SECTION – VII

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SECTION - VII

A. SCOPE OF WORKS

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1 Project Particulars

Particulars	Description
Design and Engineering	
AC Capacity	300 MW
Cumulative Inverter AC Capacity	XX MVA to deliver 300MW with PF range -0.95 to +0.95 at 50 °C at POI
Cumulative Inverter Duty Transformer Capacity	320 MVA (preferably units of 12.5 MVA)
Cumulative Power Transformer Capacity	320 MVA (2 X 160 MVA)
DC Capacity	390 MWp
Supply of PV Modules	Supply of PV Modules at the Project Site in the Scope of the Owner. The Owner shall deliver PV Modules with minimum 540 Wp Power rating and minimum efficiency of 21% at the Project site.
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	Ramagiri & Muthuvakuntla
District	Sri Sathyasai
State	Andhra Pradesh
Latitude & Longitude	Refer Annexure – I: Tentative Land Layout with Contour Details
Altitude	
Available Land Area	1178.8 acres (approx.) Refer Annexure I: Tentative Land Layout with Contour Details
Type of Land	Govt. Land & Assigned Land
Ownership	Solar Energy Corporation of India Limited (on lease)
Access	

Nearest Urban Area	Anantapuramu
Nearest Highway	NH 44 (Bengaluru – Hyderabad)
Nearest Railway Station	Dharmavaram
Nearest Airport	Kempagowda International Airport, Bengaluru Other nearby Airports: Kadapa & Puttaparthi
Power Evacuation	
Solar Park Substation Transformer (33/220 kV) Capacity	2 × 160 MVA
Solar park Substation Switching Scheme (220 kV)	Double Bus Scheme with Bypass-Isolator (Main Bus-I & Main Bus-II/Transfer Bus) Refer Annexure – M (SLD – Plant End Substation)
ISTS RE Pooling Substation	PGCIL 400/220 kV Substation, Pavagada (Connectivity has been obtained by SECI) Refer Annexure K (Indicative SLD Interconnecting Substation)
Point of Interconnection	
Transmission Line from Pooling Substation to Interconnecting Substation	220 kV, Partially on S/C Towers and partially on M/C Towers. Total distance from Plant End Substation to Interconnecting Substation ~ 18 kms. Single circuit line on S/C towers – 13 Km Single circuit on MC towers (to be done by OTHERS) – approx. 5 Km Please refer Annexure – L: 220 kV Transmission Line Right of Way for details
Design Parameters	
Design Ambient Temperature	50 °C
Basic Wind Speed (IS 875-3)	33 m/s
Seismic Zone (IS 1893-1)	Zone II
Hourly rainfall intensity for storm water drainage	75 mm/hr
Performance Ratio (at 220 kV side of Plant Pooling Substation)	

For Operational Acceptance	81.50% **Note**: 1. PR shall be estimated as per the procedure mentioned in Annexure-A: PG Test Procedure. 2. PV Module degradation shall be considered for subsequent years during O&M period.
During O&M Period	
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 300 MW (AC) Solar PV Power Project, and performance demonstration with associated equipment and materials on turnkey basis along with 5 (five) years comprehensive operation and maintenance from the date of commissioning.

All works shall be executed as per Technical Specifications provided in Section VII-B.

A brief summary of the scope of work by the Bidder and SECI/ Others is summarised in table below. The details are provided elsewhere in this specification.

SL No	Item of work	Scope by SECI	Scope by Bidder
1.	Supply of solar PV modules at Site	✓	
2.	Unloading and storage of solar modules at site		✓
3.	Payment of Statutory Fees for Auxiliary Connection	✓	
4.	Supply, Erection, Testing, Commissioning of Plant as per the detailed Scope of Work		✓

5.	220KV OHL from AP-04 till PGCIL Pawagada	✓	
6.	220KV OHL from Solar Park SS gantry till AP-04		✓

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 for review and approval prior to detail engineering. Indicative Engineering and Design Management Schedule and Construction Schedule are provided as Annexures A and B respectively, to this Section.

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. The data for the PV modules (drawings, GTP and PAN files) to be procured by the Owner shall be provided to the Contractor for this estimation.

3.3 All documents and drawings (soft copy) shall be submitted to the Employer 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 shall return the document / drawing to the Contractor with category of approval marked thereon. Five nos. of hard copies of approved documents and drawings shall be submitted to the Employer. 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 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 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.
- The Contractor shall also submit a study report analysing the response of the plant in case of transients (HVRT, LVRT, VAR injection & absorption, etc)
- 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 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 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.

3.10 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 6 (six) to 11 (eleven) months from date of award of the Contract. The EPC Contractor shall consider PV Modules of 540 W_p power rating and minimum efficiency of 21% for 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 is in the scope of the EPC Contractor. 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 Combiner Box (SCB) along with mounting structure in case of central inverter configuration. In case solar cables are connected to DC cable via Insulation Piercing Connector (IPC), instead of SCB, String Isolation Box (SIB) along with mounting structure shall be provided.

4.5 Solar Cables of appropriate size and rating from PV Modules to SCB / IPC / 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 IPC to SIB (in case IPC is used) 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 DC Cables of appropriate size and rating from SCB / SIB 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.

4.9 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 transformers 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 over head canopy.

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 Solar park Substation with required number of 33 kV outdoor bays (including provision of extension on each side of the bus bar in future) , required no. of 33/220 kV transformers, four nos. of 220 kV Bays (Two Transformer Bays, One Line Bay & One Bus Coupler Bay) including Substation Automation System. Busbars, Equipment of Line Bay and Bus Coupler Bay shall be suitable for evacuation of 350 MW. (Refer Annexure M: SLD of 220kV Plant End (Solar Park) Station)

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 350 MW) 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.

4.18 220 kV bay at interconnecting substation (suitable for evacuation of 350 MW) as per

CTU drawings/specifications including shifting or replacement of substation equipment / materials, permits and approvals, CTU supervision and maintenance charges.

4.19 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.

4.20 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.

4.21 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.

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

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

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

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

4.26 Communication cables including end terminations and other required accessories.

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

4.28 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.

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

4.30 Lightning Protection System for entire plant area.

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

4.32 Weather monitoring station shall include but not be limited to the following:

- Pyranometers – Two in Horizontal Plane for GHI and two in inclined plane – Minimum 4 (Four) Nos.
- Ultrasonic Anemometer (wind speed and direction) – 1 (one) no.
- Temperature Sensor (ambient and module surface) – 5 (five) nos.
- Sensors required for measurement of following parameters
    - (i) Sun rise and sun set timings
    - (ii) Cloud cover (Okta)
    - (iii) Rainfall (mm)
    - (iv) Relative humidity (%)
- Power source to the all sensors wherever required
- Data Logger

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.

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 Combiner Box / String Isolation 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 SCB / String inverter / IPC 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 IPC to SIB along with termination at both the ends in case IPC is used.

5.7 Laying of DC cables from SCB/SIB to Central inverter along with termination at both the ends in case of Central Inverter configuration.

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

5.9 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.

5.10 Installation, Testing and Commissioning of Inverter transformers including fire protection system.

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

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

5.13 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 Outdoor bays in 33/220 kV Solar Park Substation along with termination at both the ends including Right of Way, permits and approvals.

5.14 Installation, Testing and Commissioning of 33/220 kV Solar Park Substation with required number of 33 kV outdoor bays, 33/220 kV transformers, four nos. of 220 kV Bays (Two Transformer Bays, One Line Bay & One Bus Coupler Bay).

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

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

5.17 Installation, Testing and Commissioning of 220 kV bay and associated accessories for integration of Solar PV Power Plant at the interconnecting substation as per CTU drawings/specifications including shifting or replacement of substation equipment /

materials, permits and approvals, CTU supervision and maintenance charges.

5.18 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.

5.19 Installation, Testing and Commissioning of 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.

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

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

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

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

5.24 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.

5.25 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.

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 Annexure – I 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 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. This survey shall be completed within 30 days from award of work.

6.2 Conducting geotechnical investigation of the plant area is in the scope of the contractor. Preliminary geotechnical investigation has been conducted by the Employer with 10 nos. of boreholes drilled at locations indicated in the location map attached with Geotechnical Investigation Report (Annexure – E). The Employer shall not be responsible for any variations in soil characteristics and other conditions, between those observed during preliminary site visit and detailed investigations to be carried out by the Contractor during contract execution and there shall be no compensation what so ever in the contract price on this account. This work shall be completed within 60 days from award of work.

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

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

6.5 Construction of chain link fence around the entire plant area, including one entry gate for each land parcel.

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 Combiner Box, String Isolator Box, AC Combiner Box / LT Switchgear panel, Power Conditioning Unit, Inverter Transformer, Auxiliary Transformer, 33 kV Switchgear panel, Power Transformer, Substation Equipment, lighting mast, watch tower, lightening arrestor and other electrical equipment. Mounting structure of 220 kV substation equipment and gantry shall be as per CTU drawings.

6.8 Construction of Inverter Stations, Main Control Room and Substation 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 (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 foundation for 220 kV Overhead Transmission Line from 33/220 kV Solar Park Substation to Interconnecting Substation and associated civil works.

6.17 Construction of foundation and / or mounting structure for 220 kV Switchgear Bay and associated accessories for integration of Solar PV Power Plant at the Interconnecting Substation as per CTU drawings/specifications.

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

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

6.20 Construction of wet type or dry type module cleaning system as per specifications.

6.21 Suitable arrangement of water shall be ensured to cater to day-to-day requirement of drinking water and permanent water supply for module cleaning (in case of wet type Module Cleaning System) and other needs of SPV power plant during entire

O&M period.

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

6.23 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 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. SECI has obtained stage-II connectivity at the interconnecting 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.

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 (Annexure – H), after commissioning of the 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 nominated staff, which shall have prior approval from the Employer.

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

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 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 raise commercial bills on consumers.
- Periodic cleaning of solar modules as approved by the Employer and water quality as per the recommendations of OEM
- Replacement of Modules, Invertors/PCU's and other equipment as and when required during the O&M period without additional cost to Employer

8.12 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 commissioning and successively the complete Solar Photovoltaic 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 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 shall enter into an O&M Agreement with the Contractor as per **Annexure H:** Operation & Maintenance Agreement subsequent to Plant Operational Acceptance.

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 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), the Contractor shall immediately report the accidents, if any, to the Employer showing the circumstances under which it happened and the extent of damage and/or injury caused.

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 shall maintain vigilance for the security of the Solar Power Plant at his own cost, including deputation of security personnel . The security services shall be maintained during currency of the O&M Contract.

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 immediately. A monthly report shall be sent to Employer 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.

The Matrix below is an indicative Schedule to be adhered for finalization of Engineering and Design Documents. The EPC Contractor shall submit detailed MDL for the approval of the Employer in accordane with the same.

Engineering and Design Indicative Schedule

		Month											
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
1	**Preparatory Studies**												
a	Topographical Survey Report												
b	Geotech Study Report												
c	Boundary Fence Layout												
d	Design Basis Report (Electrical and Civil)												
e	Preliminary Mathematical Model of Plant in PSS/E												
2	**Basic Design and Engineering**												
a	Energy Yield Estimation												
b	PV Array Layout												
c	AC SLD												
d	DC SLD												
e	Transmission Line Route												
3	**Major Equipment GTP and GA Drawings - Group I**												
a	Power Conditioning Unit												
b	Inverter Duty Transformer												
c	Power Transformer												
d	Switchyard SLD and Layout												
e	MCR Layout - Equipment & Architecture												
4	**Major Equipment GTP and GA Drawings - Group II**												
a	220 kV Switchgear												
b	33 kV Switchgear												
c	MMS Design Basis Report and GA Drawings												
d	MMS Fabrication Drawings												
e	Civil Design - PV Array, Switchyard, MCR												
f	Protection SLD												
g	SCADA Architecture												
5	**Detailed Engineering Drawing**												
a	Cable GTP												
b	Cable Schedules												
c	Earthing												
d	Roads and Drains												
e	Illumination - Outdoor and Indoor												

f	Transmission Line - 220 kV, 33 kV												
6	**Studies**												
a	PSS/E - Detailed Model - Final												
b	Relay Co-ordination												
7	**Other Documents**												
a	MQPs												
b	FQPs												
c	Weather Monitoring Station												
d	Testing Equipment - GTPs												
e	Site Testing and Commissioning Plans and Procedures												

Note: For each equipment, the First Submission shall include QR Docs (if applicable), Type Test Reports, GTP, GA.

Sub Section VII -B -Annexure B

The Matrix below is an indicative Schedule to be adhered for finalization of Engineering and Design Documents. The EPC Contractor shall submit detailed MDL for the approval of the Employer in accordane with the same.

Manufacturing, Delivery & Construction Schedule

		Month											
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
1	Storage area												
2	Boundary Fencing & gates												
3	Power Conditioning Unit												
4	Inverter Duty Transformer												
5	Power Transformer												
6	220/33 KV Switchyard												
7	MCR												
8	220 kV Switchgear												
9	33 kV Switchgear												
10	MMS												
11	MMS Fabrication Drawings												
12	civil foundations - MMS & PV array												
13	Civil works - switchyard, inverter stations												
14	Protection panels												
15	SCADA												
16	Cables												
17	Roads and Drains												
18	Transmission Line - 220 kV, 33 kV												
19	Installation of equipment												
20	Testing and commissioning												

Annexure – N

Equipment Inspection Category

All equipment is classified into three categories namely, Category – A, Category – B and Category – C on the basis of pre-dispatch inspection requirement by SECI and EPC Contractor.

Category	**Stake holder**	**Pre-dispatch inspection**
Category – A	SECI	Yes
	EPC Contractor	Yes
Category – B	SECI	No
	EPC Contractor	Yes
Category – C	SECI	No
	EPC Contractor	No

However, SECI reserves the right to conduct pre-dispatch inspection for Category-B and Category-C equipment also.

S. No.	**Equipment Code**	**Equipment**
Category – A		
1.	PCU	Power Conditioning Unit
2.	ITR	Inverter Transformer
3.	HTP	HT Switchgear Panel
4.	PTR	Power Transformer
5.	CRP	Control & Relay Panel
6.	MMS	Module Mounting Structure[#]
7.	SCADA	SCADA
Category – B		
1.	SMU	String Monitoring Unit
2.	ATR	Auxiliary Transformer
3.	SC	Solar Cable (Module to SMU)
4.	DCC	DC Cable (SMU to PCU))
5.	LTC	LT Cable (PCU to Inverter Transformer)

6.	HTC	HT Cable (Inverter Transformer to Power Transformer)
7.	LTP	LT Panels (ACDB & DCDB)
8.	SWO	Substation Equipment – CT, PT, CB, Isolator etc.
9.	ABT	Metering Set (Main, Check, Standby)
10.	NIFPS	Nitrogen Injection Fire Protection System
Category – C		
1.	TLC	Transmission Line Conductor/Cable
2.	LDC	LT Distribution Cable
3.	UPS	Uninterrupted Power Supply
4.	BBC	Battery Bank and Battery Charger
5.	EES	Earth Electrode and Accessories
6.	LPS	Lightning Protection System
7.	CMC	Communication Cable
8.	TEA	Telemetry Equipment and accessories
9.	LED	Plant Illumination equipment and accessories
10.	WMS	Weather Monitoring Station
11.	CCTV	CCTV Camera
12.	FAS	Fire Alarm System
13.	TI	Testing instruments
14.	CPC	Control and Power Cables
15.	SCC	Solar Cable Connector
16.	CTK	Cable Termination Kits
17.	TLT	Transmission Line Tower/Pole and Accessories
18.	FST	Fasteners
19.	OTR	Equipment Pre-Approved by DISCOM/TRANSCO

* Material inspection to be done prior to manufacturing

Proto-type inspection to be done prior to manufacturing

1. **Category – A**

The Contractor shall give inspection call to SECI for pre-dispatch inspection of Category – A equipment at Manufacturer's/Supplier's factory. The inspection call shall be given only after the approval of equipment documents under Category – I as per Drawing and Document Control Index and be attached with internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. Inspection call should be given at least 7 working days before the scheduled start date of pre-dispatch inspection for a location within India and 15 working days in case of a foreign country. Based on the inspection report and compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by SECI.

2. **Category – B**

For Category – B equipment, the Contractor shall intimate SECI about the proposed inspection at least 3 working days before the scheduled start date of pre-dispatch inspection. Such intimation shall be given only after the approval of equipment documents under Category – I as per Drawing and Document Control Index and be attached with internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. SECI will participate in the pre-dispatch inspection, if required.

If SECI participates in the pre-dispatch inspection, based on the inspection report and compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by SECI. In case SECI does not participate in the pre-dispatch inspection, the Contractor shall submit the Inspection Report signed by Contactor and Manufacturer/Supplier Representatives to SECI for issuance of Material Dispatch Clearance Certificate (MDCC).

3. **Category – C**

For Category – C equipment, the Contractor shall submit internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. For all equipment inspected by the DISCOM, Inspection Report/Test Report signed by DISCOM shall be submitted to SECI for information and payment recommendation.

The methodology proposed for conduct inspection and issuance of MDCC is as under:

Category	Inspection done by	MDCC issued by

A	SECI and / or Customer	SECI	Inspector will submit the inspection report to SECI along with his observations, if any. In case of any observation reported by Inspector, then Contractor shall submit compliance report for the same to SECI. SECI shall review the inspection report, along with the compliance report submitted by Contractor, in line with the approved QAP and Drawings/Documents and if found satisfactory, shall recommend issue of MDCC. MDCC shall be issued by HRL.
B	EPC contractor (SECI optional)	SECI	Contractor shall submit all the test report / material certificates to SECI. SECI shall review these documents and if found satisfactory, shall recommend issue of MDCC. MDCC shall be issued by HRL.
C	COC by Manufacture / Supplier	SECI	EPC contractor will verify the CoC and issue the MDCC which will be verified by SECI and countersigned by HRL.

SECTION - VII

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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 PCU, combiner boxes, DC cables, module mounting structures, transformer, CT, PT, LT/ HT cables, interfacing panels, switch gears & other associated equipment 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:

(Signature)

Date: Name and Designation of bidder

A Electrical System

1 String Combiner Box / String Isolator 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 SCB / SIB 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 SCB. One spare input terminal along with connector shall be provided for each SCB.

1.2.3 Every SCB 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 DC switch disconnector of suitable rating shall be provided at SCB output / SIB 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 SCB input. Cable gland (double compression metallic) of suitable size for DC cables shall be provided at the SCB output / SIB.

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.

1.3 Warranty

The SCB/SIB 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.

2 Solar and DC Cables

2.1 Standards and Codes

Cable	From	To	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SCB / IPC	Copper/ XLPO	1.5 kV DC	IS 17293 / IEC 62930
DC Cable	SCB / IPC	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 SCB/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 Alternatively, solar cables may be connected to DC cable via Insulation Piercing Connector (IPC) through fuse. DC cable and Insulation Piercing Connector may be laid over ground on GI cable trays. Insulation Piercing Connector shall be UV resistant, flame retardant, water proof and rated for IP 67.

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

2.8.7 DC cables from SCB 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 fan with proper ducting shall be provided for cooling keeping in mind the extreme climatic condition of the site as per the recommendations of OEM to achieve desired performance and life expectancy.

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

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, among others.

(i) DC/AC over current

(ii) DC/AC over voltage

(iii) DC reverse polarity

(iv) DC earth fault

(v) AC under voltage

(vi) AC under frequency/over frequency

(vii) Islanding

(viii) Over temperature

(ix) Lightning surges

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 and Power Plant Controller (PPC). 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 and Power Plant Controller. 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.

3.9.2 Routine Tests

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

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**
VA Rating	As per system design requirement	
Voltage Ratio	33 kV / Inverter output voltage	As per system design
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)	Continuous application (Outdoor/Indoor)
Winding	As per system design requirement	2
Frequency	50 Hz	50Hz

Nos. of Phase	3	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement	Dyn11
Cooling	ONAN	ONAN / AN
Tap Changer	OCTC, No. of steps shall be as per system requirement	
Impedance at 75°C	As per Inverter Manufacturer requirement	As per system requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)		
Top Oil	50°C	As per IS/IEC
Winding	55°C	As per IS/IEC
SC withstand time (thermal)	2 second	2 second
Short Circuit Apparent power	As per system requirement	
Termination	As per system requirement	
Bushing rating, Insulation class (Winding & bushing)	36 kV – porcelain bushings 1.1 kV – epoxy bushings	As per the system requirement
Noise level	As per NEMA TR-1	
Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7	
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute 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.

4.4 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 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.

4.6.1.3 Type tests mentioned in Clause 4.6.1.1(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

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
Number of phases	3
Power frequency withstand voltage	70 kV (r.m.s.)
Lightning impulse withstand voltage	170 kV (peak)
System fault current	25 kA / 1s
Internal Arc Classification	IAC-A, FLR, System Fault Current for 1s

RMU Requirement: 3 VCBs, 1 Metering PT((2 cores, 50 VA), 1 Cast Resin Power VT (250 VA)	
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3 sec – CO – 3min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C2
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2S for metering at outgoing feeder), 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class 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.

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.

5.4 <u>Circuit Breakers</u>

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 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.

5.5.3 All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO).

5.5.4 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.

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

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

5.5.7 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

5.5.8 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

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

5.5.10 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.

5.5.11 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.

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

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

5.5.14 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.

5.6 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 Switchgear 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 (M2 Class)	IEC 62271-100	6.101.2
Basic short-circuit test-duties	IEC 62271-100	6.106
Relays		
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility	IEC 60255-26	

requirements		
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional Requirements	Relevant standards of IEC 60255-1xx series	
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.

5.12.2 Routine Tests

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

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 approval.

6.4 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 'FRLS' at every metre
(iii) Sequential marking of length of the cable in metres at every metre

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 <u>Warranty</u>

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 <u>Testing</u>

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

6.8 <u>Installation</u>

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 inverter 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.

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 be with two independent sources for reliable auxiliary power supply.

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 <u>Standards and Codes</u>

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	As per system fault current

service short-circuit breaking capacity	
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 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 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

9.2.2 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.

9.2.3 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.

9.2.4 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%.

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.

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, 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.

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 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.

11.2.2 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.

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

11.2.4 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.

11.2.5 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.

11.2.6 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.

11.2.7 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.

11.3 <u>Earthing of PV array field</u>

11.3.1 All PV Modules, Module Mounting Structures (MMS) and String Combiner Box (SCB) 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 SCB/SIB 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 PV Module 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 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).

11.8 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 NF C 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 NF C 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 NF C 17-102 shall be submitted during detailed engineering for approval.

12.6 Lightning Protection System for Plant Pooling Substation

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

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

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

12.6.4 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.

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 Zone level (i.e. SCB level) parameters.

(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) Generate, store and retrieve user configurable Sequence of Event (SOE) Reports.

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

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. Indicative SCADA Schematic Diagram along with Indicative I/O List has been attached in Annexure-N.

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 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.

14.3 <u>Industrial IoT Controllers & Data Acquisition</u>

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, etc.)

14.3.3 Shall have local storage for a minimum of 2 weeks (in case of network failure).

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, USB data cards.

14.4 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.

14.5 Functionalities

14.5.1 In case of central inverter configuration, SCADA system shall enable PV array Zone monitoring i.e. the total current from each String Combiner Box shall be monitored on the DC side of the inverter.

14.5.2 The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC& AC Equipment including inverters, weather station, MFM, Transformer and Switchgear (LT & HT Panels) at regular intervals not greater than one minute.

14.5.3 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.

14.5.4 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.

14.5.5 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.

14.5.6 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.

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

14.5.8 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.

14.5.9 Power Plant Control: SCADA system shall provide required interface to the local SCADA operator to set various power control modes (active/reactive power/frequency/PF) through the inverters over industry standard communication protocols like Modbus over TCP/IP.

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

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

14.6 Earthing

14.6.1 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.

14.6.2 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 SCBs, Inverters, WMS and Switchgear panels.

14.7 Communication Cable Laying

14.7.1 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.

14.7.2 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.

14.7.3 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.

14.7.4 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.

14.8 Control Cabinets / Panels / Desks at Main Control Room

14.8.1 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.

14.8.2 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.

14.9 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.

14.10 Hardware at Main Control Room

14.10.1 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.

14.10.2 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, 32GB RAM (expandable to 64 GB RAM), 4 × 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (RedHat Linux or equivalent Linux OS, Oracle/MySQL or Windows or 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	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 500GB hard disk, 25" 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	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 500GB hard disk, 25" 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.

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

14.11 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 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.

15.4 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.

15.5 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 -A (Scope of Works), Power Transformer of 33/220 kV ONAN/ONAF with OCTC 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 <u>Standards and Codes</u>

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 Cylinde–s - 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.

(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.

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

(i) Thermostatically controlled space heater with switch for isolation

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

(iii) 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 <u>Construction</u>

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 failsafe 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 <u>Operating Mechanism and Control</u>

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 <u>Operation</u>

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

19.7.2 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

19.7.3 General Requirements

19.7.3.1 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.

19.7.3.2 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.

19.7.3.3 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.

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

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

19.7.3.6 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.

19.7.4 Current Transformer

19.7.4.1 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.

19.7.4.2 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.

19.7.4.3 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.

19.7.4.4 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.

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

19.7.4.6 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.

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

19.7.5 <u>Capacitor Voltage Transformer</u>

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

19.7.5.2 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.

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

19.7.5.4 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.

19.7.5.5 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.

19.7.5.6 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.

19.7.5.7 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.

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

19.7.5.9 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.

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

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.

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 / Aluminium.
Colour Temperature	5700 K (cool day light)
Colour Rendering Index	> 65
Moisture protection in case of casing damage	IP 65 (driver unit shall preferably be totally encapsulated)

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 80micron. 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.

21.1 Pyranometer

21.1.1 The Contractor shall provide Class-A pyranometers (ISO 9060:2018 classification) along with necessary accessories for measuring incident solar radiation in horizontal plane and plane of the 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.

21.2 Temperature Sensor

The Contractor shall provide minimum 5 (five) temperature sensors (1 (one) for ambient temperature measurement with shielding case and 4 (four) for module temperature measurement). The temperature sensor shall be Resistance Temperature Detector (RTD)/ Semiconductor type with measurement range of 0°C to 80°C. The instrument shall have valid calibration certificate.

21.3 Anemometer

Anemometer shall be ultrasonic type for wind speed and direction monitoring conforming to ISO 16622.

