

37.3 Tie-Transformer/ power transformer foundations:

Foundations of transformer shall be designed for Equipment, seismic and wind loads. Block foundations shall be provided for the main transformer block. Oil soak pit shall be provided around the transformer to prevent spillage of oil from transformer onto the ground. The oil soak pit shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer along with 10 minutes of fire water considering only 40% of the volume as available voids between gravel filling. However, in case a separate oil collection pit (burnt oil pit) is provided for the transformer, the minimum volume of oil soak pit around transformer shall be provided as one-third of the oil volume of transformer. The oil collection pit (burnt oil pit) in such

cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. Free space of 250mm height above gravel fill shall be provided in the soak pit. This free volume above the gravel free shall not be considered in effective capacity calculations. In capacity calculations for oil collection pit (burnt oil pit) the volume below the invert level (IL) of inlet pipe shall be considered, the inlet pipe shall be laid with adequate slope to avoid back flow of oil to the transformer soak pit. In oil collection pit, a min. free board of 300 mm shall be provided over IL of the inlet pipe. The transformer oil soak pit and oil collection pit (burnt oil pit) shall also be provided with a sump (min. 500x500x500mm) at the corner to allow disposal of water/oil from the soak pit. A rung ladder with 20 dia. MS rungs (painted with 2 coats of epoxy paint over 2 coats suitable primer) shall be provided in the oil collection pit.

Arrangement for moving the transformer in place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer foundations.

Fire protection wall shall also be provided between the transformers wherever required as per relevant standards and statutory requirements. The height and thickness of fire protection wall between transformers shall be as per system and statutory requirements Fire wall shall be provided with an independent foundation.

300 mm thick PCC M20 (1:1-1/2:3) encasement all around the pylon supports for firefighting system shall be carried out up to top of gravel filling. Supply and erection of complete fire-fighting system including pylon supports with anchor fasteners for HVW / N2 spray system shall be as defined under scope of work.

Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

37.4 Gravel filling:

Gravel filling shall be provided in the switchyard extension area inside the fence as indicated in the tender drawing with broken stone filling which shall consist of two layers. The first layer shall be 75mm thick base course of 20mm of normal size and second layer shall be 75mm thick surface course of 40mm nominal size. Each layer shall be compacted by using half ton roller with 4-5 passes and suitable water sprinkling. Before laying the gravel/stone fill, the top layer of the soil shall be treated for anti-weed considering the type of weeds found in the vicinity. The anti-weed - soil sterilization details such as manufacturer's name, their specification, test certificate,

etc. shall be furnished for Owner's approval. Any modification if required in the proposed anti-weed treatment chemical shall have to be done by the contractor at no extra cost to the Owner. The contractor shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall be commenced from the date of completion of work or date of handing over, whichever is later.

37.5 Cable trenches:

RCC cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 250 mm above the finished grade level (FGL) so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits. Heavy duty precast RCC covers with 20 dia. MS lifting hooks shall be provided over the cable trench. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. The design and other requirements of the cable trench shall be as specified under Cl. No. 33.

37.6 Switch yard storm water drains:

The design and other requirements of switch yard drainage system shall be as specified under Cl. No. 7: Surface/ Area drainage. RCC box/pipe culvert shall be provided for road and drain crossings.

37.7 Switch yard roads:

Internal service roads shall be provided in the switch yard as required and per the approved layout. The road shall be of min. 3.0m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL to avoid flooding of roads during rains and 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 design and other requirements of roads shall be a specified under Cl. No. 6.

37.8 Chain link fencing:

The entire switch yard area shall be provided with chain link fencing with main gate(s) and wicket gate(s) as per approved layout. The design and details shall be as specified under Cl. No. 34.6.

37.9 Switch yard control building and other buildings shall be provided as required as per approved building layout. The buildings shall be of RCC framed structure. The design and details including finishing items and construction of all the buildings shall be as specified under relevant clauses of this specification.