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 Sensors required for measurement of following parameters shall also be provided.

(i) Sun rise and sun set timings
(ii) Cloud cover (Okta)
(iii) Rainfall (mm)
(iv) Relative humidity (%)

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: Covering complete perimeter of Plant Area to capture all possible intrusion

(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 <u>Standards and Codes</u>

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 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.

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 has to do the power evacuation and integration to and with the designated substation 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.

25.2 The Contractor shall get the route approval from the Employer 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.

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 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. 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 for approval/ accord.

B Civil, Mechanical and Plumbing Works

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 <u>Standards & Codes</u>

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 at 20m x 20m grid, or as directed by the Engineer, only with the help of digital surveying instruments like Total Station/ Auto level.

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, by fly-levelling and establish two permanent bench marks (PBM) at site. All subsequent transfer of levels shall be carried out with respect to these PBMs. The work shall also include constructing permanent reference pillars (RP) at suitable locations 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 While carrying bench mark to the project site, levels shall also be established on the permanent objects like culverts etc. at least on one object in every 1 (one) km if available along with route with adequate description about the objects. These levels shall be maintained at site & also mentioned in the survey report to facilitate locating these objects later on.

2.5 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.

2.6 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.

2.7 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. **Error! Reference source not found.**.

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 25m 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. 500mm 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.

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

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

(iv) Granular/ gravel sub-base course (CBR>20%), conforming to Cl. 401 of MORD specs: 175 mm compacted thick, compacted to 100% of max dry density

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

(vi) 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. **Error! Reference source not found.** ‘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

Note: For the design of underground structures, friction angle of soil shall be considered as 30° and soil unit weight shall be considered as 18 kN/m^3.

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). However, minimum values for k_1, k_2 and k_3 shall be 0.94, 1.0 and 1.0 respectively.

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 structures.

10.10 Module Mounting Structure (additional requirements):

10.10.1 WL shall be considered as detailed below for estimation of WL under primary loads:

(i) WLx (downward, C_p+), WLz (downward, C_p+): Load due to positive pressure on design tilt angles of MMS members for wind acting in both (±X, ±Z) directions.

(ii) WLx (upward, C_p-), WLz (upward, C_p-)): Load due to negative pressure on design tilt angles of MMS members 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.

10.10.2 **Mono slope free standing canopy profile in North-South configuration:**

For estimation of WL on modules, Table-8 of IS-875 part-3 shall be considered corresponding to roof angle of module (tilt w.r.t the ground). WL (downward) and WL (upward) on modules (laid in the profile of mono slope canopy) shall be applied for each slope such that the center of pressure should be at 1/3rd of slant length (0.3 × length of each slope/canopy) from windward end (for simplicity, the wind load distribution may be taken as triangular with max. value at windward end of each slope/canopy). Solidity ratio (∅) may be taken as 0.0. However, in case of string inverter mounted directly underneath MMS the solidarity ratio shall be taken as 0.5.

10.10.3 **Double sloped free standing canopy profile in East-West configuration:**

For estimation of WL on modules, Table-9 of IS-875 part-3 shall be considered corresponding to roof angle of module (tilt w.r.t the ground). The load shall be applied as uniformly distributed (corresponding to centre of pressure at mid-point of the slope)

Solidity ratio (∅) may be taken as 0.0. However, in case of string inverter mounted directly underneath MMS the solidarity ratio shall be taken as 0.5.

10.10.4 Apart from this distribution, any other distribution of wind load based on wind tunnel studies may be followed subject to the approval of the employer.

Note: Wind tunnel studies shall be specific to the site topography as well as array layout and shall be conducted in BLT tunnel as per guidelines specified in IS:875 – part 3 and ASCE MOP 67. The wind tunnel studies shall be conducted with appropriate scale (however, not less than 1:50) model in boundary layer tunnel and must be vetted and validated from an IIT.

10.10.5 In design of MMS (for height of structures from ground less than 10 m), 20% reduction in wind pressure as per Note under Cl. 6.3 of IS 875 – Part 3 is not permitted in case of purlins (members supporting modules), which shall be designed against action of WL corresponding to full wind pressure.

10.11 <u>Design Load combinations</u>

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 + LL
  - (ii) DL + LL ± WLx
  - (iii) DL + LL ± WLz

(iv) DL + LL ± ELx

(v) 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 (Min 350 mm for column depth more than 175 mm) 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 1200mm 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 <u>Helical/ Screw Pile</u>

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. **Error! Reference source not found.**.

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^{o}, 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
- Minimum grade of steel for sections conforming to IS: 811 & IS: 4923 shall be E350 conforming to IS: 2062 and Y_{St} 310 conforming to IS: 1608 respectively.

13.7 VOID.

13.8 Aluminium-Zinc Alloy metallic coated steel strip or sheet of grade YS350 and minimum coating class AZ200 conforming to IS 15961: 2012 may also be used for fabrication of purlin sections. In such a case, all the sections of the base metal exposed after cutting of members and punching of holes shall be provided with sprayed aluminium-zinc alloy coating corresponding to Grade – A (service life >20 years) conforming to IS:5905 suitable to corrosion class at project site environment.

13.9 The minimum thickness excluding anti corrosive treatment (BMT) of various elements of MMS structure shall be as following:

- Stub/ column – 3.15mm,
- Rafter – 2.5mm
- Purlin –1.5 mm.
- Other members – 2.0 mm

13.10 The primary loads and load combinations for design of MMS structure shall be as specified under Clause No. **Error! Reference source not found.**. The design shall be done by Working stress method and no increase in allowable stress shall be permitted.

13.11 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

13.12 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.

13.13 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.

13.14 In double sloped free-standing canopy, at all frames columns supporting the opposite slopes of the canopy shall be connected using a tie-member.

13.15 Lateral restraint to compression flange if any due to PV panels including back rails of the module is not permitted in purlin design.

13.16 The vertical diagonal bracing shall be provided in end spans and every alternate span for all rows of columns of each unit (table) of MMS. The bracing arrangement shall be centre line symmetric.

13.17 MMS shall support SPV modules at a given orientation & tilt and shall absorb and transfer the mechanical loads to the ground properly.

13.18 Welding of structure at site shall not be allowed and only bolted connections shall be used.

13.19 The MMS structure shall be hot dip galvanized with zinc coating of 610 GSM and/or minimum thickness of 80 microns for protection against corrosion. Galvanization shall conform to IS-2629, 4759 & 4736 as applicable.

13.20 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.

13.21 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.

13.22 The galvanization of all members shall be done after fabrication of members and cutting of holes to ensure galvanization of all cut/ exposed edges.

13.23 In case the proposed section is made up of Aluminium, anodized coating shall be min. Gr. AC25 and shall conform to IS: 1868.

13.24 The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels at the same time.

13.25 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.

13.26 Fasteners and washers to be used for erection of mounting structure and for fixing the module shall be of stainless steel grade SS 304, with property class A2-70 conforming to relevant ISO standard and must sustain the adverse climatic conditions to ensure the life of the structure for 25 years.

13.27 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).

13.28 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.

13.29 The MMS foundation shall be designed as per Cl. No. 12.

13.30 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.

13.31 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. 13.30 and no embedment of column leg in foundation is permitted).

13.32 The array structure shall be grounded properly using maintenance free earthing kit.

13.33 The bidder/manufacturer shall specify installation details of the PV modules and the support structures with appropriate diagram on the construction and assembly drawings.

13.34 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.

13.35 The length of one unit (Table) of MMS shall not generally be more than 10m.

13.36 VOID.

13.37 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.

13.38 The length of any cold formed section (CFS) shall not be more than 5.5 m.

13.39 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.

13.40 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.

13.41 The purlin splice shall comprise of flange and web splice plates and splice design shall conform to Annexure-F of BIS:800. For simplicity in fabrication, the splice member may be of CFS channel section without lips (CU). There shall be min. four number of bolts on either sides of joints in web zones and one number of bolt on either side of joint in flange zones.

13.42 For same member type, same section shall be used.

13.43 When any sag or tie member to the purlin (rod, angle or channel) is provided, it shall not be considered in modelling the structure for analysis except its effect as lateral support to the purlin members in strength design.

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.

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 RCC parapet wall of 450 mm clear height all-around which shall form a projected band at roof level. For weather protection all doors and windows shall be provided with 450mm wide RCC chajja. However, chajja for rolling shutter shall be 750mm wide.

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 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 Security Room/ Cabin

16.2.3.1 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.

16.2.3.2 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.

16.2.3.3 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.

16.2.3.4 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.

16.2.3.5 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.

16.2.3.6 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.

16.2.3.7 Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

16.2.3.8 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.

16.2.3.9 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.

16.2.4 Watch Tower

Watch tower 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 <u>Store area, Equipment Area</u>

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.

17.2 SCADA Room, Control cum Office Room, Supervisor Room and Lobby

1200 mm X 1200 mm thick Heavy duty vitrified tile (8mm thick or more) flooring with matching skirting of 100mm height.

17.3 Battery Area/Room

Acid/ Alkali resistant tile flooring and 2100 mm height dado, Floor and dado tiles - 20mm and 12 mm thick respectively. However, in case of maintenance free batteries, vitrified tile (8mm thick) flooring and dado shall be provided.

17.4 Toilet

- 40 mm thick Ceramic tile (8mm thick) flooring and glazed tile (6mm thick) 2100 mm height dado.
- 20mm thick Granite stone finish over platform for wash basin.

17.5 Pantry

40 mm thick 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.

17.6 Passage/ Corridor

40 mm thick Heavy duty vitrified tile (8mm thick) flooring with matching skirting of 100mm height.

17.7 Steps

Kota stone (20 thick) or 50 thick mosaic tiled flooring in white cement.

17.8 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 (5th 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.

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 In case of transformer oil tank capacity ≥ 2000 litres, the transformer foundation shall have its own soak pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil in case of emergency. The retention capacity of the soak pit shall be equal to volume of the transformer oil (excluding free space above gravel) and it shall be filled with granite stone gravel of size 40mm, uniformly graded, with 200 mm free space above gravel fill.

34.3 In case of transformer oil tank capacity more ≥ 5000 litres, the soak pit shall be connected to a separate burnt oil pit through GI discharge pipe (300 mm dia) which shall be suitably sized to accommodate full oil volume (excluding free board above the bottom of inlet pipe) of the transformer connected to it. The inlet pipe shall be provided proper slope to avoid any backflow of the incoming oil. In this case the capacity of the soak pit of the transformer may be reduced max. up to 1/3rd of the total transformer oil volume. The burnt oil pit shall be further connected to oil separation/ treatment system. The water shall be discharged into the nearest drain by gravity flow or pumping after suitable treatment as per statutory and code provisions.

34.4 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.

34.5 The area around the transformer and equipment shall be covered with uniformly graded granite stone gravel of size 40mm.

34.6 The area shall be provided with galvanized chain link fence with min. height 1.8m and a main gate of 3.5m width.

34.6.1 The fencing shall be of galvanized iron chain link mesh fabric with internal, corner and stay posts of hot dipped GI angle (min. ISA 65x65x6 mm). MS angle posts shall conform to IS 2062. The fence post shall have split end of length 150 mm, for proper anchorage in to the foundation concrete. 34.6.2 All GI posts shall be supported with min. 300 mm dia. and 850 mm deep (below GL) piles in M20 cement concrete (nominal mix 1:1.5:3). The pile shall project 150 mm above GL. The column posts shall be extended into the pile up to 950mm 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. 34.6.3 Spacing of intermediate posts shall not be more than 2.5m. 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. 34.6.4 The GI chain link mesh fabric (40x40 mm with min. wire gauge 3.15mm, both ends twisted) and fencing shall conform to IS: 2721.34.6.5 Each fence panel shall be provided with 35x35x3 mm GI edge angle at top and bottom with mesh fabric firmly secured to them and to intermediate support angles.34.6.6 All MS sections shall be painted with 2 coats of epoxy paint of approved make and shade over 2 coats of zinc chromate primer.

34.6.7 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.

34.6.8 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.

34.6.9 The transformer yard fencing work shall conform to CEIG requirements.

34.7 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 <u>Wet Cleaning System</u>

35.1.1 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.

35.1.2 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.

35.1.3 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.

35.1.4 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.

35.1.5 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.

35.1.6 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.

35.1.7 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.

35.1.8 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.

35.1.9 Module cleaning procedure and pressure requirement at discharge point shall be as per the recommendation of PV module manufacturer. However, discharge pressure at outlet shall not be less than 5kgf/cm^2 (0.5 MPa).

35.1.10 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.

35.2 Dry Cleaning System

35.2.1 The dry cleaning system shall be robotic type with microfibre or polymer based brushes.

35.2.2 Supplier Qualification: The Robotic Cleaning System Supplier/Sub-Contractor must have experience of having successfully completed Design, Engineering, Installation, Testing and Commissioning of Robotic Module Cleaning systems for at least 2 Solar PV Projects of minimum capacity of 5 MW in the last 5 years. Such systems must have been in satisfactory operation for at least 12 months from the date of Commissioning. The Contractor shall submit supporting documents as credentials, including Purchase Orders, Commissioning Reports, Performance Certificate of successful operation from the procurer.

35.2.3 The Scope of Supply and installation shall include module cleaning system units, docking stations, communication tools, charging system, spares, remote operation management & analytics tools, SCADA communication tools and any other system related requirement required for successful installation & operation of the system.

35.2.4 The system shall be designed for operation under the climatic conditions at site, as specified elsewhere in this specification. Module cleaning system shall be effective under a relative humidity of minimum 75% or as per site specific value observed over last 25 years.

35.2.5 The Robotic Cleaning system shall be self-powered, with battery backup (no external supply). The battery shall be compliant with IEC 62133: Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications.

35.2.6 The Contractor shall ensure the efficacy of the module cleaning system with respect to the local soil. The Contractor shall submit a test report for applicability of proposed cleaning system for site specific soil as per standardized testing procedures from an accredited laboratory.

35.2.7 The compatibility of the Robotic Cleaning System with the PV Modules so as to maintain the validity of the PV Module Performance Warranties shall be the responsibility of the Contractor. Contractor shall submit a certificate of conformance from the PV Module Supplier to this effect.

35.2.8 Impact of cleaning brush/microfiber on the coatings of modules shall be tested as per IEC 62788-7-3.

35.2.9 Robotic cleaning system shall be provided with docking stations and arrangement of rails for movement. Docking stations shall be provided at the start and end of MMS table rows as per requirement. Design of docking station and rails shall conform to relevant Indian standards or as per OEMs recommendations.

35.2.10 Unless specified otherwise in OEMs recommendations, material for docking stations and rails shall be anodized extruded Aluminium (Class designation 64430 and 65032 conforming to IS: 733) or galvanized steel (grades as applicable for MMS). The minimum thickness of anodization coating and galvanization coating shall be 25 microns and 80 microns respectively.

35.2.11 The cleaning robot shall have provision to return to its docking station automatically in the event of wind gust of pre-defined criticality, which shall be identified during detailed engineering. High wind scenario refers to the wind speed beyond which the cleaning robots shall not be recommended to operate by the Equipment Supplier.

35.2.12 The system shall be able to withstand site specific wind speed in standing position at docking station.

35.2.13 The system shall be able to be functional in variable ground slopes of minimum 5-degree with reference to the ground.

35.2.14 The necessary design considerations for the mounting the robotic system shall be incorporated in the Module Mounting Structure design, foundation design as well as PV array layout, in addition to the specifications provided elsewhere in this Section.

35.2.15 The Robotic Cleaning system shall be integrated with the Plant SCADA.

35.2.16 The Contractor shall set up a Prototype in the factory to match actual designed MMS, Bridge and Docking station, with modules of appropriate rating for each table length, prior to mass production.

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:

Open RCC storm water drains shall be provided on both sides of the road and inside switchyard area for proper drainage. All drains shall be designed for maximum runoff velocity of 1.8 m/sec.

RCC box/pipe culvert shall be provided for road, rail and trench crossings.

The design and other requirements of switch yard drainage system shall be as specified under Cl. No. 7.

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 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 <u>Support structure for weather monitoring device</u>

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.

C Quality Assurance and Inspection of Civil Works

1 Introduction

1.1 This part of the specification covers the sampling, testing and quality assurance requirement (including construction tolerances and acceptance criteria) for all civil and structural works covered in this specification.

1.2 This part of the technical specification shall be read in conjunction with other parts of the technical specifications, general technical requirements & erection conditions of the contract which covers common QA requirements. Wherever IS code or standards have been referred they shall be the latest revisions.

1.3 The rate for respective items of work or price shall include the cost for all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirement including construction tolerances and acceptance criteria and as specified in subsequent clauses of this part of the technical specifications.

1.4 The QA and QC activities in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / contract documents shall be carried out at no extra cost.

1.5 The contractor shall prepare detailed construction and erection methodology scheme which shall be compatible to the requirements of the desired progress of work execution, quality measures, prior approvals from statutory authorities etc. if any and the same shall be got approved from the Engineer.

1.6 If required, work methodology may be revised/ reviewed at every stage of execution of work at site, to suit the site conditions, work progress commensurate with project schedule by the contractor at no extra cost to the Engineer

2 QA and QC Manpower

2.1 The contractor shall nominate one overall QA coordinator for the contract detailing the name, designation, contact details and address at the time of post bid discussions.

2.2 All correspondence related to Quality Assurance shall be addressed by the contractor’s QA coordinator to the Engineer.

2.3 Employer/ Consultant shall address all correspondence related to Quality issues to the contractor’s QA coordinator. The contractor’s QA coordinator shall be responsible for co-ordination of Quality activities between various divisions of the contractor and their sub-vendors on one hand & with Engineer on the other hand.

2.4 The contractor shall appoint a dedicated, experienced and competent QA & QC in-charge at site, preferably directly reporting to the Project Manager, supported as necessary by experienced personnel, to ensure the effective implementation of the approved QAP.

2.5 The contractor shall finalize and submit a deployment schedule of QA & QC personnel along with their details to Engineer for approval/ acceptance and further shall ensure their availability well before the start of the concern activity.

3 Laboratory and Field Testing

3.1 The contractor shall make necessary provisions to provide all facilities required for QA & QC activities by setting up a field laboratory for QA and QC activities in line with the indicative field QA & QC laboratory set-up.

3.2 The Laboratory building shall be constructed and installed with adequate facilities to meet the requirement of envisaged test setup. Temperature and humidity controls shall be available wherever necessary during testing of samples.

3.3 The quality plan shall identify the testing equipment/ instrument, which the contractor shall deploy and equip the field quality laboratory for meeting the field quality plan requirements.

3.4 The contractor shall furnish a comprehensive list of testing equipment/ instrument required to meet the planned/scheduled tests for the execution of works for Engineer's acceptance/ approval.

3.5 The contractor shall mobilize the requisite laboratory equipment and QA & QC manpower at least 15 days prior to the planned test activity as per the schedule of tests.

3.6 In case contractor desires to hire the services of any established laboratory nearby for any field tests then he shall ensure that the subject laboratory is well equipped with all requisite testing facilities and qualified QA & QC staff and this shall not affect in anyway the work progress.

3.7 All equipment and instruments in the laboratory/ field shall be calibrated before the commencement of tests and then at regular intervals, as per the manufacturer's recommendation and as directed by the Engineer. The calibration certificates shall specify the fitness of the equipment and instruments within the limit of tolerance for use. Contractor shall arrange for calibration of equipment and instruments by an NABL / NPL accredited agency and the calibration report shall be submitted to Engineer.

3.8 The tests which cannot be carried out in the field laboratory shall be done at a laboratory of repute. This includes selected IITs, NCB, CSMRS, reputed government / autonomous laboratories / organizations, NITs and other reputed testing laboratories. The test samples for such test shall be jointly selected and sealed by the engineer and thereafter these shall be sent to the concerned laboratory through the covering letter signed by Engineer. Test report along with the recommendations shall be obtained from the laboratories without delay and submitted to Engineer.

3.9 Based on the schedule of work agreed with the Engineer and the approved FQP, the contractor shall prepare a schedule of tests and submit them to the Engineer and organize to carry out the tests as scheduled/agreed.

4 Sampling and Testing of Construction Materials

4.1 The method of sampling for testing of construction materials and work / job samples shall be as per the relevant BIS / standards / codes and in line with the requirements of the technical specifications / quality plans.

4.2 All samples shall be jointly drawn, signed and sealed wherever required, by the contractor and the engineer or his authorized representative.

4.3 The contractor shall carry out testing in accordance with the relevant IS standards/ codes and in line with the requirements of the technical specifications / quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

4.4 All testing shall be done in the presence of Engineer or his authorized representative in a NABL accredited / Govt. Laboratory acceptable to Engineer.

4.5 The test samples shall be jointly selected and sealed and signed by the Site-in-charge and thereafter these shall be sent to the concerned laboratory.

4.6 The test report along with the recommendations shall be obtained from the laboratory without delay and submitted to Engineer.

5 Purchase and Service

5.1 All structural steel shall be procured only from main steel producers In case of non-availability of some of the sections with main steel producers, the contractor may propose to procure the sections from the re-rollers of the main steel producers, the name of such re-rollers will have to be cleared by the Engineer for which details such as BIS approval, main steel producer's approval, past experience for production of sections of specified material, details of machines, plant, testing facilities etc.

5.2 Confirmation that the process control and manufacturing of steel sections by re-rollers shall be same as that of main steel producers, that billets for re-rolling will only be sourced from main steel producers shall be furnished with regard to re-roller.

5.3 For Module Mounting Structures (MMS), sources of steel other than those specified under this clause may also be used subject to the condition that they otherwise meet the requirements of the Technical Specifications / Bid documents. Even after clearance of re-rollers, induction of billets with identified and correlated Mill test certificates (MTC) in the process of re-rolling, sampling of steel, quality checks thereof and stamping of final product for further identification and correlation with MTC prior to dispatch shall be the responsibility of the contractor and these shall be performed in presence of the authorized representative of the main Contractor.

5.4 Reinforcement steel shall be procured only from main steel producers and Mill test certificates (MTC) shall be obtained and submitted to the Engineer for correlation.

6 Field Quality Plan

6.1 Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans to Employer for approval, which shall detail out for all the works, equipment, services, quality practices and procedures etc. in line with the requirement of the technical specifications to be followed by the contractor at site.

6.2 This FQP shall cover all the items / activities covered in the contract / schedule of items required, right from material procurement to completion of the work at site.

6.3 An Indicative Field & Manufacturing Quality Plan for civil, structural and MMS works is enclosed with this specification for reference as Annexure-F.

7 General QA Requirements

7.1 The contractor shall ensure that the works, BOIs and services under the scope of Contract, whether manufactured or performed within contractor's works or at his subcontractor's premises or at the project site or at any other place of work, are in accordance with Technical specification, applicable standards / codes, approved drawings / data sheets / quality plans and BOQ. All the works, BOIs and services shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

Equipment	UOM	Approx. Qty.
Cube moulds for cement testing	nos.	4
Sieve shaker	nos.	1
Sieve for sand, coarse and fine aggregate	set	1
Sieve for coarse aggregate	set	1
Slump testing equipment	nos.	6
Oven	nos.	2
Physical balance	nos.	1
Thermometer	nos.	4
Burret	nos.	2
Measuring cylinder	nos.	9
Measuring flask	nos.	3
Compression testing machine	set	1
Cube mould for concrete	nos.	10
Mechanical weighing machine	nos.	1 (100kg capacity)
Drum type concrete mixer (for trial mixes)	nos.	1

Proctor testing equipment	set	1

7.2 Notes

- The equipment listed above is indicative and minimum required. Additional equipment, if any, required for successful completion of work shall be provided /arranged by the contractor.
- All test reports/ inspection reports shall be submitted in soft copy also and shall be available at site for easy access to the Engineer.

Based on the schedule (L2/L3 Network), Quality control & Quality Assurance Work plan shall be finalized by the contractor and the same shall be submitted to Engineer for acceptance/approval.

Annexure – A

Functional Guarantee Test Procedure

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1 INTRODUCTION

This document lays down the procedures and requirements for conducting Functional Guarantee tests including scope of the tests, procedures for the tests, reporting formats and process for determining test results in accordance with the Tender Specifications, applicable standards and industry best practices.

2 FUNCTIONAL GUARANTEE TESTS FOR SOLAR PV PLANT

The Functional Guarantee shall comprise of a set of visual/mechanical/Electrical checks followed by a Performance Guarantee (PG) Test of the Plant Facilities in which estimation of Performance Ratio (PR) shall be carried out.

2.1 PERFORMANCE GUARANTEE (PG) TEST

A Performance Guarantee test shall be carried out after the commissioning of Plant Facilities to demonstrate that the plant has achieved the **Guaranteed Performance Ratio** in line with requirements under section VII of the bidding document. This will be one of the pre-conditions for the Plant Operational Acceptance. Performance Guarantee (PG) test period would be continuous measurement of 30 consecutive days. The test shall be conducted in accordance with the IEC-61724 as per the methodology described in Technical Specifications under section VII of the bidding document. General requirements & Procedure of PG test are described further in Section 2.1.3 & Section 2.1.4 respectively. The report shall contain all the measured energy and Met data values, calculations, results and conclusions.

2.1.1 **Pre-PG Test**

2.1.1.1 The EPC Contractor shall perform start-up tests after completion of Commissioning and Test Procedure as per Annexure – C: Plant Documentation, Commissioning and Test Procedure and recording of punch points.

2.1.1.2 Performance Guarantee Test shall commence immediately after all issues arising from the functional/ start-up test have been rectified.

Note:

(a) All measurement(s) shall be carried out taking proper safety precaution.

(b) Also it shall be ensured that to avoid any loose connection at the terminal points for which measurement procedure is conducted.

(c) Ensure proper functioning (e.g. Mustimeters shall be calibrated) of all measuring instruments before conducting above measurement procedure.

(d) The above test procedure shall be conducted in presence of site in-charge.

2.1.2 Performance Ratio

The Performance Ratio (PR) of the PV Plant **in a reporting period** shall be calculated as follows (according to IEC 61724).

$$PR_{temp.corrected} = \frac{E_{out}}{\sum_k \left(\frac{(C_k \times P_n) \times (G_{i,k} \times \tau_k)}{G_{i,ref}} \right)}$$

Where,

E_{out} Cumulative Plant Generation measured at Plant End ABT meter over the **duration of reporting period** (kWh), (1/4) hour

P_o Installed nominal peak power of PV modules, i.e. Nameplate rating at STC (kW_p)

P_n $P_n = P_o X(1 - DFXn)$, where DF is the module degradation factor, which shall be considered as per PV Module Datasheet, n is the is the number of years of operation after operational acceptance. For operational acceptance, $n = 0$

τ_k Duration of the k^{th} recording interval, i.e. (1/60) hour

$\sum_k$ Summation over all recording intervals in the reporting period, (1/4) hour

$G_{i,k}$ Average irradiance measured at the Plane of Array (POA) at the commencement of time interval τ_k (kW/m^2) (**average of all Pyranometers installed in various sites**)

$G_{i,ref}$ Irradiance value at which P_o is determined, i.e. 1 kW/m^2

C_k Power rating temperature adjustment factor and can be calculated as below

$Ck = 1 + \gamma \times (T_{avg\_mod,k} - T_{ref})$

γ Temperature coefficient of power with negative sign ($°C^{-1}$)

$T_{avg\_mod,k}$ Avg. PV Module temperature measured at the commencement of time interval 'τ_k' (°C) (**average of all Module Temperature sensors installed**)

T_{ref} PV Module temperature at which P_o is determined, i.e. 25°C

2.1.3 General Requirements

- The PG test shall commence within 60 days of the commissioning of Plant Facilities.
- The PG test shall be carried out for a period of 30 days at site by the Contractor in presence of the Employer/ Employer's Representative/ Owner's Engineer.
- The date of commencement of the PG Test shall be communicated in advance and agreed upon by both parties i.e. SECI and EPC Contractor. Any consecutive 30 days period (excluding interruptions that last entire day on account of grid outage or as per hindrance record maintained at site or weather conditions) for the purpose of conducting PG test shall be mutually discussed and agreed between SECI and EPC Contractor.
- These tests shall be binding on both the parties to the contract to determine compliance of

the equipment with the guaranteed performance parameters.

- The test shall consist of guaranteeing the correct operation of the Plant Facilities, by way of the performance ratio based on the reading of the energy produced and delivered to the grid (ABT meter) and the Plane of Array incident solar radiation.

2.1.4 **PR Test Procedure**

2.1.4.1 Pre-Test Requirements

(1) Before the commencement of PG test, the plant shall have completed Pre-PG tests as per Clause 2.1.1 above and SCADA system and WMS shall be fully commissioned and functional.

(2) Pyranometer Tilt Angle & Cleanness: The pyranometers & Tilt Angle shall be verified before the test commences and **then visually inspected at regular intervals for cleanliness during the tests**.

(3) The Pyranometers and Temperature sensors used for the purpose of the PG Test shall have valid calibration certificates.

(4) Trial Run: The PG Test for Plant Facilities shall commence with a trial run for 7 consecutive days. SECI shall estimate the PR for the Trial Run period and revert within 3 working days. Post the trial run period, the 30 days PG test will commence after communication from SECI.

2.1.4.2 **General Procedure for the PR Test**

(1) **Data Collection**: The EPC Contractor shall provide the raw data as per **Annexure-1 (Format for Raw Data Submission)** to SECI. PV Power Plant test related parameters are collected in one-minute and 15 intervals for the 30 (Thirty) days reference period. The data shall consist of the following at a minimum:

- Irradiance at Collector's (i.e. PV Module) POA; (Source: SCADA, Temporal Resolution: 1 minute) Average values form all the sites will be considered
- Other Met Data received from installed WMS; (Source: SCADA, Temporal Resolution: 1 minute)
- Energy generated at Plant (kWh) (Source: Plant TVM Meter from SCADA, Temporal Resolution: 1 minute)
- Energy injected into grid (kWh) (Source: Plant End ABT Meter, Temporal Resolution: 15 minute)
- PV Module Temperature recorded from the temperature Sensors (^{o}C) (Source: SCADA, Temporal Resolution: 1 minute)

(2) **Data Cleaning/Filtering:** The data shall be filtered so that the data set is free of nuisance data points and bad data that exhibit a high degree of error (such as errors caused by faulty instrumentation). The following criteria shall be excluded from the dataset used for this test:

- **Missing data:** Time blocks with missing 1-minute records shall be interpolated using average interpolation method.
- **Nuisance or bad data** – Nuisance data points or bad data that clearly exhibit a high degree of error (eg. due to rainy/cloudy weather or meteorological measurement equipment that is identified as being out of calibration or requiring adjustment). A 15-minute time-block shall be *explicitly* flagged through a flag parameter on account of this factor after recording reasons thereof (**Note**: no filtration shall be done on site data). The same shall be corroborated/verified by SECI. Suitable statistical methods may be applied to identify such erroneous data.
- **Grid Interruptions** – Time periods (15-minute time blocks) of the grid interruptions at the utility substation, recorded manually jointly by EPC Contractor and SECI representatives shall be eliminated. Grid outage period, if any, shall be verified from SCADA.
- Any Force majeure conditions
- **Radiation Criteria –** Radiation on Plane of Array (POA) less than 200 W/m^2
- Shutdown explicitly demanded by the Owner/DISCOM/STU/CTU.
- **Note**: Minimum 24 Nos of 15-minute time blocks shall be considered to account the day for PR estimation. Otherwise the PR test shall be extended to another day.

(3) Estimation of Daily PR

- **For each reporting period (15-min time-block)** of cumulative plant generation measured at plant end ABT meter, PR shall be calculated as per the formula given in Clause no. 2.1.2
- The same shall be recorded on daily basis for each reporting period from 6:00 am to 6:00 pm as per the format provided at **Annexure-2: Sample for Daily PR Report**
- Considering minimum 24 Nos of 15-minute time blocks to account the day for PR estimation, **Daily PR shall be estimated as the average of PR calculated for 15-min time blocks falling within 99% confidence interval**.
- This exercise shall be carried out & recorded for a period as specified in Point (4) below.
- The filled-in format (Daily PR Report) shall be signed by both the parties (EPC Contractor and SECI) and each party will keep one copy for record.

(4) Final PR Calculation

- Final PR of the plant facility shall be calculated as the **average of daily PRs for 30**

consecutive days.

2.1.4.3 PR Test Pass/Fail Criterion:

The Functional Guarantee condition for the purpose of Provisional Acceptance of the Plant Facilities shall be considered to have been met if **the average of daily PRs (for 30 days*) is greater than or equal to the guaranteed Performance Ratio (PR).**

***** 30 days excluding any interruption due to rainy/cloudy day or allowable Interruptions as per this document. Interruptions due to communication breakdown only may be exempted based on specific approval to the effect that generation is not affected and equipment failure is not attributable. In such case, the test shall be extended for affected no. of days (up to 5 days)

- During the PG test, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of a breakdown, the test may be resumed once the complete system is rectified and working properly.
- If the If the EPC Contractor is not able to demonstrate guaranteed PR during this period, **two more chances shall be given** to demonstrate the same after incorporation of suitable corrective measures. In case the contractor fails to achieve guaranteed PR even after the two more chances, further action shall be taken as per the provisions of contract.

Note: The test shall be repeated for 30 days in case of any outage of following equipment (as applicable) for more than 7 days.

- Power Transformer/Inverter Duty Transformer
- Power Conditioning Unit
- HT Switchgear Panel
- SCADA and data logger combined
- Tilted pyranometer
- Other WMS sensors

3 LIQUIDATED DAMAGES FOR SHORTFALL IN PR

For every 0.01 shortfall in PR below the specified PR value, liquidated damages of 1% of the Contract Value shall be levied. In case the Plant PR Shortfall is more than 0.05 below the specified PR value, then the total plant will be accepted on “as-is basis” & no payments will be made to the contractor pertaining to ‘Operation Acceptance’ milestone in line with the defined payment terms. However, any other earlier pending/running payments as may be applicable, will be paid to the contractor as usual.

Annexure -1 (Format for Raw Data Submission)

Temporal Resolution: 1 Minute

Date & Time dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source: TVM)

Temporal Resolution: 15 Minute (Every 15th Min record from the 1 Min Data)

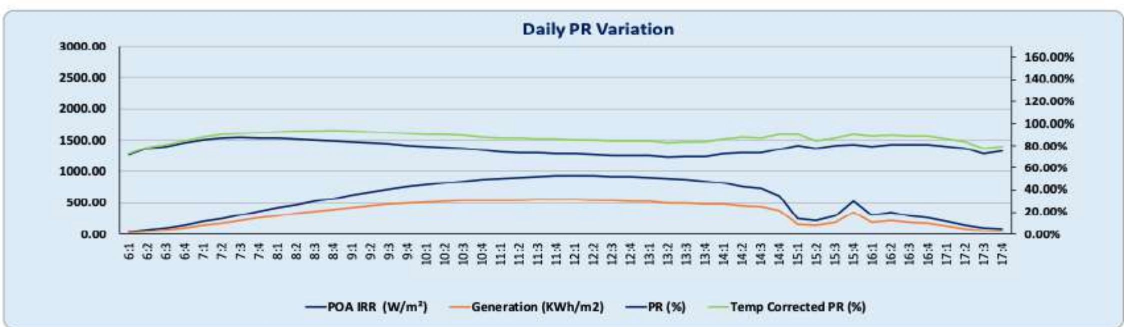
Date & Time Dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (° C)	Ambient Temp. (° C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction(°)	Generation (kWh) (Source: TVM)	Explicit Removal Flag* (0 or1)	Remarks

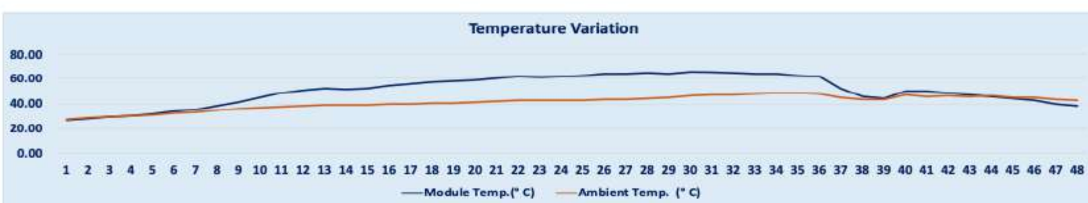
***** Explicit Removal Flag: 0 indicates time block considered; 1 indicates time block not considered.

Annexure-2 (Sample Daily-PR Report)

SPV Power Plant								PG Test Start Date	-
Date	PR	Temp corrected PR	Valid No. of Time Blocks considered (out of 48)	Avg Module Temperature	Avg POA IRR (W/m2)	Total Generation (KWh) (from 6:00 am to 6:00 pm)	Criterion	1. Time period from 6:00 AM to 6:00 PM (48 15-min Time Blocks) is con 2. Average PR (temp corrected) of 15 min time blocks where POA Irradiance is greater than 200W/m2 and not explicitly removed	
03/06/23	76.77%	87.15%	40	54.81	573.04	32718.71		3. Guranteed PR : 80 %	

Time Block	Date & Time	Humidity	Wind Speed (m/s)	Module Temp.(° C)	Ambient Temp. (° C)	POA IRR (W/m²)	POA RAD (k-Wh/m²)2	GHI (W/m²)	Cum Generation (kW-h)	Gen ABT	Scaled Generation	PR	Temp Corrected PR	Date	Explicit Removal	Flag for POA <200 W/m2	Comments
6:1	03/06/2023 06:00:00	95.89	0.48	26.70	27.25	40.80	0.0104	53.93	48.86	48.864488	24.43	72.17%	72.66%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
6:2	03/06/2023 06:15:00	91.75	0.07	28.17	28.36	69.47	0.0176	93.67	137.77	88.90599	44.45	77.57%	78.56%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
6:3	03/06/2023 06:30:00	86.78	0.55	29.41	29.53	105.33	0.0267	138.93	275.76	137.98499	68.99	79.58%	81.01%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
6:4	03/06/2023 06:45:00	84.72	0.77	30.42	30.20	151.00	0.0382	193.67	480.07	204.31882	102.16	82.38%	84.20%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
7:1	03/06/2023 07:00:00	80.69	0.87	31.78	31.16	199.67	0.0503	250.33	758.53	278.45999	139.23	85.14%	87.51%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
7:2	03/06/2023 07:15:00	76.63	0.73	33.92	32.47	249.33	0.0628	304.40	1113.87	355.33982	177.67	87.09%	90.31%	03/06/23	TRUE	FALSE	
7:3	03/06/2023 07:30:00	74.26	0.90	35.49	33.37	303.00	0.0762	358.53	1546.21	432.33266	216.17	87.29%	91.11%	03/06/23	TRUE	FALSE	
7:4	03/06/2023 07:45:00	67.05	1.39	37.86	34.43	359.27	0.0903	415.87	2056.76	510.55665	255.28	86.98%	91.70%	03/06/23	TRUE	FALSE	
8:1	03/06/2023 08:00:00	59.38	1.03	41.49	35.65	415.40	0.1043	474.20	2643.43	586.66199	293.33	86.53%	92.65%	03/06/23	TRUE	FALSE	
8:2	03/06/2023 08:15:00	52.85	1.83	45.13	36.73	468.87	0.1176	529.47	3299.72	656.29699	328.15	85.83%	93.34%	03/06/23	TRUE	FALSE	
8:3	03/06/2023 08:30:00	49.11	1.68	48.43	37.79	520.73	0.1306	582.00	4020.24	720.51816	360.26	84.85%	93.63%	03/06/23	TRUE	FALSE	
8:4	03/06/2023 08:45:00	44.38	2.29	50.74	38.50	572.47	0.1435	632.93	4804.83	784.59082	392.30	84.11%	93.77%	03/06/23	TRUE	FALSE	
9:1	03/06/2023 09:00:00	41.76	2.54	52.16	39.10	620.47	0.1555	679.27	5646.61	841.77632	420.89	83.28%	93.41%	03/06/23	TRUE	FALSE	
9:2	03/06/2023 09:15:00	40.55	4.05	51.82	38.87	669.87	0.1679	725.67	6549.93	903.32567	451.66	82.80%	92.75%	03/06/23	TRUE	FALSE	
9:3	03/06/2023 09:30:00	39.99	3.41	52.56	39.19	715.27	0.1792	767.80	7499.37	949.43499	474.72	81.52%	91.62%	03/06/23	TRUE	FALSE	
9:4	03/06/2023 09:45:00	38.73	3.49	54.55	39.67	757.40	0.1897	805.67	8485.80	986.42998	493.21	80.01%	90.73%	03/06/23	TRUE	FALSE	
10:1	03/06/2023 10:00:00	38.57	3.65	55.64	39.91	792.47	0.1984	836.80	9505.12	1019.3182	509.66	79.05%	90.09%	03/06/23	TRUE	FALSE	
10:2	03/06/2023 10:15:00	37.93	3.45	57.07	40.46	820.87	0.2055	861.73	10549.49	1044.3768	522.19	78.20%	89.71%	03/06/23	TRUE	FALSE	
10:3	03/06/2023 10:30:00	37.61	3.93	57.89	40.60	846.67	0.2119	884.80	11613.24	1063.7515	531.88	77.25%	88.95%	03/06/23	TRUE	FALSE	
10:4	03/06/2023 10:45:00	36.27	3.19	59.07	41.27	867.93	0.2171	904.27	12680.44	1067.1957	533.60	75.63%	87.56%	03/06/23	FALSE	FALSE	
11:1	03/06/2023 11:00:00	33.92	3.00	60.34	41.89	887.00	0.2219	920.07	13753.89	1073.4476	536.72	74.43%	86.69%	03/06/23	FALSE	FALSE	
11:2	03/06/2023 11:15:00	32.28	3.12	61.58	42.26	903.13	0.2260	932.60	14838.29	1084.3995	542.20	73.83%	86.48%	03/06/23	FALSE	FALSE	
11:3	03/06/2023 11:30:00	30.53	3.63	61.13	42.43	916.07	0.2291	935.73	15931.49	1093.1985	546.60	73.41%	85.81%	03/06/23	TRUE	FALSE	
11:4	03/06/2023 11:45:00	29.64	3.03	61.88	42.77	927.73	0.2320	945.67	17033.21	1101.7213	550.86	73.07%	85.72%	03/06/23	TRUE	FALSE	
12:1	03/06/2023 12:00:00	28.59	3.60	62.34	42.92	932.93	0.2334	946.47	18131.91	1098.7028	549.35	72.43%	85.15%	03/06/23	TRUE	FALSE	
12:2	03/06/2023 12:15:00	28.19	2.63	63.76	43.63	931.53	0.2328	947.47	19216.36	1084.4462	542.22	71.66%	84.81%	03/06/23	TRUE	FALSE	
12:3	03/06/2023 12:30:00	27.93	2.67	64.24	43.42	923.80	0.2309	937.00	20282.07	1065.717	532.86	71.01%	84.23%	03/06/23	TRUE	FALSE	
12:4	03/06/2023 12:45:00	27.50	2.84	64.46	43.81	917.13	0.2292	926.87	21338.36	1056.2852	528.14	70.90%	84.19%	03/06/23	TRUE	FALSE	
13:1	03/06/2023 13:00:00	26.58	2.51	64.25	44.78	903.67	0.2257	909.73	22377.62	1039.265	519.63	70.83%	84.02%	03/06/23	TRUE	FALSE	
13:2	03/06/2023 13:15:00	25.43	1.87	65.22	46.47	886.80	0.2216	889.53	23380.47	1002.8472	501.42	69.64%	82.99%	03/06/23	TRUE	FALSE	
13:3	03/06/2023 13:30:00	24.70	1.92	65.29	47.12	867.87	0.2168	868.07	24368.03	987.56266	493.78	70.08%	83.54%	03/06/23	TRUE	FALSE	
13:4	03/06/2023 13:45:00	24.78	2.01	64.69	47.11	847.33	0.2117	845.00	25337.71	969.67798	484.84	70.48%	83.78%	03/06/23	TRUE	FALSE	
14:1	03/06/2023 14:00:00	23.28	1.75	63.95	47.59	817.87	0.2021	813.60	26293.31	955.59632	477.80	72.75%	86.18%	03/06/23	FALSE	FALSE	
14:2	03/06/2023 14:15:00	22.54	1.81	64.01	48.47	752.20	0.1897	763.60	27201.72	908.41583	454.21	73.68%	87.31%	03/06/23	FALSE	FALSE	
14:3	03/06/2023 14:30:00	22.63	1.35	62.69	48.45	727.80	0.1816	725.00	28071.84	870.11766	435.06	73.70%	86.78%	03/06/23	FALSE	FALSE	
14:4	03/06/2023 14:45:00	21.79	1.90	61.46	47.88	615.27	0.1496	614.33	28820.61	748.77165	374.39	77.01%	90.15%	03/06/23	TRUE	FALSE	
15:1	03/06/2023 15:00:00	23.19	1.24	51.98	44.87	245.40	0.0613	258.40	29141.19	320.58199	160.29	80.50%	90.24%	03/06/23	TRUE	FALSE	
15:2	03/06/2023 15:15:00	25.40	1.69	45.63	43.02	219.73	0.0550	217.00	29417.98	276.78165	138.39	77.40%	84.36%	03/06/23	TRUE	FALSE	
15:3	03/06/2023 15:30:00	25.75	1.64	44.08	43.21	289.07	0.0749	291.80	29807.40	389.42049	194.71	79.99%	86.60%	03/06/23	FALSE	FALSE	
15:4	03/06/2023 15:45:00	23.97	1.47	49.73	47.23	521.73	0.1304	512.87	30493.75	686.35149	343.18	80.96%	89.85%	03/06/23	TRUE	FALSE	
16:1	03/06/2023 16:00:00	24.38	1.39	50.12	45.49	299.73	0.0743	294.93	30876.56	382.80898	191.40	79.26%	88.11%	03/06/23	FALSE	FALSE	
16:2	03/06/2023 16:15:00	23.92	1.03	48.38	46.33	343.53	0.0849	335.27	31323.22	446.66715	223.33	80.96%	89.31%	03/06/23	TRUE	FALSE	
16:3	03/06/2023 16:30:00	23.79	1.42	46.76	45.77	289.40	0.0721	287.73	31701.29	378.06216	189.03	80.70%	88.39%	03/06/23	FALSE	FALSE	
16:4	03/06/2023 16:45:00	23.65	1.11	45.91	46.01	260.53	0.0647	256.33	32041.65	340.35866	170.18	80.92%	88.31%	03/06/23	FALSE	FALSE	
17:1	03/06/2023 17:00:00	23.53	1.12	44.35	45.17	208.73	0.0517	207.00	32309.09	267.44699	133.72	79.57%	86.25%	03/06/23	FALSE	FALSE	
17:2	03/06/2023 17:15:00	23.64	1.03	42.25	44.59	151.27	0.0373	150.67	32497.32	188.22849	94.11	77.71%	83.46%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
17:3	03/06/2023 17:30:00	25.35	0.84	39.84	43.49	103.07	0.0256	103.60	32618.57	121.24699	60.62	72.82%	77.41%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
17:4	03/06/2023 17:45:00	26.49	1.11	38.09	42.43	83.13	0.0205	84.53	32718.71	100.14316	50.07	75.00%	79.14%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2





Annexure – B

Mandatory Spares

S. No.	Equipment/Material	Quantity (For each type and rating)
1	MC4 compatible connectors (including Y-connector if used)	1% of total supply
2	String Combiner Box / String Isolator Box	0.5% of total supply
3	Power Conditioning Unit	
	(i) Central Inverter	One set of spares for each type / rating of inverter subject to a minimum of spares corresponding to 10% of each type / rating of inverter rounded off to the next higher integer for the following items - IGBT modules for one complete inverter - AC and DC fuses - air filters - cooling fans - electronic cards of each type - harmonic filter units - digital display units - switches, push buttons and indication lamps - diodes of each type & rating - resistors of each type & rating
	(ii) String Inverter (if applicable)	0.5% of total supply
4	Inverter Transformer	
	(i) HV bushing with metal parts and gaskets	2 set
	(ii) LV bushing with metal parts and gaskets	2 set
	(iii) WTI with contacts	2 set
	(iv) OTI with contacts	2 set
	(v) Buchholz relay	2 set
	(vi) Magnetic Oil Gauge	2 set
	(vii) Breather assembly	2 set
	(viii) Complete set of gaskets & valves	2 set
	(ix) Tap Changer Contact Assembly	2 set
5	Power Transformer	

S. No.	Equipment/Material	Quantity (For each type and rating)
	(i) HV bushing with metal parts and gaskets	1 set
	(ii) LV bushing with metal parts and gaskets	1 set
	(iii) WTI with contacts	1 set
	(iv) OTI with contacts	1 set
	(v) Buchholz relay	1 set
	(vi) Magnetic Oil Gauge	1 set
	(vii) Breather assembly of Main tank	1 set
	(viii) Cooler Fan with motor, Contactor, Relay and MCB	1 set
	(ix) Insulating Oil	10%
	(x) Complete set of gaskets & valves	1 set
	(xi) Tap Changer Contact Assembly Spares	1 set
	(xii) Pressure release device	1 set
6	33 kV Circuit breaker / switchgear assembly	
	(i) Circuit breaker pole	2 nos.
	(ii) Contact assembly (for indoor panels)/ Contact flange (for outdoor CB)	Suitable for one 3-phase CB
	(iii) Closing coil	2 nos.
	(iv) Tripping coil	2 nos.
	(v) Spring charging motor	2 nos.
	(vi) Relay (each type)	2 nos.
	(vii) Meter (each type)	2 nos.
	(viii) Current Transformer	2 nos.
	(ix) MCCB	2 nos.
	(x) MCB	2 nos.
	(xi) Fuse	10% of total supply
	(xii) Indicating lamp	10% of total supply
	(xiii) Rotary switch	10% of total supply
7	33 kV outdoor disconnector	
	One pole (metallics & insulators)	2 sets
	Fixed and moving contact assembly	4 sets

S. No.	Equipment/Material	Quantity (For each type and rating)
	Drive mechanism box	1 set
	Relays, contactors, switches and push buttons	Two of each type
8	33KV LA, CT & VT (indoor and outdoor)	One of each type together with terminal connectors
9	Control and Relay Panel	
	(i) Relay (each type)	1 no.
	(ii) Meter	1 no.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Indicating lamp	10% of total supply
	(vi) Rotary switch	10% of total supply
	(vii) BCU	1 no.
10	LT Switchgear	
	(i) ACB	1 no.
	(ii) MCCB	2 nos.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Relay	2 nos.
	(vi) Meter	2 nos.
	(vii) Current Transformer	2 nos.
	(viii) Voltage Transformer	2 nos.
	(ix) Contact Assembly	2 sets
	(x) Indicating lamp	10% of total supply
	(xi) Rotary switch	10% of total supply
11	DC Cable	1 Drum
12	AC Cable	1 Drum
13	Communication Cable	1 Drum
14	Control Cable	1 Drum
15	Fuse	10% of total supply
16	33 kV Internal Transmission Line (if applicable)	

S. No.	Equipment/Material	Quantity (For each type and rating)
	(i) Line supports, MS Angle, Back Clamp, Top Clamp, Earthing Coil, Insulators	2 set
	(ii) Conductor	1 km
	(iii) Jointing Sleeves, Stay set complete with turn buckles, stay wire, stay insulators, Anti-climbing Devices, Danger Boards	2 set
17	220 kV Solar Park/Pooling Substation Equipment	
	(i) SF6 Circuit Breaker	
	(a) One complete pole of Circuit Breaker, pole column, Interrupter, with driving mechanism Box and MB but without support structure	1 no.
	(b) Grading capacitors (if applicable)	1 no.
	(c) Rubber gaskets, O rings and seals for SF6 gas (complete replacement for one breaker)	1 set
	(d) Trip coils with resistor	2 nos.
	(e) Closing coils with resistor	1 no.
	(f) Molecular filter for SF6 Circuit for 1 Pole of CB	2 nos.
	(g) Terminal pads and connectors	2 nos.
	(h) Corona rings	1 no.
	(i) Relays, power contactors, switch-fuse units, limit switches, push buttons, timers and MCBs etc.	1 set
	(j) Pressure switches	1 set
	(k) Auxiliary Switch Assembly	1 set
	(l) SF6 gas	1 complete fill for at least two CBs
	(ii) Disconnector	
	(a) One complete pole of disconnector including support insulator with 1 E/S with motor operating mechanism for main isolator and earth switch (excluding structure)	1 no.
	(b) Copper contact fingers for female & male contacts	2 set

S. No.	Equipment/Material	Quantity (For each type and rating)
	(c) Open/Close Contactor Assembly, Timer, Key Interlock push button switch & auxiliary switches	1 set
	(d) Limit switch	2 nos.
	(e) Terminal pads & Connectors	3 nos.
	(f) Corona shielding ring	3 nos.
	(iii) Surge Arrester	1 no.
	(a) Complete surge arrester excluding support structure	1 no.
	(b) Surge counter / monitor	5 nos.
	(iv) Current Transformer (excluding support structure / common JB)	1 no.
	(v) Voltage Transformer (excluding support structure / common JB)	1 no.
	(vi) Bus Post Insulator	3 nos.
	(vii) Conductor	200 m of each type
	(viii) Erection Hardware Items (Insulator strings & Hardware, Clamps & Connectors)	3 nos. of each type
	(ix) Terminal Clamps	1 set
	(x) Lugs	20 of each type
	(xi) Heat shrinkable Termination and Jointing kits	5% of Total quantity used
18	220 kV Transmission Line	
	(i) Steel Tower - Transmission towers including body and leg extensions (complete) including stubs and hangers, cleats, Galvanized Steel Sections (for replacement), nuts and bolts	15% of each member / component used in each type of tower
	(ii) Conductor Joint Sleeve, Earth Wire Joints, Armor Rods, Suspension insulator string with fittings and clamp, Tension insulator string with fittings and clamp	2 set
	(iii) Conductor, Earth Wire and OPGW	1 km each

Spares, if used, during the O&M period shall be replenished by the Contractor. All the mandatory spares shall be handed over to the Employer in working condition at the end of O&M period along with list of utilized items and replaced items.