37.10 Duct banks consisting of PVC conduits for cables shall be provided with proper sealing arrangement consisting of fire-retardant sealing compound.

37.11 Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.

37.12 Design, construction and joints of all the structures shall be as per relevant Indian Standard Codes unless specified otherwise.

37.13 All foundation embedment, inserts, block-outs required for mounting of equipment and supporting any other facility like pipes etc. shall be provided.

37.14 All cable trenches shall be provided with suitable MS insert plates for fixing support angles of cable trays.

37.15 Broad gauge rail (52kg/m minimum) shall be used for rail tracks required for movement of Transformer.

38 Miscellaneous structures

38.1 Support structure for weather monitoring device

38.1.1 Weather monitoring device shall be mounted on tubular steel pole of required height. The pole shall conform to IS: 2713.

38.1.2 The pole shall be secured to an independent RCC foundation structure through Base plate and Anchor bolt assembly.

38.1.3 The support structure shall be hot dip galvanized.

38.2 Support structures for SCB/String Inverter

38.2.1 SCB/String Inverter shall be mounted on a structural steel supporting frame comprising of ISMC columns at both ends, horizontal framing members and members for cable support. Minimum size for column members shall be ISMC 75.

38.2.2 Column post shall be supported with 300 mm (min.) diameter and 850 mm (min.) deep below GL piles in cement concrete (nominal mix 1:1:2). The column post shall be extended into the piles up to 800 mm (below GL) with 50mm cover at the bottom.

38.2.3 The pile shall project 200 mm above GL.

38.2.4 The support structure shall be hot-dip galvanized and of adequate height to ensure min. ground clearance of 800 mm to SCB/String Inverter unit.

38.3 LA Mast and Foundation (Other than Sub-station)

38.3.1 LA Mast shall be self-supporting structure with GI tubular pole of required height. The pole shall conform to IS 2713.

38.3.2 The pole shall be supported on RCC pedestal and foundation structure through base plate and anchor bolt assembly.

38.3.3 200 mm long, 20 dia. rods shall be welded to the pole at 300 mm c/c for access to the device for maintenance purposes.

38.3.4 The support structure shall be hot-dip galvanized. Minimum depth of foundations shall be 1200 mm below GL.

39 Pre-Engineered Building (PEB)

39.1 General:

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, etc. Each item of PEB like panels, masonry, plastering, flooring, foundation, fittings etc. shall be suitable for complete life of solar plant.

39.2 Design parameters and design loads shall be as per Cl. 10: Design Loads. Limiting deflections shall be as per IS 800.

39.3 Structure and material specification:

Component	Description	Reference Standard
Primary Structural Members: including the transverse rigid frames, columns, corner columns, end wall wind columns, beams, truss member, base pate.	Steel frame members with minimum thickness 4 mm with minimum yield strength of 350 MPa	IS 2062 min Grade E350 Quality A
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	Minimum thickness 3.15 mm. Secondary members for purlins and Girts shall have minimum yield strength of 350 MPa. Miscellaneous secondary members shall have minimum yield strength of 250 MPa.	IS 2062: Quality A

the structure.		
Other Details:		
Paint and Coating	The structural steel shall be hot-dipped galvanized (Min 610 GSM), conforming to IS: 4759 or relevant Indian standard. Cladding sheet 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) over 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.	
Rolling shutter	Shall conform to IS: 6248.	
Wall & Roof Cladding	Unless specified otherwise, 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/m3 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.	
Roof Insulation and detail	Both metal sheets shall have an under insulation of minimum 150 mm thick PUF 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. 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 and detail	Unless specified otherwise, all voids of external and internal metalled walls shall have an under insulation of minimum 120 mm thick PUF with proper supports etc. as approved. Both the walls should be separated by spacers system made up of steel and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations.

39.4 PEB shall be provided with suitable bracing system including roof (plan) and vertical bracings.