Annexure – C

Plant Documentation, Commissioning and Test Procedure

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1 INTRODUCTION

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

2 CODES AND STANDARDS

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

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

3 COMMISSIONING

3.1 GENERAL

3.1.1 Objective

The Commissioning Procedure defined in this document aims to:

- Verify that the power plant is structurally and electrically safe
- Verify that the power plant is structurally and electrically robust to operate for the

specified lifetime of a project

- Verify that the power plant operates as designed and its performance is as expected

3.1.2 General Requirements before Starting the Commissioning Process

- The modules shall be stabilized (sufficiently exposed after 200 kWh/m² reaching the PV plane)
- The tests shall be conducted under stable weather conditions
- The process shall be witnessed by the Owner or their duly appointed representative.
- Soiling losses shall not be accounted for in the assessment of Results. Therefore, adequate Module cleaning exercise shall be undertaken prior to commencement of Commissioning process.

- The following equipment shall be used during the commissioning process (Refer Section VII B:Technical Specifications for testing instruments):
  - Earth resistance tester
  - IV curve tracer
  - Insulation tester
  - Digital multi-meter
  - Clamp meter
  - Infrared camera
  - Digital lux meter
  - Electroluminescence camera, power supply and accessories
- All testing equipment shall possess valid calibration certificate issued from approved laboratories.

4 Cold Commissioning

4.1 DC COMMISSIONING

4.1.1 Visual Inspection

The visual inspection shall be conducted on 5% of the system split in subareas equally distributed in the field. Unless otherwise specified, Approved Cat I Drawings shall be referred for correctness/verification. At least following aspects shall be verified visually on the DC side:

- Sizing of the DC fuses for running conditions, for the maximum voltage and the maximum current.
- Sizing of the string cables including overcurrent protection considering the current carrying capacity under operating conditions
- Cables protected against mechanical damage
- Functionality of the main DC switch
- Fixation of the modules to the mounting structure
- Termination of the cables to the inverter
- Where the PV system includes functional earthing of one of the DC conductors, the functional earth connection shall be specified and installed to the requirements of IEC 62548.
- Laying and installation of cables
- Fixation of the grounding electrodes
- Grounding of all conductive parts and connected to the equipotential bonding system of the PV plant
- The torque values in the mounting structure, combiner boxes, bars and joints shall match the manufacturer specifications
- Where protective earthing and/or equipotential bonding conductors are installed, they shall be parallel to and bundled with the DC cables
- Electrical circuits and devices shall be labelled.
- The PV modules shall be in a good condition (no visible serial defects such as yellowing, delamination, scratches, etc.).
- Functioning of fire protection equipment.

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. All items shall be categorized as “critical”, “important” or “minor”.

4.1.2 Pre-Energizing Tests

4.1.2.1 Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the DC circuit forming the PV array in accordance with a Sampling Plan:

- Electrical Continuity test: This test shall be performed on the earthing and/or equipotential bonding conductors, in the PV array field. Connection of such conductors to earthing pit shall also be verified.

- Polarity test: Polarity of DC cables shall be verified. After verifying the correctness of polarity, marking on cable shall be checked for correctness

  Note: Polarity test shall be performed before closing the switches or string overcurrent protective devices are inserted

- Combiner box test: The purpose of this test is to ensure all strings are connected correctly to the combiner box. The test procedure is as follows and shall be performed before any string fuses / connectors are inserted for the first time:

i) Select a volt meter with voltage range at least twice the maximum system voltage.

ii) Insert all negative fuses / connectors so strings share a common negative bus.

iii) Do not insert any positive fuses / connectors.

iv) Measure the open circuit voltage of the first string, positive to negative, and ensure it is an expected value.

v) Leave one lead on the positive pole of the first string tested, and put the other lead on the positive pole of the next string. Because the two strings share a common negative reference, the voltage measured should be near-zero, with an acceptable tolerance range of ±15 V.

vi) Continue measurements on subsequent strings, using the first positive circuit as the meter common connection.

vii) A reverse polarity condition will be very evident if it exists – the measured voltage will be twice the system voltage.

- String open circuit voltage test, V_{oc} (under stable weather conditions): The purpose of this test is check the modules connection in string as per the design. The V_{oc} of PV string should be measured using suitable measuring device before closing any switch or string overcurrent protective devices, where fitted.

The measured string V_{oc} will be assessed to ensure it matches the expected value (typically within 5 %) in one of the following ways:

a) Compare with the expected value derived from the module datasheet or from a detailed PV model that takes into account the type and number of modules and the module cell temperature.

b) Measure V_{oc} on a single module, then use this value to calculate the expected value for the string.

c) For systems with multiple identical strings, voltages between strings can be compared.

- String circuit current test, Isc (under stable weather conditions): The purpose of this test to check the correctness of system, operational characteristic and PV array wiring. These tests are not to be taken as a measure of module / array performance. The test procedure will be as follows:

i) Ensure that all switching devices and disconnecting means are open and that all PV strings are isolated from each other.

ii) Create a temporary short circuit into string under test by using any of the following method:

(a) use of a test instrument with a short circuit current measurement function (e.g., a specialized PV tester);

(b) a short circuit cable temporarily connected into a load break switching device already present in the string circuit;

(c) use of a "short circuit switch test box" – a load break rated device that can be temporarily introduced into the circuit to create a switched short circuit.

iii) Measure the short circuit current (Isc) using a suitably rated measuring instrument.

iv) After taking the reading, interrupt the short circuit using a suitable load break switching device and check the zero value of current before changing any other connections.

v) Compare the measure value of Isc with the expected value. For systems with multiple identical strings, measurements of currents in individual strings shall be compared. These values should be the same (typically within 5 % of the average string current). Note: An I-V curve test can be performed as an alternative to this test (see 4.3).

- Functional tests: The following functional tests shall be performed:

i) Switchgear and other control apparatus shall be tested to ensure correct operation and that they are properly mounted and connected.

ii) All inverters forming part of the PV system shall be tested to ensure correct operation. The test procedure should be as defined by the inverter manufacturer.

Functional tests that require the AC supply to be present (e.g., inverter tests) shall only be performed once the AC side of the system has been tested.

- Insulation resistance of the DC circuits: Test procedure to conduct this test will be as follows:

i) Before commencing the test adopt the following safety measure to avoid any potential shock hazard

(a) Isolate the testing area.

(b) Do not touch any metallic surface, module back sheet or the module terminals when performing the insulation test.

(c) Appropriate personal protective clothing / equipment should be worn for the duration of the test.

ii) Isolate the PV array from the inverter (typically at the array switch disconnector)

iii) Disconnect any piece of equipment that could have impact on the insulation measurement (i.e. overvoltage protection) in the junction or combiner boxes.

iv) The insulation resistance test device shall be connected between earth and the array cable(s) or combiner bus bar. Connections can be made between earth and array negative followed by a test between earth and array positive or between earth and short circuited array positive and negative.

v) Follow the IR test device instructions to ensure the test voltage and readings in megaohms. When the system voltage (Voc at STC X 1.25) is higher than 500V, the test voltage shall be 1,000V and the minimum insulation resistance 1 MΩ.

vi) Ensure the system is de-energized before removing test cables or touching any conductive parts.

4.1.2.2 Sampling Plan:

At least 2 strings from 2 SMUs shall be randomly chosen by the Owner connected to each Inverter.

Acceptance criteria

The DC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 62446:2016 – 6.

4.2 AC COMMISSIONING

4.2.1 Visual Inspection

The visual inspection shall be conducted on 5% of the system. In general, the requirements specified in the IEC 60364-6 -6.4.2 apply. At least following aspects shall be verified visually on the AC side:

4.2.1.1 General requirements

- Protective requirements against electric shock
- Protection against fire and heat
- Choice, setting, selectivity and coordination of protective and monitoring devices
- Sizing of cables regarding voltage drop and ampacity as per approved Drawings.
- Sizing of protective and monitoring devices as per approved Drawings
- The circuit breakers are correctly located
- Selection, location and installation of suitable isolating, overvoltage protective devices and switching
- The equipment and protective measures are appropriate for the external influences and mechanical stresses
- The diagrams, warning notices or similar information attached to the wall inside the inverter housing or the control room
- Proper fixation of the cables to the collector bars in the AC combiner box
- Proper labelling of all electrical circuits and devices including the neutral conductor and protective conductor as well as correct connection of single pole devices to the phase conductors
- Adequacy of termination and connection of cables and conductors
- The warning labels and technical documentation physically displayed
- Selection and installation of earthing arrangements, protective conductors and their

connections

- The existence and correct use of protective conductors and protective equipotential bonding conductors (PEB)
- Measures against electromagnetic disturbances implemented
- Easy access to the operational devices for maintenance
- Any exposed conductive parts connected to the earthing system
- The RCD type has been selected according to the requirements of the IEC 62548
- The isolation means of the inverter on the AC side are functional and correctly sized
- The fire protection requirements according to the approved design shall be given

4.2.1.2 Requirements for the inverter

- Installation as per manufacturer's instructions and compliance with IEC 62548
- Inverters properly fastened to the ground
- Inverter properly earthed
- Inverter incoming/outgoing cables properly isolated, labelled and connected
- The connections for phase sequence L1, L2, L3 and N in the correct order
- All cable terminations properly done
- Nameplate data. The minimum requirements for the production of a name plate are –
    - name and origin of the manufacturer; –
    - model or type name;
    - serial number;
    - electrical parameters: Vdcmax, Vmppmin, Vmppmax, Idcmax, Pac,r, Vac,r, f r , Iacmax;
    - degree of protection;
    - overvoltage category;
    - safety class.
- The displays - check / readout show plausible results
- The filters are clean and properly maintained
- The cooling outputs of the inverters are free from obstruction
- The DC circuit breaker is functional
- The DC insulation monitoring correctly installed
- The fuses at the DC entrance correctly sized

- The location of the inverter(s) in the field matches the approved design
- Protection against self-loosening of clamps and screws
- The string inverter anchored to the mounting structure
- The mechanical assembly is robust
- The inverters are fixed to non-flammable mechanical elements

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as “critical”, “important” or “minor”.

4.2.2 Pre-Energizing Tests

Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the AC circuit forming the PV array:

- Continuity of conductors. The requirements in IEC 60364-6:2016 – 6.4.3.2 apply
- Insulation resistance of the electrical installation. The requirements in IEC 60364-6:2016 – 6.4.3.3 apply
- Insulation resistance testing to confirm the effectiveness of protection by SELV, PELV or electrical separation. The requirements in IEC 60364-6:2016 – 6.4.3.4 apply
- Insulation resistance/impedance of floors and walls. The requirements in IEC 60364-6:2016 - 6.4.3.5 apply
- Polarity test. The requirements in IEC 60364-6:2016 - 6.4.3.6 apply
- Testing to confirm effectiveness of automatic disconnection of supply. The requirements of the IEC 60364-6:2016 – 6.4.3.7 apply
- Testing to confirm the effectiveness of additional protection. The requirements of the IEC 60364-6:2016 – 6.4.3.8 apply.
- Test of phase sequence. The requirements of the IEC 60364-6:2016 – 6.4.3.9 apply
- Functional tests. The requirements of the IEC 60364-6:2016 – 6.4.3.10 apply
- Voltage-drop. The requirements of the IEC 60364-6:2016 – 6.4.3.11 apply

Acceptance criteria

The AC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 60364 – 6.

4.2.3 Additional Pre-Energizing Tests

All of the below tests shall be conducted in accordance with the supplier's installation/commissioning manuals.

4.2.3.1 Distribution boards and combiner boxes

Site testing on distribution boards shall include:

- Mechanical functional test of all components including mechanical interlocks
- Electrical functional test of all control and protection wiring against the approved switchgear schematics
- Power frequency overvoltage test (flash test) on the switchgear including circuit-breakers in the test circuit
- Low resistance duct or test on the switchgear including circuit-breakers in the test circuit
- Visual inspection
- Verification of earthing

4.2.3.2 Inverters

Site testing on inverters shall include:

- Full test procedure as defined by the inverter manufacturer
- A full mechanical functional test of all components including mechanical interlocks
- Verification that the inverter operational parameters have been programmed to local regulations
- Electrical functional test of all control and protection wiring against the approved switchgear schematics as per approved MQP/FQP
- Insulation resistance test and earth residual current monitoring test
- Anti-islanding functionality
- High Voltage overvoltage test
- SCADA and metering calibration & functionality test

4.2.3.3 HT Switchgear

Site testing on outdoor circuit-breakers shall include:

- Functional check of all wiring, interlocks, auxiliaries and pressure devices
- Timing test and travel curve
- Visual inspection

4.2.3.4 LV/MV transformers

Transformer commissioning shall include:

- Visual inspection, alignment, earthing and labelling
- Functional check of all wiring against the approved transformer schematics
- Testing and calibration of all transformer protection and monitoring devices
- Insulation resistance test
- Functional test of off-circuit/on Circuit tap changer and check of the continuity of all windings

4.2.3.5 Substation/Power Transformers

- Ratio measurement on all tap changer settings
- Winding resistance measurement on highest, lowest and nominal tap settings
- Insulation resistance between all windings, and each winding to earth
- Insulation resistance core-to-earth
- Oil sample tests: breakdown strength, moisture content, and dissolved-gas content
- Transformer differential protection scheme testing

Acceptance criteria

The test results shall be aligned with the manufacturer specifications stated in the installation manual.

4.3 IV CURVE TESTING

The requirements of the IEC 62446-1:2016 – 7.2 apply. Following normative references shall be considered while performing the IV curve test:

- IEC 61829:2015 Photovoltaic (PV) array - On-site measurement of current-voltage characteristics
- IEC 60891:2009 Photovoltaic devices - Procedures for temperature and irradiance

corrections to measured I-V characteristics

2 % of the module strings shall be measured. If $\Delta P_{stringN}$>5%, all the modules within that string shall be I-V characterized. Modules with ΔP_N>5% shall be replaced. If more than 5% of the measured strings of the first sample show ΔP_N>5%, another 2% shall be inspected. If more than 5% of the measured strings in the second sample show ΔP_N>5%, another 5% shall be inspected. If more than 5% of the measured strings in the third sample show ΔP_N>5%, another 10% shall be inspected. If more than 5% of the measured strings in the fourth sample show ΔP_N>5%, another 10% shall be inspected. The reference power value is the flash list value minus the light induced degradation (LID) value in the datasheet/module warranty.

Acceptance criteria

The power determination analysis will be passed when less than 5% of the modules measured in the last sample show ΔP_N<5%.

5 Hot Commissioning

5.1 INFRARED INSPECTION

Following normative references apply:

- PV array infrared camera inspection procedure **(**IEC 62446-1:2016 - 7.3) and IEC 62446-3 TS Ed.1.0 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 3: Outdoor infrared thermography of photovoltaic modules and plants (draft)
- The infrared inspection shall be applied both to the PV modules and the BOS components

The inspection sample will depend on the project size and shall be agreed with the OWNER. The following values serve as an orientation:

- Large scale ground mounted PV plants
  - PV modules: 100%
  - Inverters: 100%
  - Combiner boxes: 100%

Acceptance criteria

The following conditions shall be met simultaneously:

- 0.2% or less of the inspected modules show thermal gradients at the cell level of T > 10 K
- 0.2% or less of the inspected modules show thermal gradients at the junction box level of T > 10 K
- 0.2% or less of the inspected modules show inactive cell strings
- No PID is detected
- All module strings are connected and producing
- All inverters are connected and producing

5.2 INVERTER AVAILABILITY TEST

5.2.1 Calculation of the Operation Time

It shall be calculated on inverter level. The operation time starts as soon as the inverter switches on. Therefore, only the logged irradiation values during the operation time of the inverter shall be considered. Irradiation values logged before or after the inverter running time shall be disregarded.

5.2.2 Calculation of the Downtime

The downtime relevant for the availability calculation is any time in which a part or a subpart of the system is not operational. The outage periods shall be considered again on inverter level. Only complete outages shall be taken into consideration. System black-out periods due to following reasons shall not flow into the calculation (i.e., excluded events):

- A failure in the distribution grid or the transformer substation, making it impossible to transmit the generated power
- Solar radiation below the level needed to obtain the minimum operating voltage to start the inverter operation
- Causes of Force Majeure.
- Occurrences of anomalies in the power supply system (frequency differences or voltage surges) that trigger the protective systems of the plant or the limit settings of the inverter

Any forced disconnection shall be documented and recorded.

Acceptance criteria

The system availability shall be at least 99% during the testing period.

5.3 SINGLE AXIS TRACKER AVAILABILITY TEST (IF APPLICABLE)

The tracker availability test shall be carried out in parallel to the inverter availability test and shall have the same duration. During the test, all trackers shall follow the sun according to the angles established in the tracking mechanism. A loss of availability shall be considered when the angle of inclination of one or more trackers deviates by more than 2° from the theoretical angle. The angles of inclination of each tracker shall be recorded with a resolution of 1min via the SCADA system.

Acceptance criteria

The tilt angle of each tracker shall lie within a ±2° range during 99.5% of the operational time.

5.4 SCADA AND WEATHER STATION RELIABILITY

5.4.1 Visual Inspection

- Installation of the communication system architecture diagram according to the specifications
- Functional Tests conducted during FAT for Pre-Dispatch Inspection shall be repeated.
- SCADA shall be linked to all protection relays, disturbance recorders and other substation equipment using the communications protocol
- Visual check on the assembly of all joints and on the as-installed condition of all components, including:
    - The irradiation sensor is not shaded and is installed at the correct tilt angle and under CCTV coverage.
    - Ambient temperature and module temperature sensor are installed properly (Reference IEC 61724)
    - Mechanical anchorage of the sensors is robust
- Complete calibration certificates of all the instruments shall be provided

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as “critical”, “important” or “minor”.

6 Battery Energy Storage System (if applicable)

6.1 VISUAL INSPECTION

Before energizing the BESS, following visual checks shall be made to check the required design compliance:

- Installation of protective cover for live, hot and cold parts, and the adequate distance from the person;
- Installation of fence, wall, locking system of doors and access panels, and notice boards
- Installation of ventilation system;
- Installation of firefighting system;
- Installation of lightning protections devices.
- Wiring
  - All wiring shall be continuous and without splices.
  - Wiring that may be exposed to mechanical damage are placed in conduit or armoured.
  - Wires have permanent and durable identifying labels or markings on both ends.
  - Control and instrumentation wiring shall be separated from power and high-voltage wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips.
  - BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner.
  - Cable systems do not block access to equipment by personnel. There are no exposed current-carrying or voltage-bearing parts.

6.2 CONTINUITY TEST

Continuity of power, control and auxiliary circuit in the system shall be verified through visual inspection, continuity tester and insulation resistance test.

Phase sequence and terminal marking shall also be verified with drawing and design documents.

6.3 EARTHING TEST

Following element to be check according to the design and applicable standards:

- Proper connection of the earthing busbar to the local earthing busbar;
- Individual earthing connection of main equipment to the earthing busbar;
- Connection of earthing cables to structures via proper connectors to prevent corrosion from dissimilar metals.

6.4 INSULATION TEST

For low-voltage EES systems, the insulation resistance test and withstand voltage test shall be performed according to IEC 60364-6.

For EES systems exceeding 1 kV AC or 1,5 kV DC, the withstand voltage test shall be performed according to IEC 61936-1.

6.5 FUNCTIONAL TEST

6.5.1 Start and stop test

Check start and stop operation of BESS system with the startup/shutdown command manually and automatically.

6.5.2 Alarms Functional Test

Alarms initiation from the BESS in case of following conditions:

- Emergency trip switch.
- Loss of the low-voltage AC or utility grid voltage.
- An AC circuit breaker trip (either side of transformer).
- Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
- Smoke/fire alarm.
- Control logic trouble.
- A DC ground fault (simulated).
- Remote disable (no reset required).
- grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
- Abnormal voltage
- Islanding condition.
- Protection or control scheme failures, including the following:
  - Failure of local interconnection protection system
  - Failure of critical breaker trip coil or interrupting device
  - Loss of DC supply

6.5.3 Load tripping test

Check the interlock of BESS with the main

6.5.4 Operating cycle test

Check for any abnormalities such as rise in temperature, noise level and vibration in ESS system during rated input and output power operation.

6.5.5 Storage Settings

Verification of settings/control points and provision for modification of various set points and fixed operation/control settings associated with the various control functions.

Operator Controls:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.
- Reset cut-out selector switch to disable remote or local reset signals.
- A selector switch to manually set the operating state (that is, the shutdown, disconnect, or operate state) and to have the control system set the operating state automatically.
- A selector switch to manually set the operating mode and to have the control system set the operating mode automatically.

6.5.6 Communication test

Verified that measuring, alarm, fault indication, message and control and monitoring system operations are correct transmitted and received by the SCADA system.

6.6 SYSTEM RATING VERIFICATION

BESS rating including rated power, energy available at rated power, and the performance of the BESS associated with different performance metrics mentioned herein taken at the beginning of life shall be based on a set of ambient operating conditions specified by the BESS Original Equipment Manufacturer (OEM) for the Project site. The Contractor shall also provide an indication of how the performance of the BESS with respect to the metrics is expected to change over time, to account for time and use of the system, and report the same periodically.

An energy capacity test shall be performed at the time of Commissioning, in accordance with procedure mentioned below and is intended to be used to determine the dispatchable energy capacity of the BESS at the time of commencement of Operation. In conducting the energy capacity test, the Contractor shall provide a detailed and documented charging procedure within the specifications of the BESS. The energy capacity tests conducted on the BESS shall be documented to allow for tracking performance degradation.

Available/Dispatchable/Throughput energy shall be tested in accordance with the following procedure under the standard testing conditions specified in IEC 62933-2-1 (Cl. 5.1.3):

Measurement:

System shall be charged to the full available energy level. Subsequently, the BESS (appropriate modular sub-unit thereof) shall be discharged and charged at rated power between the lower and upper SOC* limit (as recommended by the OEM for current application). Power during charge and discharge shall be recorded at regular intervals of time documented by the OEM to provide a statistically valid resolution. The associated energy input (Ei), including all BESS functional, parasitic and auxiliary consumption and energy output (Eo) of the BESS shall be calculated from the recorded power. Discharged energy should be recorded as per the readings in the ABT Meter(s) at the point of interconnection of the BESS with the Solar PV array,

** SOC recorded, shall be as reported by the Battery Management System.*

The above process shall be repeated multiple times, with minimum rest period between charging and discharging, if so recommended, so as to record data for a specified no. of cycles (n). The reference performance test value for stored energy shall be calculated as the mean of the values of Eo and Ei as measured for discharge and charge respectively.

The procedure shall be repeated (one cycle each) with power levels at 75%, 50%, and 25% of rated power and documented.

Criterion: BESS stored Energy capacity shall be at least total energy dispatchable as specified in the Section V: Technical Specifications at rated Power at the time of commissioning.

2. Round-trip energy efficiency (RtE, η) shall be determined as a function of the charge and discharge power and calculated using the following formula:

$$\eta_p = \frac{\sum Eo}{\sum Ei}$$

where,

$\sum Ei$ is the sum of Energy input to the BESS over n cycles

$\sum Eo$ is the sum of Energy output from the BESS over n cycles η_p is the Round Trip Efficiency at charge/discharge Power, P (expressed as a percentage of rated power)

Eo and Ei shall be determined as per point 1. above.

Criterion: $\eta_{p,}$ as determined through the process described above shall be >80% at the time of commissioning.

Note: The tests are intended to be carried out over a continuous period. The value of n shall be at least 3 for 100% rated Power and 1 for 25%, 50% and 75% of rated power as per procedure laid down in Annexure B.

3. BESS Response time: shall be measured as the sum of the following two entities: 1-> The time elapsed between the instant when a command to change set point from rest to discharge is sent to the BESS (T_0) and the instant when the BESS starts responding to the discharge command signal (T_1), the BESS being in active standby state and 50% SOC at T_0 i.e., $T_1 - T_0$

   2-> Time elapsed in seconds between the instant the ESS output transitions from no discharge i.e. 0% (T_1) to discharge and the instant it attains rated power capacity(T_2) (or from no charge (T_1) to charge state and the instant it attains rated charge rate(T_2)) i.e. $T_2 - T_1$

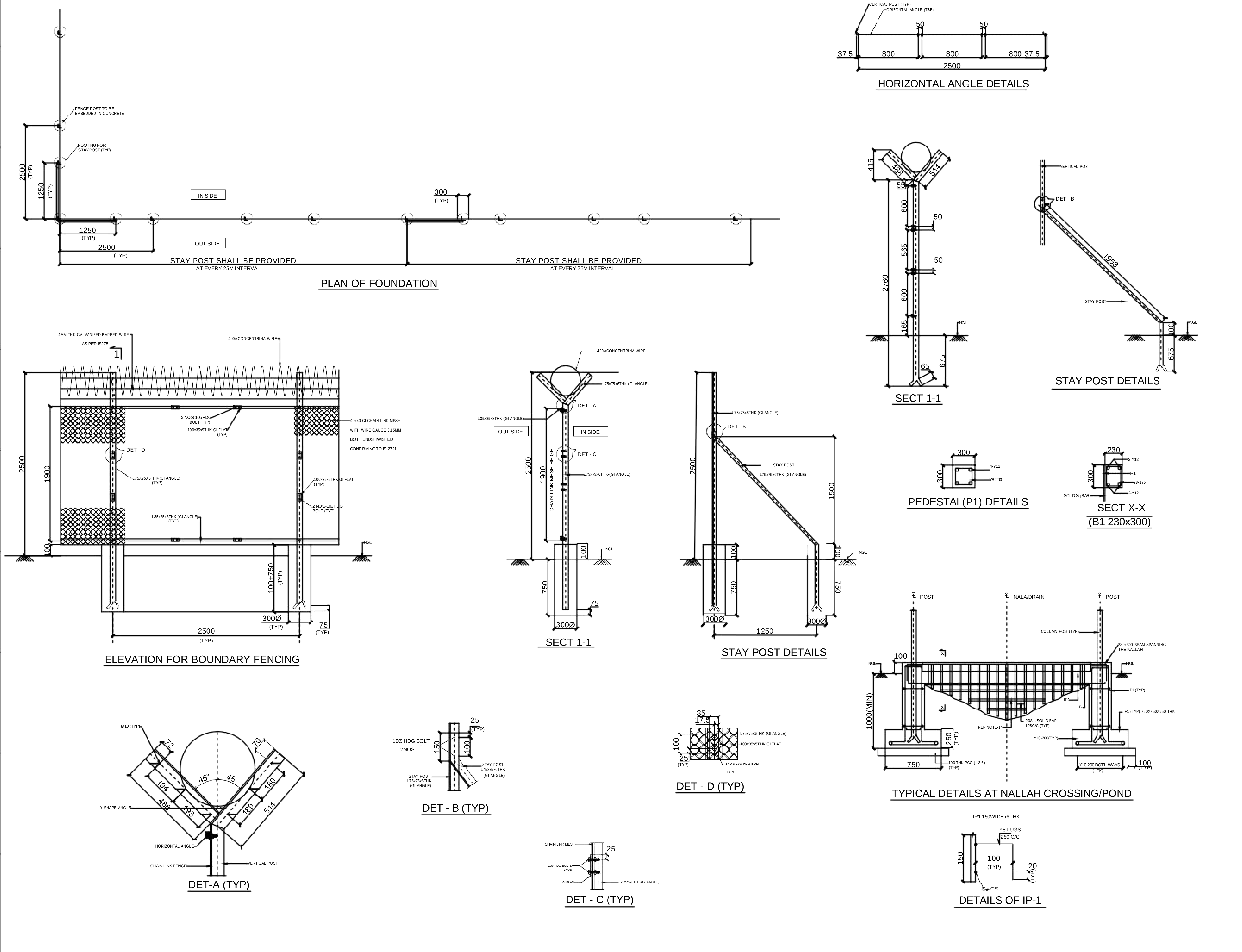
$$\mathbf{RT} = (T_2 - T_1) + (T_1 - T_0) = \mathbf{T_2 - T_0}$$

Where T_0 , T_1 and T_2 are timestamps:

T_0 :	Instant when a command to change set point is received at BESS boundary be identified in advance);
Data Format:	dd/mm/yyyy hh:mm:ss.00
T_1 :	Instant when the BESS starts responding to the Command signal;
Format:	dd/mm/yyyy hh:mm:ss.00
T_2 :	Instant when the BESS attains 100% of full discharge rate when dischargin full charge rate;
Format:	dd/mm/yyyy hh:mm:ss.00

Annexure – D

Tender Drawings



LEGEND

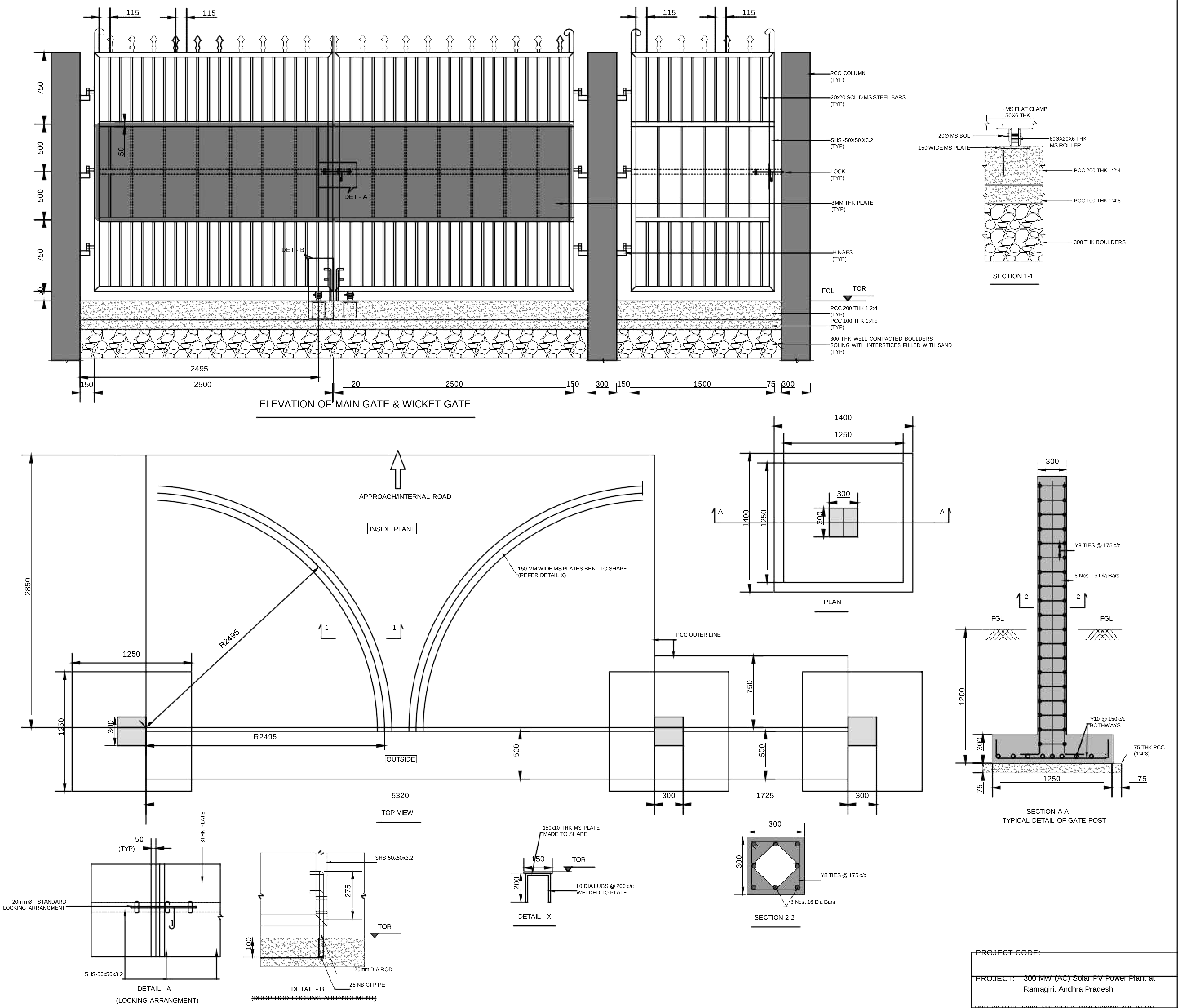
PCC	PLAIN CEMENT CONCRETE
NGL	NATURAL GROUND LEVEL
DET	DETAIL
TYP	TYPICAL
HDG	HOT DIP GALVANIZED
GI	GALVANIZED IRON
Eq	EQUAL
T&B	TOP & BOTTOM

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATION IN METERS.
2. ALL STRUCTURAL STEEL WORKS SHALL CONFORM TO IS:2062 GRADE-E250.
3. ALL DIMENSIONS TO BE CHECKED BEFORE FABRICATION OF STEEL WORK.
4. GALVANIZATION ON WIRES SHALL CONFORM TO IS:4826 HEAVY DUTY.
5. GALVANIZATION THICKNESS SHALL BE 80 MICRONS MIN.
6. TOP OF FENCE SHALL FOLLOW THE NATURAL CONTOUR OF LAND.
7. BARBED WIRE SHALL BE OF MINIMUM 4MM DIA AND OF APPROVED MAKE. IT SHALL CONFORM TO IS:278.
8. THE BARBED WIRES SHALL BE INSERTED IN THE SLOTTED HOLE AND BINDED WITH BINDING WIRES.
9. TWO STAY POST SHALL BE PROVIDED AT EVERY CORNER COLUMN POST AND WHEREVER CHANGE IN ELEVATION/LEVEL.EVERY TENTH INTERMEDIATE POST SHALL BE PROVIDED WITH A STAY POST.
10. GRADE OF CONCRETE SHALL BE M20 (1:1.5:3) WITH 20MM NOMINAL SIZE GRADED AGGREGATES AS PER IS:456.
11. ALL REINFORCEMENT SHALL BE HIGH STRENGTH TMT BARS OF GRADE FE500D CONFORMING TO IS:786.
12. CLEAR COVER TO REINFORCEMENT SHALL BE AS FOLLOWS:
    FOOTING = 50MM, COLUMN = 40MM & BEAM = 25MM.
13. HOLE DIAMETER SHALL BE 2MM LARGER THAN BOLT DIA.
14. A GRILL OF 20MM SQ. SOLID MS BAR WELDED TO IP1 AT SPACING OF 125MM C/C, WITH 20SQ HORZ.BARS OR 35MMX5MM THK FLAT WELDED TO VERTICAL SQ BARS AT SUITABLE INTERVALS (MIN. 3 NO OF THE BARS/FLATS) SHALL BE PROVIDED IN LIEU OF TOE WALL.
15. HEIGHT OF THE VERTICAL SQ SOLID MS BAR WILL VARY BASED ON ACTUAL NALLAH/DRAIN DEPTH.
16. POST ON EITHER SIDE OF NALA SHALL BE SUPPORTED WITH PEDESTAL & FOOTING ARRANGEMENT WITH A BEAM SPANNING ACROSS THE NALLAH/POND TO SUPPORT THE GRILLAGE AS SHOWN.
17. THE FOUNDATION OF THE STAY POSTS SHALL BE OF THE SAME SIZE AS THAT OF THE MAIN POSTS.
18. THE CHAIN LINK MESH FABRIC SHALL BE FIXED AT THREE POINTS EACH TO THE TOP AND BOTTOM EDGE ANGLES USING 100x35x5 GI FLATS.
19. ALL MS PART SHALL BE PAINTED WITH 2 COATS OF EPOXY PAINT OVER 2 COATS OF ZINC CHROMATE PRIMER.
20. ALL WELDS SHALL BE 6MM THICK UNO.
21. THREE NOs. OF 4MM THICK BARBED WIRES SHALL BE FIXED TO EACH ARM OF THE Y-SHAPED ANGLE SUPPORTS, ALONG WITH 400MM DIAMETER GI CONCERTINA WIRE.
22. SPACING BETWEEN BOTTOM OF FENCE AND GROUND LEVEL SHALL NOT BE MORE THAN 100MM.

PROJECT CODE:	CHAIN LINK FENCE DRAWING	DRAWN	CHKD.	APPR.
PROJECT: 300 MW (AC) Solar PV Power Plant at Ramagiri, Andhra Pradesh		DATE	DATE	DATE
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MM		PART/DWG NUMBER-		
TOLERANCES: NO D.P. / ONE D.P. / TWO D.P. / ONE D.P.				
SCALE: NTS				

SHEET	
REV.	
SHEET SIZE	A1



LEGEND

FGL — FINISHED GROUND LEVEL
TYP — TYPICAL
THK — THICK
NB — NOMINAL BORE
TOR — TOP OF ROAD

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. DO NOT SCALE THE DRAWING. ONLY DIMENSIONS PROVIDED SHALL BE FOLLOWED.
3. CONCRETE SHALL BE OF M25 WITH 20MM NOMINAL SIZE GRADED AGGREGATES CONFORMING TO IS:456-2000.
4. REINFORCEMENT BARS SHALL BE OF HIGH YIELD STRENGTH TMT BARS OF GRADE FE500D CONFORMING TO IS:1786.
5. BENDING OF BARS SHALL CONFORM TO IS:2502.
6. LAP LENGTH/DEVELOPMENT LENGTH OF BARS SHALL BE 50xDIA OF SMALL BAR.
7. ANY DISCREPANCY IN THE DRAWING SHALL BE BROUGHT TO THE NOTICE OF ENGINEER IN CHARGE BEFORE EXECUTE OF WORK.
8. DRAWING SHALL BE READ IN CONJUNCTION WITH THE RELEVANT LAYOUT DRAWINGS.
9. CLEAR COVER TO MAIN REINFORCEMENT:
   a) FOOTING - 50 MM b) PEDESTAL - 40 MM c) COLUMN - 40 MM
10. HINGE, LOCKING ARRANGEMENT AND DROP RODS SHALL BE OF HEAVY DUTY TYPE.
11. ALL STRUCTURAL STEEL WORKS SHALL CONFORM TO IS:2062 GRADE-A & E-250.
12. WELD SIZE SHALL BE MIN 5 MM UNLESS NOTED OTHERWISE. ONLY SHOP WELDING SHALL BE PERMITTED.
13. GATE SHALL BE PROVIDED WITH THE PROJECT NAME PLATE (2.5 M X 1 M, 3 MM THICK MS PLATE) ON BOTH PANELS. DETAILS TO BE PROVIDED ON NAME PLATE SHALL BE SUBJECT TO APPROVAL FROM SECI.
14. ALL STRUCTURAL STEEL, GATE AND NAME PLATE SHALL BE PAINTED WITH 2 COATS OF EPOXY (TOTAL DFT 150 MICRONS) PAINT OF APPROVED MAKE AND SHADE OVER 2 COATS OF SUITABLE PRIMER.

~~PROJECT CODE:~~

PROJECT: ~~300 MW (AC) Solar PV Power Plant at~~ Ramagiri. Andhra Pradesh

~~UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MM~~
~~TOLERANCES~~

~~NO D.P.~~	~~ONE D.P.~~	~~TWO D.P.~~	~~ONE D.P.~~	SCALE
				NTS

ENTRANCE GATE DRAWING

DRAWN	CHKD.	APPR.	SHEET
~~DATE~~	~~DATE~~	~~DATE~~	~~REV.~~
PART/DWG NUMBER-			SHEET SIZE A1

Annexure – E

Geotechnical Investigation Report

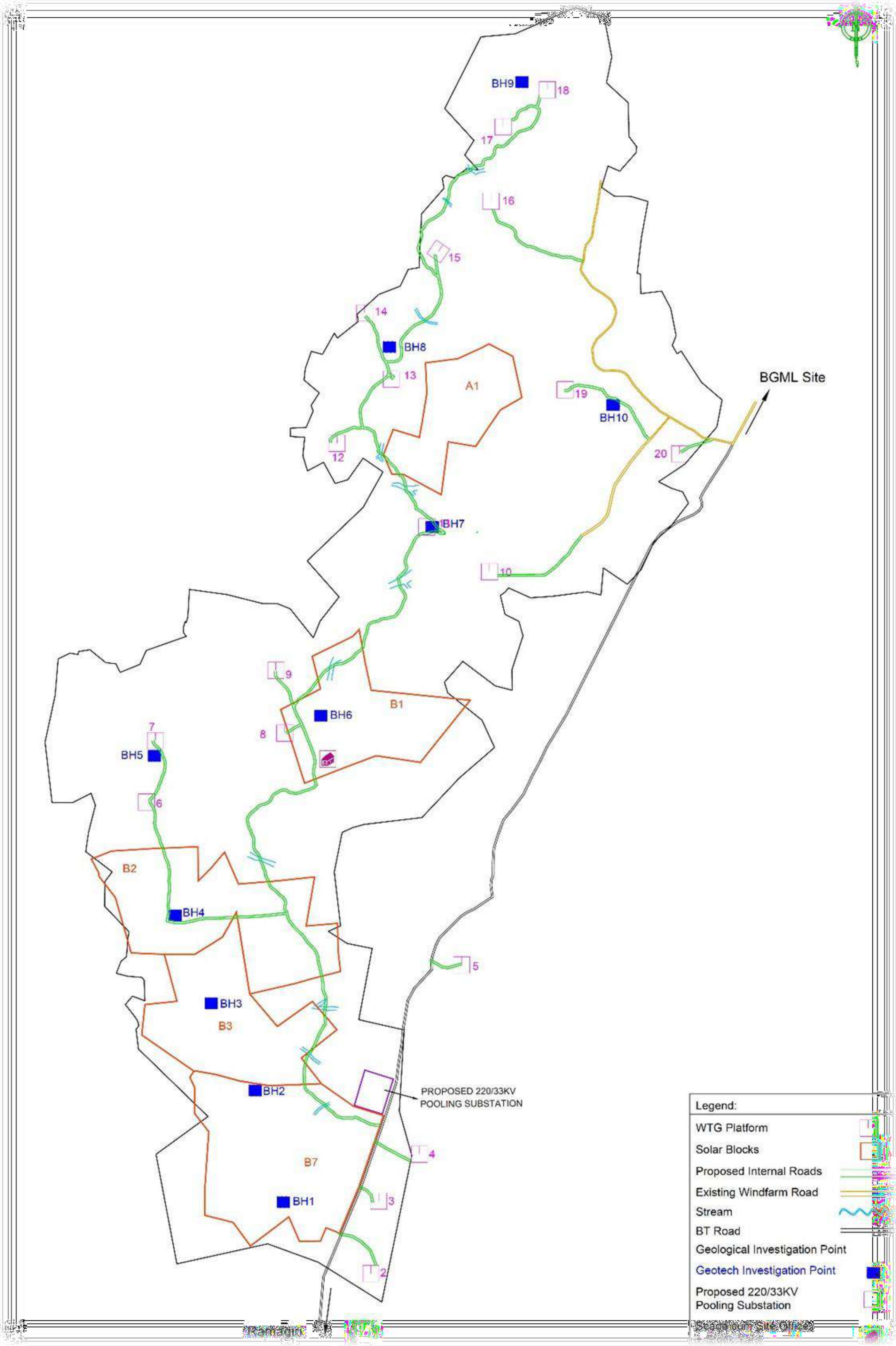


Figure 24: Map Showing Geo Technical Investigation Locations in the Park

5.5.1 Bore Hole Log Sheet:

FIELD BORE LOG CHART

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-1 **DIA :** 150mm/Nx **WATER TABLE :** **GROUND LEVEL** -

DATE : 28/02/2018 **COMPLETED :** 2/02/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD	Water Colour	Rate of Drill Min/ Mts
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)	(%)		
0.0	1.0	1.0	Silty Gravel	++++ ++++	1.0	DS										
1.0	2.0	1.0	Hard Rock		Core Sample				-	50	Total small	50	-	26		
2.0	3.0	1.0			Do					63	Total small	63	-			
3.0	4.0	1.0			Do				67	67	1+small	67	67			
4.0	5.0	1.0			Do				10+14+14= 38	84	3+small	84	38			

Table 16: Log Sheet for Bore Hole Location 1

FIELD BORE LOG CHART

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-2 **DIA :** 150mm/Nx **WATER TABLE :** **GROUND LEVEL** -

DATE : 27/02/2018 **COMPLETED :** 28/02/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD	Water Colour	Rate of Drill Min/ Mts
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)	(%)		
0.0	1.0	1.0	Silty Gravel	++++ ++++	1.0	DS										
1.0	1.5	0.5		++++ ++++	1.5	SPT	11cm/50blows	>50	-							
1.5	2.8	1.3		++++ ++++	2.5	DS										
2.8	3.8	1.0	Hard Rock		Core Sample				15	82	1+small	82	15			
3.8	4.8	1.0			Do				-	70	Total small	70	-			
4.8	5.0	0.2			Do				-	20	Total small	20	-			

Table 17: Log Sheet for Bore Hole Location 2

FIELD BORE LOG CHART

CLIENT : Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-3 **DIA :** 150mm/Nx **WATER TABLE :** 2.0m **GROUND LEVEL** -

DATE : 22/02/2018 **COMPLETED :** 26/02/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD (%)	Water Colour	Rate of Drill Min/ Mts
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)			
0.0	1.0	1.0	Silty Gravel	+ + + + + + + +	1.0	DS										
1.0	1.5	0.5	Boulder	0 0 0 0 0 0 0 0					-							
1.5	2.5	1.0	Silty Gravel	+ + + + + + + +	2.5	DS										
2.5	3.0	0.5		+ + + + + + + +	3.0	SPT	10cm/50blows	>50								
3.0	4.0	1.0	SDR													
4.0	5.7	1.7														
5.7	6.7	1.0	Hard Rock		Core Sample				-	47	Total small	47	-			
6.7	7.7	1.0			Do				-	45	Total small	45	-			
7.7	8.7	1.0			Do				-	46	Total small	46	-			

Table 18: Log Sheet for Bore Hole Location 3

FIELD BORE LOG CHART

CLIENT : Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-4 **DIA :** 150mm/Nx **WATER TABLE :** **GROUND LEVEL** -

DATE : 12/02/2018 **COMPLETED :** 15/02/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD (%)	Water Colour	Rate of Drill Min/ Mts
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)			
0.0	1.0	1.0	Silty Gravel	+ + + + + + + +	1.0	DS										
1.0	2.0	1.0	Hard Rock		Core Sample				29	80	1+small	80	29			
2.0	3.0	1.0			Do				10	62	1+small	63	10			
3.0	4.0	1.0			Do				29	68	1+small	68	29	28		
4.0	5.0	1.0			Do				30+29=59	89	2+small	89	59			
5.0	6.0	1.0			Do				12	58	1+small	58	12			

Table 19: Log Sheet for Bore Hole Location 4

FIELD BORE LOG CHART

CLIENT : Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-5 **DIA :** 150mm/Nx **WATER TABLE :** 0.50 m **GROUND LEVEL** -

DATE : 16/02/2018 **COMPLETED :** 18/02/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD	Water Colour	Rate of Drill
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)	(%)		Min/ Mts
0.0	0.8	0.8	Silty Gravel	++++ ++++												
0.8	1.5	0.7	Boulder	0000 0000	1.0	DS										
1.5	1.7	0.2		0000 0000												
1.7	2.5	0.8	Silty Gravel	++++ ++++	2.5	DS										
2.5	3.0	0.5		++++ ++++	3.0 3.0	DS SPT	10cm/50blows	>50								
3.0	4.0	1.0	Hard Rock				Core Sample		-	50	Total small	50	-			
4.0	5.0	1.0					Do		-	57	Total small	57	-			
5.0	6.0	1.0					Do		13+24=37	67	2+small	67	37			

Table 20: Log Sheet for Bore Hole Location 5

FIELD BORE LOG CHART

CLIENT : Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-6 **DIA :** 150mm/Nx **WATER TABLE :** 0.70 m **GROUND LEVEL** -

DATE : 19/02/2018 **COMPLETED :** 21/02/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD	Water Colour	Rate of Drill
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)	(%)		Min/ Mts
0.0	1.0	1.0	Silty Gravel	++++ ++++	1.0	DS										
1.0	1.5	0.5		++++ ++++	1.5	SPT	14cm/50blows	>50								
1.5	1.7	0.2		++++ ++++												
1.7	2.7	1.0	Hard Rock				Core Sample		-	48	Total small	48	-			
2.7	3.7	1.0					Do		12	50	1+small	50	12			
3.7	4.7	1.0					Do		10	60	1+small	60	10			

Table 21: Log Sheet for Bore Hole Location 6

FIELD BORE LOG CHART

CLIENT : Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-7 **DIA :** 150mm/Nx **WATER TABLE :** **GROUND LEVEL** -

DATE : 2/03/2018 **COMPLETED :** 4/03/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD	Water Colour	Rate of Drill
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)	(%)		Min/ Mts
0.0	1.2	1.2	Silty Gravel	+ + + + + + + +	1.0	DS										
1.2	2.0	0.8	SDR		2.0	DS			-							
2.0	3.0	1.0			3.0 3.0	DS SPT	8cm/50blows	>50								
3.0	4.0	1.0			4.0	DS										
4.0	5.0	1.0			4.5 5.0	SPT DS	6cm/50blows	>50								
5.0	6.0	1.0	Hard Rock		Core Sample				-	25	Total Small	25	-			
6.0	7.0	1.0	SDR		7.0	DS										
7.0	8.0	1.0			7.5	SPT	3cm/50blows	>50								
8.0	9.0	1.0			8.0 9.0	DS SPT	2cm/50blows	>50								
9.0	10.0	1.0			10.0	DS										

Table 22: Log Sheet for Bore Hole Location 7

FIELD BORE LOG CHART

CLIENT :Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-8 **DIA :** 150mm/Nx **WATER TABLE :** **GROUND LEVEL** -

DATE : 6/03/2018 **COMPLETED :** 8/03/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m)		Length of Run (m)	Description of Strata	Log of Bore (m)	Samples		SPT		DETAILS OF ROCK SAMPLES				RQD	Avg. RQD	Water Colour	Rate of Drill
From	To				Depth (m)	Type	Pene-tration 15-30-45	N Value	≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	(%)	(%)		Min/ Mts
0.0	1.1	1.1	Silty Gravel	+ + + + + + + +	1.0	DS										
1.1	2.1	1.0	SDR		1.5 2.0	SPT DS	6cm/50blows	>50	-							
2.1	3.1	1.0			3.0	SPT	4cm/50blows	>50								
3.1	4.1	1.0			4.0	DS										
4.1	5.1	1.0			4.5	SPT	4cm/50blows	>50								
5.1	6.1	1.0			5.5 6.0	DS SPT	3cm/50blows	>50	-							
6.1	7.1	1.0			7.0	DS										
7.1	8.0	0.9	Boulders	0 0 0 0 0 0 0 0	Core sample					40	Total Small					
8.0	9.0	1.0	SDR		9.0	SPT	2cm/50blows	>50								
9.0	10.0	1.0			10.0	DS										

Table 23: Log Sheet for Bore Hole Location 8

FIELD BORE LOG CHART

CLIENT : Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-9 **DIA :** 150mm/Nx **WATER TABLE :** 3.0 M **GROUND LEVEL** -

DATE : 3/03/2018 **COMPLETED :** 6/03/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m) From	Depth (m) To	Length of Run (m)	Description of Strata	Log of Bore (m)	Samples Depth (m)	Samples Type	SPT Pene-tration 15-30-45	SPT N Value	DETAILS OF ROCK SAMPLES ≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	RQD (%)	Avg. RQD (%)	Water Colour	Rate of Drill Min/ Mts
0.0	0.6	0.6	Silty Gravel	++++ ++++												
0.6	0.8	0.2	Boulders	0000 0000					-							
0.8	1.5	0.7	Silty Gravel	++++ ++++	1.0 1.5	DS SPT	10cm/50blows	>50								
1.5	2.5	1.0	SDR		2.5	DS										
2.5	3.0	0.5			3.0 3.0	SPT DS	7cm/50blows	>50								
3.0	4.0	1.0			4.0	DS			-							
4.0	5.0	1.0			4.5 5.0	SPT DS	9cm/50blows	>50								
5.0	6.0	1.0			6.0 6.0	DS SPT	8cm/50blows	>50								
6.0	7.5	1.5			7.0 7.5	DS SPT	7cm/50blows	>50								
7.5	9.0	1.5			8.5 9.0	DS SPT	6cm/50blows	>50								
9.0	10.0	1.0			9.0 10.0	DS DS										

Table 24: Log Sheet for Bore Hole Location 9

FIELD BORE LOG CHART

CLIENT Deltacons Projects (India) Pvt. Ltd., Hyderabad

PROJECT : Soil Investigation for Proposed Wind Solar Hybrid Power Project at Ananthapur Dist., A.P .

BORE HOLE NO.: BH-10 **DIA :** 150mm/Nx **WATER TABLE :** 1.3 M **GROUND LEVEL** -

DATE : 7/03/2018 **COMPLETED :** 10/03/2018 **CASING:** **LOCATION :** Ramgiri & Muttavakuntla (V)

Depth (m) From	Depth (m) To	Length of Run (m)	Description of Strata	Log of Bore (m)	Samples Depth (m)	Samples Type	SPT Pene-tration 15-30-45	SPT N Value	DETAILS OF ROCK SAMPLES ≥10 Cm Core pieces	Total length (cm)	No. of pieces	% of Core Recovery	RQD (%)	Avg. RQD (%)	Water Colour	Rate of Drill Min/ Mts
0.0	1.5	1.5	Silty Gravel	++++ ++++	1.0 1.5	DS SPT	14cm/50blows	>50								
1.5	2.0	0.5		++++ ++++	2.0	DS			-							
2.0	3.0	1.0	SDR		2.0 3.0	DS SPT	12cm/50blows	>50								
3.0	4.0	1.0			3.0 4.0	DS DS										
4.0	4.5	0.5			4.5	SPT	10cm/50blows	>50								
4.5	6.0	1.5			5.5 6.0	DS SPT	9cm/50blows	>50	-							
6.0	7.5	1.5			7.0 7.5	DS SPT	8cm/50blows	>50								
7.5	9.0	1.5			8.5 9.0	DS SPT	7cm/50blows	>50								
9.0	10.0	1.0			9.0 10.0	DS DS										

Table 25: Log Sheet for Bole Hole Location 10

5.6 Electrical resistivity test

Resistivity and resistance data at the site locations are shown below,

GEOS CONSULTING CORPORATION

K.Venateswarlu M.Sc,
Senior Geologist,
Approved by APGWD No. AP120091617,
Recognized by APDMG No. RQP/DMG/AP/25,
Cell: 9440322969.
Email: kothuruvenkata@gmail.com

Earth Resistivity Test Report   Dated 20.03.2018

NAME OF WORK: RESISTIVITY AND RESISTANCE DATA AT THE FOLLOWING LOCATIONS MENTIONED BELOW FOR THE PROPOSED WIND/SOLAR HYBRID POWER PROJECT AT RAMAGIRI & MUTHAVAKUNTLA (VILLAGE) IN ANANTHAPURAMU DIST. A.P.,
BY M/S DELTACON PROJECTS (INDIA) PVT.LTD.,

Location No.	Co-Ordinates UTM	Elevation MTS	Resistivity Ohm.Mts	Resistance Ohms
1	770616 E 1585504 N	526	181.0	1.92
2	770445 E 1586186 N	515	169.7	1.80
3	770176 E 1586721 N	510	155.57	1.65
4	769953 E 1587258 N	509	161.22	1.71
5	769826 E 1588235 N	497	148.01	1.57
6	770843 E 1588480 N	503	153.69	1.63
7	771528 E 1589632 N	506	129.17	1.37
8	771265 E 1590734 N	505	124.45	1.32
9	772072 E 1592351 N	493	113.14	1.20
10	772664 E 1590407 N	527	132.0	1.40

Resistance derived by the formula
R= 2πr l ; where R = Resistivity
π= 22/7 ; r = resistance ; L = AB/2 = 15 Mts
Meter Details:
Make IGIS, Tarnaka, Hyderbad.
Model ! DDR –I
Sl.No. 185464.

K. VENKATESWARLU M.Sc
senior Geologist
Approved by APGWD: No. AP12009
Recognised by APDMG: No. RQP/DMG
Cell: 9440322969.

Figure 25: Resistivity and resistance data

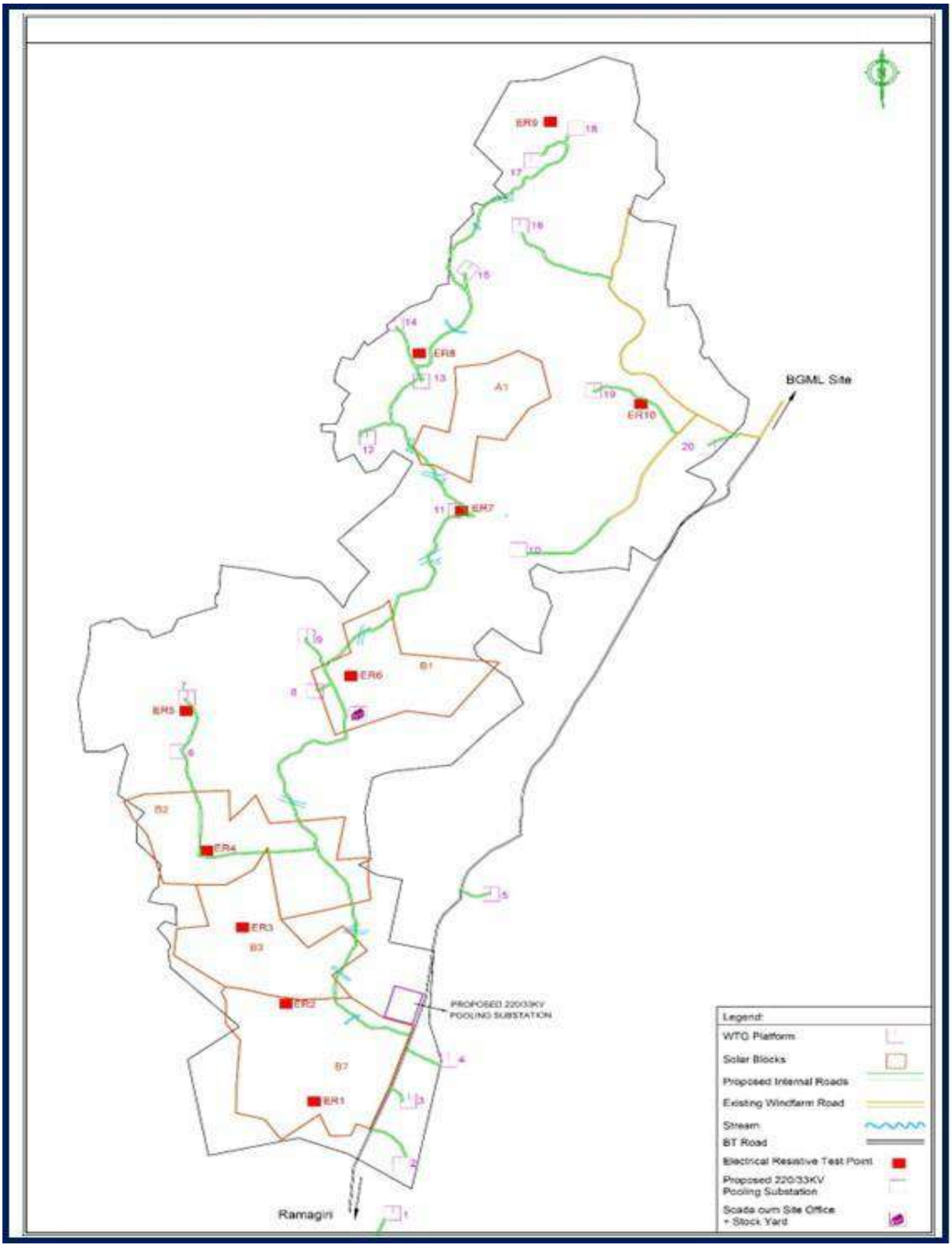


Figure 26: Map showing Electrical Resistance Investigation at Solar Park

5.7 Geological investigations.

Geological investigation has been carried out at 12 points covering the entire site by the approved Government of Andhra Pradesh Geologist. Detailed report submitted by Geologist isas attached below:

GEO CONSULTING CORPORATION

D.No.12/359, Sai Nagar, Anantapuramu – 515 001.

K. Venkatetswarulu, M.Sc.,

Senior Geologist,

Approved by A.P.G.W.D.No.A.P. 120091617

Recognised by APDMG.No.RQP/DMG/AP/25

Cell.No.9440322969,

Email: kothuruvenkata@gamil.com.

Date: 09-03-2018.

GROUND WATER INVESTIGATION REPORT

DETAILED REPORT ON GROUND WATER FEASIBILITY IN THE SOLAR PARK AREA NEAR RAMAGIRI, ANANTAPURAMU DISTRICT.

1. **Introduction :-** Hydrogeological and Geo-physical investigations are conducted to assess the ground water feasibility and to select the good acquifer zones in the solar Park area near Ramagiri, Anantapuramu District.

2. **Location** :- The area is located N 14^0 20′ 56.0″ and E 77^0 30′ 10.8″ and is near to Ramagiri Kothapalli Village and Thallimadugula area.

3. **Topography and Drainage** : The area is of huge land Scape consists of huge hillocks which are highly elevated of about 513 mtrs. above sea level. The Streams and stream-lets are flown in between the hillocks in the valleys. The area is of Archaean formations where hard Granite formations are intruded by Dykes, Biotites, Biotite schists and Quartzite vines. Rocks are metamorphosed and formed flaky material called Biotite and Muscovite veins streams and stream lets are flown in different directions.

K. VENKATESWARLU M.Sc.,
senior Geologist
Approved by AP GWD: No. AP120091617
Recognised by APDMG: No. RQP/DMG/AP/25
Cell: 9440322969.

..2..

4. **Hydrogeology :** The Study of the area observed streams and streamlets are flowing and the area is having good acquifer zones at some locations.
   3-4 Borewells and an open well are observed around the area and they are yielding at average.
5. **Geo-Physical investigations**:- Vertical Electrical soundings (VES) have been conducted at the locations (depending on the filed conditions) adopting schlumberger Configuration. In this we measure apparent resistivity in ohm. mts. at different depths (BGL). The values arised are processed and interpreted in the form of layers h1, h2, h3, & h4 by using curve matching Techniques.
6. **Lithology :**- By these layers we assess the nature of formation, Lithological variations of the earth and the fractured zones. This lithological variation is is shown below taking into consideration of the layer thickness.

(From surface) O to 2 mts -	Gravel with boulders.
2 to 8 mts.-	Dry fractured rock
8 to 100 mtrs.	Rock of minorly fractured zone
100 to 140 mtrs.	Hard Rock
140 to 170 mtrs.	Fractured Zone
170 and below	Hard rock of minor fracturing followed by basement.

7. **Recommendations**:-

Basing on the field data available and interpretation of Geo Physical values the following recommendations are made.

K. VENKATESWARLU M.Sc.,
senior Geologist
Approved by AP GWD: No. AP120091617
Recognised by APDMG: No. RQP/DMG/AP/25
Cell: 9440322969.

..2..

4. **Hydrogeology :** The Study of the area observed streams and streamlets are flowing and the area is having good acquifer zones at some locations.

   3-4 Borewells and an open well are observed around the area and they are yielding at average.

5. **Geo-Physical investigations**:- Vertical Electrical soundings (VES) have been conducted at the locations (depending on the filed conditions) adopting schlumberger Configuration. In this we measure apparent resistivity in ohm. mts. at different depths (BGL). The values arised are processed and interpreted in the form of layers h1, h2, h3, & h4 by using curve matching Techniques.

6. **Lithology :**- By these layers we assess the nature of formation, Lithological variations of the earth and the fractured zones. This lithological variation is is shown below taking into consideration of the layer thickness.

(From surface) O to 2 mts -	Gravel with boulders.
2 to 8 mts.-	Dry fractured rock
8 to 100 mtrs.	Rock of minorly fractured zone
100 to 140 mtrs.	Hard Rock
140 to 170 mtrs.	Fractured Zone
170 and below	Hard rock of minor fracturing followed by basement.

7. **Recommendations**:-

   Basing on the field data available and interpretation of Geo Physical values the following recommendations are made.

K. VENKATESWARLU M.Sc.,
senior Geologist
Approved by AP GWD: No. AP120091617
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Cell: 9440322969.

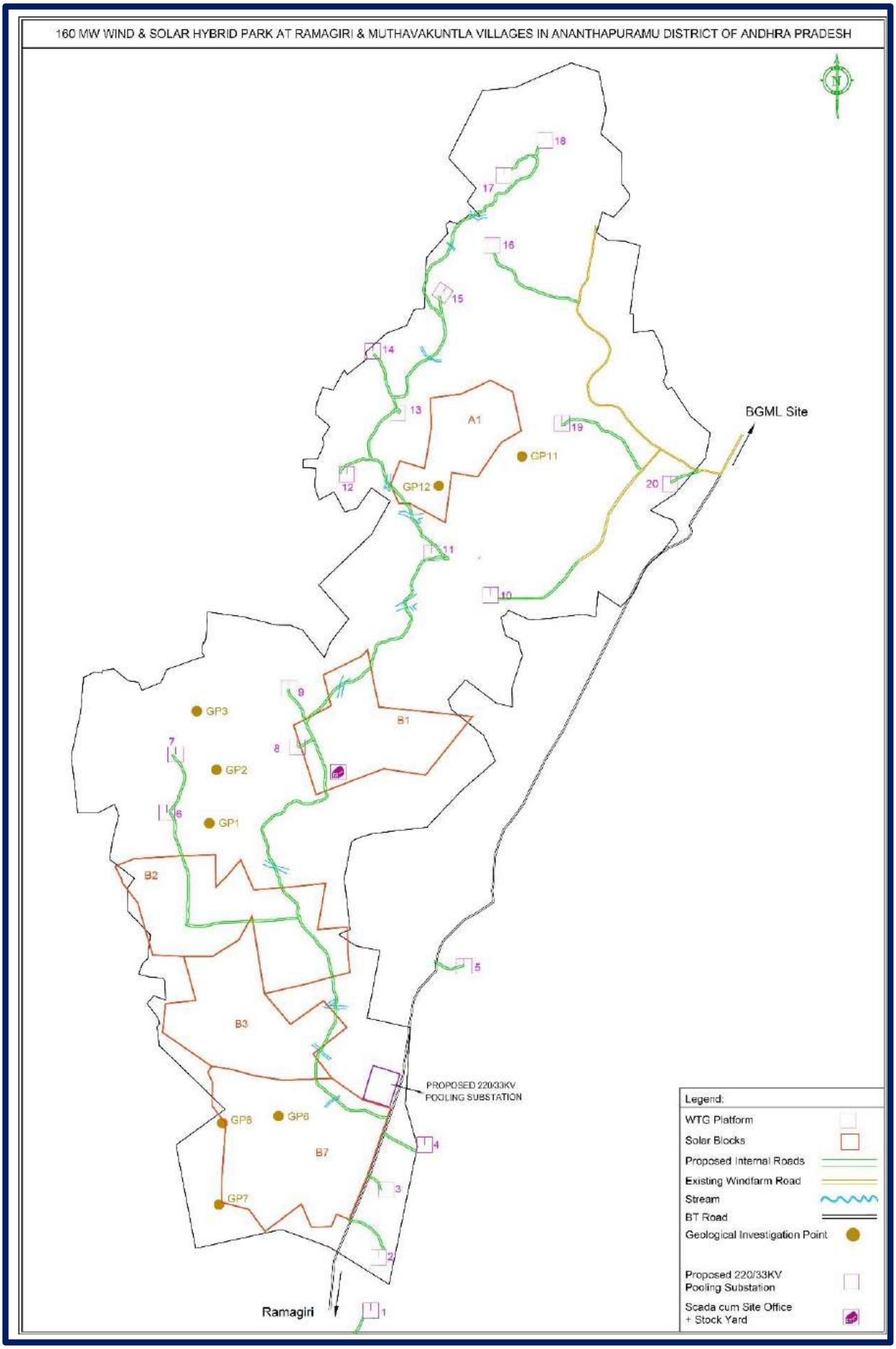

Figure 27: Solar Park Layout Showing Proposed Bore Well Locations

Annexure – F

FQP and MQP for Civil & MMS Works

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sr.No.	Activity & Operation	Instruments	Class of Check	Type of Check	Quantum of Check	Reference Documents & Acceptance Standard	Format of Record	D* (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	Cheking Agency			Remarks
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
3	1	**General Requirements**											
4	a	Availability of requisite test set-up and equipment in good working condition with valid calibration at site well before commencement of concerned activity	As required/ agreed	Critical	Physical	Once prior to start of work & Monthly there after	Tech. Specs, Construction Drawings	SR	√		x	x	**Min. list of equipment** - CTM, Set of Seives for CA & FA, Elcometer (digital), Micrometer, Multimeter, Meggar, Torque Wrench, Moulds for casting of concrete/ mortar test samples, Curing tank of adequate size, SS measuring tape - 50m, Theodolite, leveling staff and associated equipment etc. for day to day work with proper storrage racks. The equipment shall be in adequate no. matching the site progress requirements. Functioning of laboratory equipment in proper working condition to be verified on monthly basis
5	b	Submission of QA & QC manpower deployment schedule based on agreed L-2 network	As required/ agreed	Critical	Verification	Before start of work	Tech. Specs, Construction Drawings	SR	√		x	x	
6	c	Availability of QA & QC manpower deployment based on agreed deployment schedule, Periodic review for augmentation as per actual progress	As required/ agreed	Critical	Physical	Once prior to start of work & Monthly there after	Tech. Specs, Construction Drawings	SR	√		x	x	
7	d	Submission of schedule/ programme of tests and inspection of civil works (survey, excavation, concreting, backfilling, brickwork, finishing works, roads, drains etc.) to be done monthly and quarterly based on agreed schedule	As required/ agreed	Critical	Physical	Once prior to start of work & Monthly/ Quarterly there after	Tech. Specs, Construction Drawings	SR	√	x	x	x	
8	e	Submission of actual work programme min. 3 days (72 hours) in advance to facilitate planning for quality checks as per approved QP	As required/ agreed	Critical	Physical	48 hours before start of actual work	Master programme/ schedule	SR	√	x	x	x	
9	f	Stacking and storage of construction materials and components at site	IS: 4062	Critical	Physical	Random	Tech. Specs, Construction Drawings & IS: 4062	SR	√	x	x	x	
11	2	**Surveying (Execution phase)**											
12	a	Availability of Calibrated Instruments, qualified & experieced staff at site	As required/ agreed	Critical	Physical	100%	Tech. Specs, Construction Drawings, Agreed deployment schedule	Calibration Report	√	x	x	x	
13	b	Ensure correct Boundary Layout and Latitude-Longitude Coordinates,True North	construction Drawings	Critical	Measurement	100%	Tech. Specs, Construction Drawings	SR	√	x	x	x	
14	c	GL (ground level), FGL (finished ground level) and Plinth Level, Check PBM(permanent bench mark) with Total Station/ Theodolite and after conformation carryout Peg marking	As required/ agreed	Critical	Measurement	100%	Construction Drawings	SR	√	x	x	x	
16	3	**Materials**											
17	A	*Cement*											
18	i	Fineness	As per IS: 4031	Critical	Review of MTC/ Physical	One test at Lab to corelate with MTC	IS:456,IS:269,IS:8112, IS:12269,IS:1489, Tech. Specs	Manufacturers Test Certificate (MTC's) and Laboratory Test results	√	x	x	x	Each consignment/ lot of cement shall be duly correlated with MTC If cement stored is more than 60 days in godown the same shall be re-tested for conformation with MTC
19	ii	Compressive Strength											
20	iii	Initial & final setting time											
21	iv	Chemical composition of Cement											
22	B	*Coarse Aggregates (CA)*											

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sr.No.	Activity & Operation	Instruments	Class of Check	Type of Check	Quantum of Check	Reference Documents & Acceptance Standard	Format of Record	D*	Cheking Agency			Remarks
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)	(Records identified with (√) shall be issentially included by EPC vender in QA documentation)	M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
23	i	Determination of Particle size (Sieve Analysis), Flakiness index, Elongation index	As per IS: 2386	Major	Visual	Once per 100 cum or part thereof (During monsoon moisture content to be checked every day)	IS:383,IS:2386, Tech. Specs	Lab Test results	√	x	x	x	Water content of concrete to be corrected as per results of moisture content
24	ii	Moisture content											
25	iii	Crushing Value, Impact value, Abrasion value		Critical		One test at Lab for each source/ on every change of source			√	x	x	x	These tests shall be carried out while establishing design mix. In case of change of source the design mix shall be re-validated for new source
26	iv	Specific Gravity, water absorption											
27	v	Bulk Density											
28	vi	Soundness											
29	vii	Presence of deleterious materials											
30	C	*Fine Aggregate (FA)*											
31	i	Gradation/Determination of Particle size (Sieve Analysis)	Balance, Oven etc. As per IS: 2386, 383	Major	Visual	Gradation - Once per 1000 cum or part there of Mosture content - Every day	IS:383,IS:2386,IS:456 , Tech. Specs	Lab Test results	√	x	x	x	Water content of concrete to be corrected as per results of moisture content
32		Moisture Content											
33	ii	Specific Gravity and density (for design mix concretes only)	As per IS: 2386, 383	Major	Visual	One test at Lab for each source/ on every change of source							
34	iii	Water absorption (for design mix concretes only)											
35	iv	Presence of deleterious materials											
36	D	*Concrete Admixture*											
37	i	Type of admixture			Review of MTC		IS: 9103, Approved design mix		√	x	x	x	Admixture shall be of brand and type as per approved design mix.
38	ii	Physical & Chemical properties			Review of MTC		IS: 9103, Manufacturer's Brochure						Each lot/ batch of admixurture shall acompany the Manufacturer's Brochure and shall be correlated with MTC
39	iii	Suitability											
40	E	*Bricks*											
41	i	Dimensional Tolerance, shape			Measurement/ Physical	As per relevant IS code/ one sample for 30,000 nos. or part there of	IS: 1077, IS: 13757, IS: 12894, Tech. Specs, Construction Drawings	Lab Test results	√	x	x	x	Efflorescence shall be checked at each source
42	ii	Compressive Strength											
43	iii	Water Absorption											
44	iv	Efflorescence			Visual								
45	E	*Water*											
46	i	Cleanliness - Test for ascertaining limit of solids		Major		One per 3 months for each source	IS:456,IS:3025 (part 18), Tech. Specs, Construction Drawings specification	Lab Test reports	√	x	x	x	Water to be used for concrete shall be of potable quality and shall meet requirements specifed in IS: 456
47	ii	Chemical Tests to ascertain the suitability for construction purposes - pH Value, Sulphate & Chloride content					IS:456,IS:3025 (part 22, 23), Tech. Specs, Construction Drawings	Lab Test reports	√	x	x	x	
48	F	*Reinforcement Steel*											
49	i	Identification & Size		Major	Visual	Each batch of delivery	IS:432,IS:1786,IS:1852, Tech Specs	SR	√	x	x	x	Reinforcement steel shall be stored properly at site to avoid rusting
50	ii	Freedom from cracks, surface flaws, lamination				Random in each shift			√	x	x	x	
51	iii	Tensile Test		Critical	Review of MTC	Each batch of delivery	IS:432,IS:1566,IS:1786, Tech Specs	Manufacturers Test Certificate (MTC's)	√	x	x	x	
52	iv	Yield stress/proof stress											
53	v	Percentage Elongation							√	x	x	x	
54	vi	Bend/Rebend Test											
55	vii	Reverse Bend Test for HDS wire					IS:432, Tec. Specs		√	x	x	x	
57	**3**	**Structural Steel Work {Example: Chequered plate cover, Panel supports, Rungs, Cat lader, Inserts, Fencing gate (MS) etc.}**											
58	i	Strutural Steel (Raw material)-Chemical Properties, Ultimate Tensile Strength(UTS), Yield Strength (YS), Percentage Elongation, Bend test		Critical	Review of MTC	For each batch of each section	IS: 2062, IS: 8500, Tech. Specs, Construction Drawings	Manufacturers Test Certificate (MTC's)	√	x	x	x	MTC to be correlated
59	ii	Dimensional Check - Secition dimensions, thickness		Critical	Measurement	10% of total quanity at Random			√	x	x	x	For Fencing gate - dimensional check 100%

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Sr.No.**	**Activity & Operation**	**Instruments**	**Class of Check**	**Type of Check**	**Quantum of Check**	**Reference Documents & Acceptance Standard**	**Format of Record**	**D*** (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	**Cheking Agency**			**Remarks**
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		**M'fr/ Supplier or Sub-Contractor**	**EPC Contractor**	**SECI or Owner**	
60	iii	Visual checks for damages, rusting, pitting, scaling etc.		Major	Visual	100%	IS: 822, Tech. Specs, Construction Drawings, MTC, relevant BIS standards for painting	Manufacturers Test Certificate (MTC's)/ SR	√	x	x	x	
61	iv	Visual checks for welding defects, painting (surface preparation, primer coat, and Finishing coat - make and shade of paint, DFT) as applicable.		Major	Visual/ Measurement/ Review of MTC	10% of total quanity at Random			√	x	x	x	MTC to be correlated
62	v	Acceptance ofStructural steel works		Major	Physical/ Acceptance	Random	Tech. Specs, Construction Drawings	SR	√	x	x	x	
64	**4**	**Foundation System**											
65	**A**	**Bored Cast in-situ Concrete Piling (for MMS support)**											
66	**a**	**Execution**											
67	i	Ensuring correctness of layout		Critical	Physical	100%	Tech. Specs, Construction Drawings	SR	√	x	x	x	
68	ii	Checking of pile making as per drawing	Total Station	Major	Vsual								
69	iii	Checking of Centre line of Pile Group	Total Station	Critical	Physical			SR	√	x	x	x	1. During boring of pile, record SPT/ core recovery to ensure socketing length in the hard strata equivalent in terms of pile diameter in hard rock zone as per tech Specs and approved construction drawings. 2. In case of collapse of pile bore during drilling temporary MS lining shall be used. 3. Lines and levels to be checked 4. Each bore shall be cleaned of any loose materail by pressure jet washing/ cleaning by air jet 5.The column section shall pe placed and held in position in true vertical alignment using template/ tripod till initial setting of concrete 6. Concrete garde - as per Construction Drawing
70	iv	Check Pile Location	Total Station										
71	v	GL, Pile depth, diameter and alignment	As required		Measurement		IS 2911, Tech Specs, Construction Drawings						
72	vi	Cleaning/ flushing of pile bore	As required	Major	Visual								
73	vii	Insertion & positioning of Column post in the bore hole (in case of embeded col. Leg) Placement of reinforcement and foundation bolts with template (inacse of fixing of col. with base plate & foundation bolt assembly)	As required	Critical	Visual/ Measurement								
74	viii	Acceptance of Pile casting - Shape, reinforcement or col. leg embedment (as aplicable), concreting, compacting with use of needle vibrator etc.	As required/ Agreed	Major	Visual								
75	ix	Grouting u/s of base plate	As required/ Agreed	Critical	Visual	100%	Tech. Specs & Construction drawings	SR	√	x	x	x	The type, grade and thickness of grout shall be as per approved drawing
76	**b**	**Testing**											
77	i	Initial pile load test - Compression (Vertical), Lateral (Horizontal), & Pull out (Tension)	Calibrated dial gauges, jack of required capacity, datum bars etc.	Critical	Physical	100% for 3 no. for each type of test or as specified in Tech Specs, Approved test pile layout	IS 2911, Tech Specs, Construction Drawings	Test Report	√	x	x	x	1. The R/F details shall be as per approved drawing for test plie (if applicable), 2. The test load shall be up to 2.5 times of required pile capacity in case of Compression and Lateral load and 2 times in case of Pull out test as per IS: 2911 (Pt. 4), 3. The location shall be as per approved pile test programme/ layout drawing 4. The test shall be carried out as per approved methodology 5. Test report along with test records shall be submitted in standard format as per IS:2911
78	ii	Routine pile tests - Pull out and Lateral		Critical	Physical	100% for 0.5% of total no. of working piles for each type of test	IS 2911, Tech Specs, Construction Drawings	Test Report					1. The piles for routine tests shall be selected at Random to represent total no. of job piles insalled 2. The test load for vertical and pull out shall be 1.5 times the required pile capacity 3. The test shall be carried out as per approved methodology. 4. The Test report along with test records shall be submitted in standard format as per IS:2971 (Pt. 4)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sr.No.	Activity & Operation	Instruments	Class of Check	Type of Check	Quantum of Check	Reference Documents & Acceptance Standard	Format of Record	D*	Cheking Agency			Remarks
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)	(Records identified with (√) shall be essentially included by EPC vender in QA documentation)	M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
80	**B**	**Cable Trench/ Building & Equipment Foundations**											
81	**a**	Before Excavation											
82	i	Ensuring correctness of layout		Critical	Physical	100%	Tech. Specs, Construction Drawings	SR	√	x	x	x	
83	ii	Checking of trench marking & alignment		Major	Visual		Tech Specs, Construction Drawings						
84	**b**	Excavation											
85	i	Dimensional conformity including diagonal check		Ctitical	Visual / Measurement	100%	IS:3764, Tech Specs, Construction Drawings	SR	√	x	x	x	
86	ii	Excavated earth kept away from edges		Minor	Visual	Random		SR	√	x	x	x	
87	**c**	Acceptance of Trench/ Foundation casting - Shape, reinforcement, shuttering, concreting, etc.		Minor	Physical	100%	Tech. Specs, Construction Drawings	SR	√	x	x	x	
89	**5**	**Foundation Bolts / Inserts/ Concrete embedments**											
90	i	Visual check of mechanical damage and galvanising painting if applicable on inserts			Visual / Measurement	100%	As per Tech Specs, Construction Drawings	SR	√	x	x	x	
91	ii	Bolt and assecories, inserts - Dimensions (total & threaded length & dia of bolt, size & thk of embedment and lugs etc.), Nos											
92	iii	Verticality, alignment, levels, pitch distance, embeded and projected length of bolt											
93	iii	Use of template for Alignment and Level checking											
94	iv	Acceptance of foundation bolt assembly / inserts in postion											
96	**6**	**Formwork**											
97	i	Materials & Accessories	As agreed/ required	Major	Visual	Once before start of work	IS :456 , Other relevant BIS Standard, Tech. Specs, Construction Drawings	SR	√	x	x	x	
98	ii	Soundness of staging, shuttering and scaffolding including application of mould oil/ release agent	As agreed/ required	Major	Visual	Once before start of work	Manufacturer's specs, IS :3096, IS:4014, IS: 4990, Tech. Specs, Construction Drawings	SR	√	x	x	x	
99	iii	Dimensional Check, alignment & levels as per drawing and tolerences		Major	Visual/ Measurement	100%	Tech. Specs, Construction Drawings	SR	√	x	x	x	
100	iv	Proper sealing of joints, Acceptance of formwork before concreting		Major	Physical/ Visual	Before start of concreting	As per provisions, tolerences, Tech. Specs, Construction drawings		√	x	x	x	
102	**7**	**Placement of Reienforcement Steel**											
103	i	Check whether Bar bending schedule (BBS) with necessary lap, spacers & chairs is available before start of cutting & bending of bars	As agreed/ required	Major	Visual/ physical	Random in each shift at each work site	Tech. Specs, Construction Drawings, IS: 2502	SR	√	x	x	x	
104	ii	Check whether cutting and bending of bars is as per BBS and placement conforms construction drawings			Visual/ measurement								
105	iii	Check whether all joints and crossing of bars are tied properly with right gauge and annealed wire			Visual								

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106	iv	Check for proper cover,spacing of bars, spacers & chairs after the reinforcement cage has been put inside the foundation			Visual								
107	v	Check whether lapping of bars are tied properly with right gauge and annealed wire			Visual								
109	8	**Concrete**											
110	i	Availability of approved Design Mix (for all specified grades)		Critical	Physical	For each specified grade of concrete	IS :456, Tech Specs, Construction Drawings	Approved mix design	√		x	x	The concrete shall be as per approved design mix and the materials (cement, coarse and fine aggregate shall be from the same source considered during mix trials. The mix design shall be verified and approved in case of change of source of any of the matearials
111	ii	Minimum cement content (as applicable in MMS piling and foundation/ below ground works)		Critical	Physical	For piling and foundation works	IS: 456, Tech. specs, Construction drawings	SR	√		x	x	The minimum cement content shall correspond to exposure conditions and/ or, suplphate contents in ground water/ soil
112	iii	Trial mixes to ascertain the workability and cube strength	As per recommended mix design from specialist agency	Critical	Physical/ Testing	One for each mix proportion	Tech. Specs, IS: 456	Lab Test Reports	√	x	x	x	Necessary correction for moisture content and water absoption according to mix design recommendations may be carried out during trial mix
113	iv	Mixing of concrete- check for quanities of cement, CA, FA and water used, Concrete shall be homogenous	Mixing shall be done in a approved mixer/ batching plant (conforming to IS: 4926/ 4925)	Major	Physical	Mixer/ Batcher to be calibrated at the time of starting and subsequently once in tree months	IS: 4925, IS: 4926	Calibration Report/ Certificate	√	x	x	x	Review of calibration chart/ Certificate as per IS: 4926 Qty. of materials including cement consumptionshall be available through on line printer
114	v	Handling & trasportation	As required	Major	Physical	100%	As per approved/ agreed construction methodology	SR		x	x	x	Concrete shall be placed within 30 minutes of its removal from mixer
115	vi	Placement of concrete	As required	Major	Visual/ Physical	100%			√	x	x	x	
116	vii	Compacting	As required	Major	Physical	At Random			√	x	x	x	
117	viii	Curing	As required	major	Physical	At Random	IS: 456	SR		x	x	x	
119	9	**Concrete Testing & Acceptance**											
120	i	Workability - Slump Test		Critical	Physical	At the time of concrete pouring at site every 2 hrs	IS:456, IS:516,IS:1199, Tech Specs, Construction Drawings	Test Results / SR	√	x	x	x	
121	ii	Crushing strength - (Works test cubes)		Critical	Physical	Testing	IS:456, IS:516,IS:1199, Tech Specs, Construction Drawings	Test Results/ SR	√	x	x	x	**MMS Pile** - 6 cubes (3 for 7 day test & 3 for 28 day strength) per sample for each 5 cum or part there off **Building work and Equipment/ Misc foundations etc.** - 6 cubes (3 for 7 day test & 3 for 28 day strength) per sample for each 25 cum or part there off
122	iii	Acceptance of concrete work - Dimensional check (dimensions, levels etc), placement of bolts, inserts, pockets, pitch distance for bolts etc.	As required & dimensional tolerences	Major	Visual/ Measurement	100%		Joint Protocol between Civil Conractor, EPC Vendor and SECI/ Owner where applicable/ SR	√	x	x	x	
124	10	**Acceptance of Hardened Concrete**											
125	i	Dimensional check (dimensions, levels etc), workmanship, finsishing after removal of shuttering	As required & dimensional tolerences	Major	Visual/ Measurement	At Random			√	x	x	x	

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126	ii	Water tightness test for liquid retaining structures/ tanks	As required	Critical	Physical/ Testing	100%	IS: 3370 (Pt.4), Tech Specs, Construction Drawings	SR/ Test Records	√	x	x	x	Water tightness test shall be performed for Under ground (UG) water tank, Septic tank
128	11	**Excavation & filling in foundations, trenches, plinth & grading works**											
129		**Excavation**											
130		Nature, Type of soil/ rock before and during excavation		Major	Visual	Random in each shift	Tech. Specs., Construction Drawings	SR		x	x	x	
131		Initial GL before start of excavation		Major	Measurement	100%		SR	√	x	x	x	
132		Final shape/ size & dimensions of excavation		Major	Measurement	100%		SR	√	x	x	x	
133		Final excavation levels		Major	Measurement	100%		SR	√	x	x	x	
134		Side slope of final excavation		Major	Measurement	Random in each shift		SR		x	x	x	
135	12	**Fill / Backfill**											
136	i	Suitability of borrowed earth for filling (if applicable) - Grain size analysis, Atterberg limits, Free swell index, Organic matter		Major	Physical	One in every 2000 cum or part there of for each type and source of fill material subject to min. 2 samples	IS: 2720 (Pt. IV), IS: 2720 (Pt. XI), Tech Specs, Construction Drawings	Lab Test Results/ SR	√	x	x	x	The parameter should not be worse than the parameter of the existing soil in plant area
137	ii	Optimum moisture content (OMC), Max. dry density (MDD) before fill		Critical	Visual	At Random	IS: 2720 (Pt. I), IS: 2720 (Pt.VII), Tech Specs, Construction Drawings	Lab Test Results/ SR	√	x	x	x	
138	iii	Layer thickness, Compaction procedure		Major	Visual	At Random	Approved Methodology, Tech. Specs, Construction Drawings	SR	√	x	x	x	The layer thickness, Type & Capacity of roller, No. of passes shall be as per approved methodology, Construction Drawing, Tech. Specs
139	iv	Degree of compaction - 1. Dry density by proctor needle penetration 2. Earth filling - In-situ Dry density (core cutter or sand replacement method) or Sand Filling - In-situ Relative density (Density Index)		Critical	Physical	(i)For foundation fill/ backfill - One for every 10 foundations at Random for each compacted layer (ii) For area grading/ filling - one every 1000 sqm area for each compacted layer	IS: 2720 (Pt. XXIX), IS: 2720 (Pt. XXVIII), IS: 2720 (Pt. XIV), Tech Specs, Construction Drawings	Test Results/ SR	√	x	x	x	
141	13	**Brick Masonry work**											
142	i	Soaking of Bricks before use		Major	Physical	100%	IS: 2250	SR		x	x	x	
143	ii	Grading of sand, Mortar mix / proportion, Compressive strength, Consistency		Major	Physical/ Test	At Random	IS: 2250, IS: 2116, Tech Specs, Construction Drawings / As per Design Specification	Lab Test Results/ SR		x	x	x	The sand grading shall conform to IS: 2116
144	iii	Workmanship, Verticality (Plumb) / Alignment		Major	Physical/ Measurement	100%	IS: 2212, IS: 1905, Tech Specs, Construction Drawings	SR	√	x	x	x	
145	iv	Check for Bond/closers, joints		Major	Visual	At Random	IS: 2250	SR		x	x	x	
146	v	Curing		Major	Visual	100%	IS: 2250 / As perTech. Specification	SR		x	x	x	
148	12	**Cement Plaster**											

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2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
149	i	Quality & Grading of sand, Check for mix proportion, wetting the surface etc		Major	Physical	At Random	IS: 2116, IS: 2386 (Pt. I & II), IS: 1542, Tech Specs	Lab Test Results/ SR		x	x	x	Sand to be used shall be free from deleteriousmaterials, Grading shall conform to Table-I of IS: 2116
150	ii	Plaster & grooves - Thickness, Evenness & Finishing, Trueness os palstering system		Major	Visual/ Measurement	At Random in each shift	Tech Specifications, Construction Drawings	SR	√	x	x	x	Trueness - Deviation not more than 4mm when checked with straight edge of 2m length
151	iii	Hacking, Raking of joints, Cleaning the surface, Removing all loose particles, Wetting the surface etc		Major	Visual	At Random in each shift	IS 1661, Tech Specs	SR		x	x	x	
152	iv	Curing		Minor	Physical	100%	IS 1661, Tech Specs	SR		x	x	x	
154	**14**	**Painting System- Plastered Masonry & Concrete surface**											
155	i	Materials & accessories - Approval for Paint, Color shade and Brand- Dry distemper, Oil Bound Distemeper, Acrylic Emulsion, Chemical resistant, Oil resistant Paint, Weather proof acrylic exterior paint, water proof cement paint etc.	As approved by SECI/ Owner	Critical	Review of MTC	Each batch of delivery	Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	MTC shall be correlated with the material received
156	ii	Surface preparation	As required	Minor	Physical	Random in each shift	IS: 2935 (Pt.1), Tech Specs, Construction Drawings	SR	x	x	x	x	
157	iii	Number of coats	As required	Major	Physical	Random in each shift	Tech Specs, Construction Drawings	SR	x	x	x	x	
158	iv	Application and Acceptance of painted surface	As required	Major	Physical	Each surface at Random							
160	**15**	**Floor finishes & Alied works**											
161	i	Preperation of Sub-grade			Physical	At Random for each building	Tech. Specs, Construction Drawings	SR	√	x	x	x	
162	ii	Plinth filling in layers (stone agrregates/ rubble with interstices filled with sand), ramming & compaction			Physical	At Random for each building	IS: 2720, Tech. Specs, Construction Drawings		√	x	x	x	Quality Checks as aplicable to Fill/ Back fill
163	iii	Check providing shuttering, reinforcement (if applicable)			Physical	At Random for each building	Tech. Specs, Construcion Drawings			x	x	x	Quality Checks as aplicable to Shuttering/ Reinforcement placement
164	iv	Checking the Panel size (as applicable)			Physical	At Random for each building	IS: 5491, Tech. Specs, Construcion Drawings			x	x	x	The concrete shall be cast in alternate panels in chess board fashion, panel size as specified in Construction Drawing or 25 sqm
165	v	Availability of Design mix (if applicable)			Visual	At Random for each building	Tech. Specs, Construcion Drawings	Mix Design Report/ SR		x	x	x	
166	vi	Clearance for concreting (as applicable)			Physical	100%	Tech. Specs, Construction Drawings	Joint Protocol between Civil Contractor, Eqpt. Supplier/ EPC Vendor & SECI/ Owner SR		x	x	x	
167	viii	Performing concreting ensuring Grade/Mix Proportions, Compaction, Thickness and Finish			Physical	At Random per shift	IS; 456, Tech. Specs, Construction Drawings	SR	√	x	x	x	Quality Checks as aplicabel to Concrete Work
168	viii	Curing			Visual	100%	IS: 456, Tech. Specs	SR		x	x	x	Minimum up to 10 days from date of casting
169	ix	Testing of Concrete Cubes for Flooring			Physical	One sample for every 20 Cum of concreting or part thereof for each days concreting (one sample consists of min 3 test cubes for 28 days strength)	IS:456, IS:516,IS:1199 and Design specification	Lab Test Reports					
170	x	Tiled flooring/ dado											

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2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
171	a	Material - Glazed ceramic Tiles, Vitrified Ceramic Tiles, Mosaic Tailes, Acid alkali Tiles, Heavy duty cement concrete tiles	As agreed/ required	Critical	Review of MTC & Test Reports	Each lot of material received	IS:13755, IS:1237, IS:8042, Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	MTC shall be correlated for all the parameters specified in Tech. Specs, BIS Standard
172	b	Finishing & Acceptance		Major	Physical	100%	IS: 1443, Tech Specs, Construction Drawings						
173	xi	IPS with or without IRONITE (as aplicable)		Major	Physical	At Random per shift	IS: 5491, Tech. Specs, Construction Drawings	SR	√	x	x	x	
174	xi	Fixing of Panel Dividers for finishing course (3 mm Thk Glass/ 2mm Thk Aluminium strip) (if applicable)		Major	Physical	At Random per shift	Tech Specs, Construction Drawings	SR	√	x	x	x	
175	xii	Anti abrasion/ anti wearing epoxy coating (if aplicable)											
176	a	Material	As agreed/ required	Critical	Approved Make and Type	Each lot of material received	Tech Specs, Construction Drawings, Manufacturer's Brochure/ Recommendations	manufacturer's Brochure/ SR	√	x	x	x	Material specifications to be correlated with Manufacturer's Brochure
177	b	Finishing & Acceptance		Major	Physical	100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
178	xiv	Kota stone flooring and skirting (as aplicable)											
179	a	Material	Quality, Texture, Thickness, Colour fro approved source	Major	Physical	Each batch of delivery	Tech Specs, Construction Drawings	SR	√	x	x	x	
180	b	Finishing & Acceptance		Major	Physical	100%	Tech Specs, Cosntruction Drawings	SR	√	x	x	x	
181	xv	Acid/ Alkali resistant tile flooring/ dado											
182	a	Material -Tiles, Mortar, Sealing, Fillers etc.	Thickness, Quality,	Critical	Approved source, Review of MTC/ Test Report	Each batch of delivery	Tech Specs, Construction Drawings	SR	√	x	x	x	The acid alkali resistant tile flooring nd dado shall be provided in battery room as per approved Arch finishing details
183	b	Finishing & Acceptance	Workmanship	Major	Physical	100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
184	xvi	Interlocking Blocks											
185	a	Materials	Size/ Shape, colour shade, Grade of Concrete	Critical	Approved source, Review of MTC/ Test Report	Each batch of delivery	BS: 6717, Tech Specs, Construction Drawings	SR	√	x	x	x	
186	b	Final finishing & Acceptance	As agreed/ required	Major	Physical	100%	BS: 7533 (Pt.3), Tech Specs, Construction Drawings	SR	√	x	x	x	
188	**16**	**Damp Proof Course**											
189	i	Material - Hot bitumen & water proofing materials etc.	As agreed/ required	Critical	Review of MTC	Each batch of delivery	IS: 702, Tech. Specs, Cosntruction Drawings	SR	√	x	x	x	
190	ii	Acceptance of Damp Proof Course - Thickness, Grade of PCC, Application of Bitumen layer etc.	As agreed/ required	Major		100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
192	**17**	**Grouting of pockets/ underside of base plate**											
193	i	Material	As required/ Agreed	Critical	Review of MTC/ Physical	Each batch of delivery	Tech. specs, Construction Drawings, Manufacturerr's catelogue	SR	√	x	x	x	In case of ready mixed grout MTC to be correlated with Manufacturerr's catelogue
194	ii	Type of Mix	Anti shrink cement grout/ Ready mixed - Fluid mix, stiff mix as required	Major	Physical	At Random prr shift of grout application	Tech. specs, Construction Drawings	SR	√	x	x	x	In case of cement grout anti shrink compound shall be added as per provisions of relevant IS/ Cosntruction Drawing
195	iii	Mixing, placement, application	As required	Major	Visual	At Random prr shift of grout application	Tech. Specs, Construction Drawings	SR	√	x	x	x	
196	iv	Crushing Strength - Test cubes	As required	Major	Physical/ Testing	3 cubes for entire grouting work	IS: 4031 (Pt.6), Tech Specs, Construction Drawings	SR/ Lab Test Report	√	x	x	x	

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197	v	Acceptance of Grouting	Thickness, Finished level etc.	Major	Physical	!00% of 20 % of grout work at Random	Tech. Specs, Construction Drawings	SR	√	x	x	x	
199	18	**Precast Concrete**											
200	a	**Bought Out Units (Precast boundary wall units - Slab Panels, Column etc., Trench Covers , Manhole Covers, Paver Blocks etc.)**											
201	i	Crushing strength	As required	Critical	Review of MTC/ Test Reports	100% for Each batch of delivery	IS: 456, IS:516, IS: 1199, Tech Specs, Construction Drawings	MTC	√	x	x	x	Sampling as per IS: 456, Vendor record review
202	ii	Workmanship, dimentions, R/F	As require/ agreed	Major	Review of MTC/ Physical	Each batch of delivery at Random	Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	Vendor record review, Physical check at Random
203	b	**Cast at site (if applicable)**											
204	i	Crushing strength - Test Cubes	As required	Critical	Testing		IS: 456, IS:516, IS: 1199, Tech Specs, Construction Drawings	SR	√	x	x	x	1 sample of 6 cubes (3 for 7 days strength, 3 for 28 days strength) for each 5 cum of concrete with minimum 1 sample per shift of concrete work
205	ii	Workmanship, dimentions, R/F	As required/ agreed	Major	Physical	At Random	Tech Specs, Construction Drawings	SR		x	x	x	
206	c	**Acceptance of pre-cast concrete units**											
207	i	Bought Out Units - Check for any breakage, damage during handing & trasport, erection at site (levels) etc.	As required/ Agreed	Major	Visual	At Random	Tech Specs, Construction Drawings	SR	√	x	x	x	
208	ii	Cast at site (if applicable) - Check for curing, damage during handling, erection at site (level) etc.	As required/ Agreed	Major	Visual	100% of 10% at Random	Tech Specs, Construction Drawings	SR	√	x	x	x	
210	19	**Joints In concrete**											
211	i	Joint Material - Bitumen inpregnataed fiber board, PVC water stop, Sealing compound - Bitumastic/ polysulphide, Hydrophilic strip, Expanded polysterene (thermocol) board etc.	As per manufacturer's standards	Critical	Review of MTC	Each batch of delivery	Tech. Specs, Construction Drawings, IS: 1838, IS:1834, IS:2200	MTC	√	x	x	x	
212	ii	Acceptance of installation	As agreed/ required	Major	Physical	Each installation at Random	Tech. Specs and Construction Drawings	SR	√	x	x	x	
214	20	**Underdeck Insulation Works**											
215	i	Insulation material - Mineral/ Glass wool, galvanized wire neting, Aluminium foil, fasteners etc.	As agreed/ required	Critical	Review of MTC/ Test Reports	Each lot received at site	Tech. Specs and Construction Drawings	MTC/ Test Reports/ SR	√	x	x	x	All tests as per Tech. Specifications
216	ii	Acceptance of installation	As agreed/ required	Major	Physical	Each installation	Tech. Specs and Construction Drawings	SR	√	x	x	x	
218	21	**False Ceiling**											
219	i	Materials - Gypsum board/ Tiles, Particle board tiles, Al tiles/ Strips, GI hangers, AL/ GI Tee support, AL/ GI Edge angle, Fasteners etc.	As agreed/ required	Critical	Visual/ Physical, Review of MTC	Each lot received at site	IS:2095, IS:8183, Tech. Specs and Construction Drawings	MTC/ SR	√	x	x	x	Compare MTC with Tech. Specifications and requirements
220	ii	Acceptance of Installation	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
222	22	**Doors, Windows, Ventilators, Glass/ Glazing and Grill**											

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223	i	Door Frame (Hollow steel metal, Aluminium, Wooden etc. including fittings such as hold fasts etc.)	As agreed/ required	Critical	Visual, Physical, Review of MTC/ Test Reports	Each lot received at site	Tech. Specs and Construction Drawings	MTC/ Lab Test Reports/ SR	√	x	x	x	
224	**a**	**Steel Doors**											
225	i	Materials (MS sheet & Stiffeners, fasteners,hinges, jambs, lock strike plate, hydraulic door closer, fittings and fixtures etc)	As agreed/ required	Critical	Visual/ Physical/ Review of MTC, Test Report	Each lot received at site	IS:2062, Tech. Specs and Construction Drawings	MTC/ Lab Test Report/ SR	√	x	x	x	Review of MTC/ Test Report
226	ii	Finishing & Acceptance - Surface preperation for painting, primer & finishing coat, DFT	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR	√	x	x	x	
227	**b**	**Flush Doors**											
228	i	Shutters, Teak beading	As agreed/ required	Critical	Review of MTC/ Test Report	Each lot received at site	IS:2202, Tech. Specs and Cosnstruction Drawings	MTC/ Lab Test Report/ SR	√	x	x	x	
229	ii	Acceptance	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
230	**c**	**Aluminium doors and Partition works**											
231	i	Materials- Aluminium sections (average thickness, alkali resistant, anodisation, power coating and colour shade etc.), fittings and fixtures. floor spring, hydraulic door closer, hinges, etc.	As agreed/ required	Critical	Visual/ Physical/ Review of Test Report	Each lot received at site	IS:1948, IS;1949, IS:733, IS:1285, IS:1868, IS:11857, Tech. Specs and Construction Drawings	SR/ Lab Test Reports	√	x	x	x	Review of Test Report For anodization check as per Tech. Specs and Construction Drawings Power coating, colour shade as applicable as per Tech. Specs and Construction Drawings
232	ii	Finishing & Acceptance - fabrication & erection, fitting etc..	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
233	**d**	**Grill**											
234	i	Materials - Aluminium, MS, Anodization in case of aluminium	As agreed/ required	Critical	Visual/Physical/ Review of Test Report	Each lot received at site	Tech. Specs and Construction Drawings	SR/ Lab Test Reports	√	x	x	x	Review of Test Reports
235	ii	Finishing & Acceptance - erection, fitting, painting in case of MS grill etc.	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
236	**e**	**Rolling Shutters**											
237	i	Surface finish, Thickness of plate, mechanically operated	As agreed/ required	Critical	Visual/ Physical/ review of MTC	Random for each lot of delivery	IS:8248, Tech. Specs & Construction Drawings	SR	√	x	x	x	
238	ii	Finishing and Acceptance -Painting , DFT	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
239	**f**	**Glass and Glazing**											
240	i	Material - Clear float glass, wired glass, tinted glass, ground glass, figured glass, thickness	As agreed/ required	Major	Review of MTC/ test reports	For each lot received at site	IS: 14900, IS:1081, IS: 3548, IS:5437 Tech Specs and Construction Drawings	SR	√	x	x	x	
241	ii	Installation, finishing and acceptance	As agreed/ required	Major	Visual/ Physical	Random	Tech Specs and Construction Drawings	SR	√	x	x	x	
243	**23**	**Precast Concrete Boundary Wall**											
244		Acceptance of boundary wall- Finising, Alignment Dimensions etc.	As agreed/ required	Major	Physical		Tech Specs and Construction Drawings	SR		x	x	x	For inspection of precast concrte units -refer S.No. 18
246	**24**	**Roof Water Proofing**											
247	i	Methodology for the application of water proofing system	As required	Critical	Review	for each type of treatment	Tech Specs and Const. Drawings						
248	**a**	Materials											

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249	i	Polyurethene based coating, polyester scrim cloth, extruded HD dimpled polyurethene	As agreed / required	Critical	Review of MTC/ test reports	For each lot received at site	ASTM C-836, ASTM C898 and Tech Specs /Const. Drawings	MTC/ SR	√				
250	b	Roof											
251	i	Graded under bed - Slope/ Level	As agreed / required	Major	Physical	100%	Tech Specs and Construction Drawings	SR		x	x	x	
252	ii	Elastomaric coatings -Primer coat, Finishing coat	As agreed / required	Major	Review of MTC/ test reports	Each lot of delivery	Tech Specs and Construction Drawings	MTC/ Test Reports/ SR	√	x	x	x	
253	iii	Wearing Course - PCC-Grade, chicken wire mesh, elastomeric sealant	As agreed / required	Major	Visual/ Review of MTC	Each lot of delivery of material/ Review of Test Report	Tech Specs and Construction Drawings	MTC/ Test Reports SR	√	x	x	x	2 samples of 3 no. of test cube each shall be taken for PPC work for testing of crushing strength of concrete mix, Review of MTC for Chicken wire mesh, waterproof sealant
254	c	Acceptance of Water proofing treatment	As agreed/ required	Major	Visual/ Physical	100%	Tech Specs and Construction Drawings	SR		x	x	x	
256	25	**Water Supply and Sanitary Installations**											
257	a	**Water Supply Fittings and Fixtures**											
258	i	Materials - GI/ MS/ C-PVC/ uPVC/PPR/HDPE pipes and fittings	As agreed / required	Critical	Review of MTC/ test reports	Each lot of delivery as per Specifications	IS:1239, IS:4736, IS:4985, IS:6745, IS: 4984, IS:2633, IS:2629, IS:15778, IS:15801, Tech Specs and Construction Drawings	MTC/ SR	√	x	x	x	
259	ii	Disinfection - Before use	As agreed / required	Major	Physical	Each installation	IS:2065, Tech specs and construction Drawings	SR		x	x	x	
260	iii	Hydraulic test - Before use/ Leakage	As agreed / required	Critical	Physical	Each installation	Tech Specs and Construction Drawings	SR		x	x	x	
261	iv	Acceptance & Working	As agreed / required	Major	Physical	Random	Tech Specs and Construction Drawings	SR		x	x	x	
262	b	**Sand Cast Iron/ Cast iron Pipes**											
263	i	Material - SCI / CI pipes and fittings / joints	As agreed / required	Critical	Review of MTC/ test reports	Each lot of delivery (as applicable)	IS: 1729, IS:1536, IS:1538, Tech Specs and Construction Drawings	MTC/ SR	√	x	x	x	
264	ii	Acceptance and leakage	As agreed / required	Major	Physical	Random	Tech Specs and Construction Drawings	SR		x	x	x	
265	c	**HDPE Pipes for Sewerage**											
266	i	Material- HDPE pipes and fittings/ joints	As agreed/ required	Critical	Review of MTC/ test reports	Each lot of delivery (as applicable)	IS:14333, Tech. Specs	MTC/SR	√	x	x	x	
267	ii	Acceptance & leakage	As agreed / required	Major	Physical	Random	Tech Specs and Const. Drawings	SR		x	x	x	
268	d	**HDPE Pipes for Rain water Downcomer**											
269	i	HDPE pipes and fittings/ joints	As agreed/ required	Critical	Review of MTC/ test reports		IS:4984, Tech. Specs	MTC/SR	√	x	x	x	
270	ii	Acceptance & leakage	As agreed / required	Major	Physical	Random	Tech Specs and Const. Drawings	SR		x	x	x	
271	e	**Sanitary fitting and fixtures**											
272	i	Sanitory items and fixtures i.e. water closets, urinals, wash basins, sinks, mirrors, shelves, towel rail, soap containers, geyser, water cooler, etc, water supply / sanitation pipes, manhole cover and frames etc	As agreed / required	Major	Review of MTC/ Test reports	Each lot of delivery as per Specifications	Tech Specs and Const. Drawings	MTC/Test Reports/ SR	√	x	x	x	

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273	ii	Acceptance of installations of all sanitory items and fixtures	As agreed / required	Major	Acceptance	100%	Tech Specs and Const. Drawings	SR		x	x	x	
274	**f**	**RCC Pipes**											
275	i	Material - RCC pipes	As agreed / required	Major	Review of MTC/ test reports	Each lot of delivery as per Specifications	IS: 458, Tech Specs and Const. Drawings	MTC/Test Reports/ SR	√	x	x	x	
276	ii	Acceptance and leakage	As agreed / required	Major	Physical	Random	Tech Specs and Const. Drawings	SR		x	x	x	
277	**g**	**Water Storage Tank**											
278	i	Over head / loft type	As agreed / required	Critical	Physical, review of MTC/ test reports	Each lot of delivery as per Specifications	IS:12701, Tech Specs and Const. Drawings	MTC/Test Reports/ SR	√	x	x	x	
279	ii	Aceptance and leakage	As agreed / required	Major	Acceptance	Random	IS:12701, Tech Specs and Const. Drawings	SR		x	x	x	
281	**26**	**Special Item (Switch Yard)**											
282	**a**	**Earthing Mat (Grounding System)**											
283	i	Earthing mat	As agreed / required	Critical	Physical, review of MTC/ test reports	Each lot of delivery as per Specifications	As per relevant IS and Tech. Specs / Manufacturer's, IS 3043	SR/MTC	√	x	x	x	
284	ii	Weld sizes & length	Visual/Tape	Major	Visual/ Measurement	100%	Tech Specs and Const. Drawings	SR		x	x	x	Low hydrogen electrode as per approval shall be used.
285	iii	D P test	DP test Kit	Critical	Physical	10% at random	Tech Specs and Const. Drawings	TR	√	x	x	x	
286	iv	Earth test	Earthing test kit	Critical	Physical	100%	IS:3043, Tech Specs and Const. Drawings, Relevant IS 3043	SR/ Test Report	√	x	x	x	
287	**b**	**Anti Weed Treatment**											
288	i	Anti-weed treatment materials	As agreed / required	Critical	Physical, review of MTC	Each batch of delivery	Tech Specs and Const. Drawings	SR/ MTC	√	x	x	x	
289	ii	Execution of treatment	As agreed / required	Major	Physical	Random check for each treatment	Tech Specs and Const. Drawings	SR		x	x	x	
291	**27**	**Road Work**											
292	**a**	**Construction of Sub-Grade and earthen/hard soulders**											
293	i	Standard proctor Test	As per IS: 2720	Critical	Physical	One in every 2000 cum for each type and source of fill materials	As per Tech Specs and Const. Drawings,Section 900 of MORTH specification, IS 2720 (Pt.VII)	SR	√	x	x	x	In cutting or existing levelled ground - quantum of check shall be one per 1000 SQM
294	ii	Moisture content of fill before compaction	As per IS: 2720	Major	Physical	One in every 2000 cum for each type and source of fill materials	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification, IS 2720 (Pt.II)	SR		x	x	x	In cutting or existing levelled ground - quantum of check shall be one per 1000 SQM
295	iii	Dry density by core cutter method ---- OR---- Dry density in place by sand displacement method	As per IS: 2720	Critical	Physical	One in every 500 SQM area for each compacted layer.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification, IS 2720 (Pt. XXIX)/ IS 2720 (Pt. XXVIII)	SR	√	x	x	x	Both for embankment and cut formation quantum of check - One in every 1000 SQM area for each compacted layer.
296	iv	Lines, grade and cross section	As required / agreed	Major	Physical	One in every 500 SQM area	As per Tech Specs and Const. Drawings	SR	√	x	x	x	Template, straight edge

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297	**b**	**Water Bound Macadam (Non-Bituminous) for base course and sub-base course**											
298	i	Aggregate Impact value	Agrregate Impact value Test Apparatus	Critical	Physical	One test per 200 cum of Test aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
299	ii	Grading	Set of IS Sieves	Major	Physical	One test per 100 cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
300	iii	Flakiness index and elongation index	Flakiness test gauge	Major	Physical	One test per 200cun of agregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
301	iv	Atterberg Limits of binding material	Atterberg limits determination	Critical	Physical	One test per 25 cum of binding material	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
302	v	Atterberg Limits of portion of agreggate passing 425 micron sieve	Atterberg limits determination	Critical	Physical	One test per 100cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
303	vi	Camber, surface, slope	As required / agreed	Major	Physical	One in every 500 SQM area	As per Tech Specs and Const. Drawings	SR	√	x	x	x	Template, straight edge
304	**c**	**Bituminous Macadam for base and binder course**											
305	i	Quality of binder	Penetrometre with St. needle	Critical	Physical	No. of samples per Lot & tests as per IS:73, IS:217, IS:8887 as applicable	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification, IS 73	SR	√	x	x	x	
306	ii	Aggregate Impact Value / Los angeles abrasion value	Aggregate Impact ValueTest apparatus	Major	Physical	Once per source	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
307	iii	Flakiness Index and elongation index of aggregates	Flakiness test gauge	Major	Physical	One test per 50 cum of aggregate	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
308	iv	Stripping value of aggregate (Immersion tray test)	As required / agreed	Major	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
309	v	Water sensitivity of mix	As required / agreed	Critical	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
310	vi	Grading of aggregates	Set of Sieves	Major	Physical	Two test per day per plant both on individual constituents and mixed aggregate from dryer	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR		x	x	x	
311	vii	Water absorption of aggregate	As required / agreed	Major		Initially one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR		x	x	x	

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312	viii	Soundness (Magnesium and Sodium Sulphate)	As required as per IS:2386	Critical	Physical	Once per source by each method and on every change of source	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR	√	x	x	x	
313	ix	Percentage of fractured faces	As required / agreed	Major	Physical	When gravel is used one test per 50cum of aggregates	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR		x	x	x	
314	x	Binder content and aggregate grading	Bitumen extractor	Critical	Physical	Periodic, subject to a min of two tests per day per plant	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
315	xi	Control of Temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	Thermometer	Major	Physical	At regular close intervals	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
316	xii	Rate of spread of mixed materials	As required / agreed	Major	Physical	Regular control through checks of layer thickness	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
317	xii	Density of compacted Layer	As required / agreed	Critical	Physical	One test per 250 sqm of area	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
318	**c**	**Bituminous Surfacing - Open graded premix carpet and Seal coat**											
319	i	Quality of binder	Penetrometre with St. needle	Critical	Physical	No. of samples per Lot & tests as per IS:73, IS:217, IS:8887 as applicable	IS 73,Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
320	ii	Aggregate Impact Value / Los angeles abrasion value	Aggregate Impact ValueTest apparatus	Major	Physical	One test per 50 cum of aggregate	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
321	iii	Flakiness Index and elongation indexof aggregates	Flakiness test gauge	Major	Physical	One test per 50 cum of aggregate	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
322	iv	Stripping value of aggregate (Immersion tray test)	As required / agreed	Major	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
323	v	Water absorption test		Critical	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
324	vi	Water sensitivity of mix	As required / agreed	Critical	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
325	vii	Grading of aggregates	Set of Sieves	Major	Physical	One test per 25 cum of aggregates	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	

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326	viii	Soundness (Magnesium and Sodium Sulphate)	As required as per IS:2386	Critical	Physical	Once per source by each method and on every change of source	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
327	ix	Polished stone value	As required as per BS:812(Part 114)	Major	Physical	As required	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
328	x	Temperature of binder at application	Thermometer	Major	Physical	At regular close intervals	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
329	xi	Binder content	Bitumen extractor	Critical	Physical	One test per 500 cum& not less than two tests per day	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
330	xii	Rate of spread of materials	As required / agreed	Major	Physical	One test per 500 cum and not less than 2 tests per day	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
331	xiii	Percentage of fractured faces	Bitumen extractor	Critical	Physical	When gravel is used one test per 50cum of aggregates	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
332	**d**	**Tack Coat/ Prime coat/ fog coat**											
333	i	Quality of binder	Penetrometre with Standard needle	Critical	Physical	No. of samples per Lot & tests as per IS:73, IS:217, IS:8887 as applicable	IS 73,Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
334	ii	Temperature of binder at application	Thermometer	Major	Physical	At regular close intervals	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
335	iii	Rate of spread of binder	As required / agreed	Major	Physical	One test per 500 cum and not less than 2 tests per day	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
336	**e**	**Alignment, Level, Surface regularity and rectification**											
337	i	Horizontal alignment, Surface levels and Surface regularity	As required / agreed	Major	Physical	At Random	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	x	x	x	
338	ii	Rectification	As required / agreed	Major	Physical	Each rectification	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		x	x	x	
340	**28**	**Geotechnical Investigations**											
341	i	Deployment of approved Geotechnical Investigation Agency - Equipments, Manpower etc	As required / agreed	Critical	Physical	Once before commencement of work	As per technical specifications and relevant IS Codes	SR	√	x	x	x	
342	ii	Execution of Geotechnical Investigation - locations, type etc as per scheme	As required / agreed	Major	Physical	Each Location	As per technical specifications and relevant IS Codes	SR		x	x	x	
343	iii	Collection of disturbed and undisturbed samples , their packing and storage	As required / agreed	Major	Physical	each sampling	As per technical specifications and relevant IS Codes	SR		x	x	x	
344	iv	Conducting filed tests as per investigation scheme- such as, SPT/ERT/SCPT/PLT/PMT etc	As required / agreed	Major	Physical	each field test	As per technical specifications and relevant IS Codes	SR		x	x	x	

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345	v	Submittion of Field Borelogs in approved format	As required / agreed	Major	Review	Within 24 hours after completion of each BH	As per technical specifications and relevant IS Codes	SR		x	x	x	
346	vi	Submittion of laboratory test schedule and selection of samples for laboratory testing	As required / agreed	Critical	Review and acceptance	as per consultation with engineer during dispatch of samples to approved laboratory	As per technical specifications and relevant IS Codes	SR	√	x	x	x	
347	vii	Submission of Final Geotechnical investigation report along with recommendations	As required / agreed	Critical	Physical	After completion of investigation work and review of draft reports	As per technical specifications and relevant IS Codes	SR		x	x	x	
349	**29**	**Topographical Survey Works**											
350	i	Deployment of approved Topographical Surveying Agency - Equipments, Manpower etc	As required / agreed	Critical	Physical	Once before commencement of work	As per technical specifications and relevant IS Codes	SR	√	x	x	x	
351	ii	Transfer of Permanent Bench mark to site from known location	As required / agreed	Major	Physical	Before commencement of work	As per technical specifications and relevant IS Codes	SR		x	x	x	
352	iii	Establishment of boundary pillers and survey grid, Temporary bench Marks, Measurement & recording spot levels	As required / agreed	Major	Physical		As per technical specifications and relevant IS Codes	SR		x	x	x	
353	iv	Recording features like trees, roads, transmission lines, lake, nala, river, temple, house, culverts etc. with coordinate locations	As required / agreed	Major	Physical		As per technical specifications and relevant IS Codes	SR		x	x	x	
354	vi	Submission of final Counter map showing all topographical features, record of spot levels	As required / agreed	Critical	Physical	After completion of investigation work and review of draft reports	As per technical specifications and relevant IS Codes	SR	√	x	x	x	
356	**30**	**Internal Switchyard - Site Leveling & Grading**											
357	i	Leveling Switchyard area	As required / agreed	Major	Visual / Physical	100%	As perTech. Specification and Approved Drawing	SR		x	x	x	
358	ii	Grading of 20/40mm stone / Gravel Spreading in sitchyard area	As required / agreed	Major	Physical	100%	As per Tech. Specification & Approved Drawing	SR		x	x	x	
360	**31**	**Plant Boundary Fencing (if applicable) & Gate (Also refer S.No. 3 for Steel works as applicable)**											
361	i	Fence posts (Intermediate, Stay & Corner Posts etc.) - Section size, Length, Galvanization - Grade/ Thickness, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC	Each lot received at site Random	IS:226; IS:2721; IS:278; IS:480; IS:4826 , Tech. Specs & Construction Drawings	MTC/ SR	√	x	x	x	For Structural steel checks refer S.No. 3
362	ii	Barbed wire - Dia. of line wire and barb wire, Grade of galvanization etc, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
363	iii	Tie wire - Diameter, Galvanization-Grade, tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/				√	x	x	x	
364	iv	Blade barbed/ Concertina Wire - Thickness/ Diameter, galvanization, Diameter of concertina coil, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	

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365	v	Fence Fabric- Mesh size, Wire Diameter, Galvanization-Grade, Selvage, Knuckling, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
366	vi	MS Gate - Caster weels, ball & bearings, Fixtures & fasteners etc.	As agreed/ Required	Major	Visual	100%	Tech. Specs & Construction Drawings	SR		x	x	x	
367	vi	Acceptance of Boundary Fence and gate	As agreed/ Required	Major	Physical	100%	Tech. Specs & Construction Drawings	SR		x	x	x	
369	**32**	**Tranformer Yard Fencing & Gate (Also refer S.No. 3 for Steel Works as applicable)**											
370	i	Fence posts (Intermediate, Stay & Corner Posts), Concertina Wire Support Angles - Section size, Length, Galvanization, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC	Each lot received at site Random	IS-226; IS 2721; IS-4948 , IS:480; IS:4826 Tech. Specification and Approved Drawing	MTC/ SR	√	x	x	x	For structural steel checks refer S.No. 3
371	ii	Tie wire (as aplicable) - Diameter, Galvanization, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
372	iii	Fence Fabric (chain link/ welded wire as aplicable)- Mesh size, Wire Diameter, Galvanization, Selvage, Knuckling, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
373	iv	MS Gate - Fixtures and fasteners	As agreed/ Required	Major	Visual	100%	Tech Specs andAproved Drawings	SR		x	x	x	
374	v	Acceptance of Fence & Gate	As agreed/ Required	Major	Physical	100%	Tech Specs and Approved Drawings	SR		x	x	x	
376	**33**	**Installation of Pre Engineered Building (PEB) - Security Cabin**											
377	**a**	**Receipt**											
378	i	Receipt of materials and Checking as per packing list	As agreed/ Required	Major	Visual	100%	As per Approved Drawings & Method Statement, Relevant BIS standards	SR	√	x	x	x	
379	iii	Dimensional Check	As agreed/ Required	Major	Measurement	100%			√	x	x	x	
380	iv	Visual checks for damages, rusting, pitting etc.	As agreed/ Required	Major	Visual	100%				x	x	x	
381	v	Visual checks for defects, primer coating and painting/galvanising as applicable.	As agreed/ Required	Major	Visual	100%				x	x	x	
382	vi	Nut/Bolt/Washers Checks	As agreed/ Required	Major	Visual	100%				x	x	x	
383	**b**	**Pre-Installation**											
384	i	Check that the work area is ready and safe to start installation	As agreed/ Required	Major	Visual / Dimension					x	x	x	
385	ii	Check readiness of Foundations	As agreed/ Required	Major		100%				x	x	x	
386	**c**	**Installation (as aplicable)**											
387	i	Readyness of concrete platform, foundations for installation- Size, Location, Level etc.	As agreed/ Required	Major	Visual					x	x	x	
388	ii	Check PUF side walls/ roof are installed properly	As agreed/ Required	Major	Physical					x	x	x	
389	iii	Check tightening of all Nut/Washers/Bolts	As agreed/ Required	Major	Physical					x	x	x	
391	**34**	**Structural Work for Module Mounting Structure (MMS)**					Tech. Specification, Approved Drawing & Method Statement						
437	**a**	**Manufacturing**											

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sr.No.	Activity & Operation	Instruments	Class of Check	Type of Check	Quantum of Check	Reference Documents & Acceptance Standard	Format of Record	D* (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	Cheking Agency			Remarks
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
438		**Strucural Steel (Raw Material)** Hot rolled & cold formed sections - Angle, Channel, Z-section, Box section, Plate, rod & bar											
439	i	Ultimate Tensile Strength (UTS), Yield Strength (YS), Percentage Elongation, Bend Test, Chemical Composition, Section dimensions	As agreed/ Required	Critical	Chemical composition, Mechanical, Measurement	1 Sample per 50 MT or part thereoff/ for every heat no.	IS 2062, IS 513, IS 811, IS 1079, IS 808, IS 1852, IS 1730 -Part I	MTC	√				Raw material to be procured from reputed manufacturers - like SAIL, RINL, JSPL, JSW, TISCO, ISSAR
440	ii	Visual Examination - Cracks, Scaling, Rust, Pitting, Lamination etc.	As agreed/ Required	Major	Visual	10% IS 2500, Level II, AQL 1.5	IS 2062, IS 513, IS 811, IS 1079, IS 808, IS 1852, IS 1730-Part I	SR	√	x	x	x	Material shall be free from surface defects like cracks, lamination,roughness, imperfect edges, rust, pitting & other harmful defects. Removal of minor surface defects as per IS;2062 is acceptable. Witness for 10% sample. Record review for every material
441		**Boughtout Item (Hardware - Nuts, Bolts and Washers - plain, spring)**											
442	i	Mechanical & Chemical Properties	As agreed/ Required	Critical	Chemical composition, Mechanical	1 sample per 5 MT or part thereoff	IS 1327 (Part 17) eq./ ASTM standard	MTC/ Lab test Report	√	x	x	x	
443	ii	Dimensional check (Dia., Thickness, Total stem length & Threaded length etc.)	As agreed/ Required	Major	Measurement	IS 1327 (part 17) eq 10 pieces per lot per member type	IS 6639, IS 2016,IS 6610 & IS 3063 / ASTM standard	Vendor Records	√	x	x	x	Witness for sample. Record review for every material
444	iii	Galvanizing - Mass per Sqm, Thickness (DFT)	As agreed/ Required Alcometer	Major	Visual, Measurement	IS 1327 (part 17) eq 10 pieces per lot per member type	For Hot dip galvanizing should be maintained 43 microns (min) and average 54 microns as per IS 1367 (part XIII) eq.	Vendor Records	√	x	x	x	Record review Random sample inspection/ measurement
445	b	**In Process Inspection**											
446		**Structural Item Fabrication**											
447	i	Straightening	As agreed/ Required	Major	Visual	100%	0.2% of total length	Vendor Records	√	x	x	x	Record review
448	ii	Cropping (Cutting)	As agreed/ Required	Major	Visual	100%	Approved drawing	Vendor Records	√	x	x	x	Record review
449	iii	Identification/ Marking	As agreed/ Required	Major	Visual	100%	Approved drawing Marking Shall be done with the help of permanent paint marker using stencil as per Drawing	Vendor Records	√	x	x	x	Record review Random sample inspection
450	iv	Punching/ Drilling of Holes	As agreed/ Required	Critical	Measurement	1 piece per 25 pieces	IS 802/ Approved drawing	Vendor Records	√	x	x	x	Record review
451		Edge Security							√	x	x	x	
452	v	Overall Length	As agreed/ Required	Major	Measurement	1 piece per 25 pieces	IS 802/ Approved drawing	Vendor Records	√	x	x	x	Record review Random sample measureemnt
453	vi	Bending	As agreed/ Required	Critical	Measurement	100%	IS 801, 811/ Approved drawing	Vendor Records	√	x	x	x	
454		Cross Section Dimensions							√	x	x	x	Record review
455	vii	Welding	As agreed/ Required	Major	Visual	100%	Approved Welding Procedure & Welder Qualification	Vendor Records	√	x	x	x	Record review Random sample ispection
456	viii	Visual Examination - Black spots, Porosity, Spatter, Rust bleed points, Weld dimensions	As agreed/ Required	major	Visual	100%	Tech. Specification, Approved Drawing	Vendor Records	√	x	x	x	Record review Raddom sample inspection (The fabricated material shall be free from
457	ix	DP Test (as necessary)	As agreed/ Required	Major	Chemical	Shift wise/ random	As and when required	Vendor Records	√	x	x	x	
458	x	Final Inspection of Fabricated Parts - Cross section dimensions, Thickness (before galvanization)	As agreed/ Required	Critical		10 % in lot size of 100 nos.	IS- 802, IS 807, IS 811 and relevant applicable eq. standards , approved drawings, Tech spec	Vendor Records	√	x	x	x	
459		**Galvanizing**											
460	i	Zinc - Ingot, Molten metal in galvanizing bath	As agreed/ Required	Critical	Chemical	1 sample from each batch of ingot supply	IS 2629	MTC Lab test report	√	x	x	x	Purity of Zn 98.5% MTC to be correlated. Molten metal in the galvanizing bath ≥ 98.5 % by mass of zinc.
461		**Pre Galvanizing**											

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2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
462	i	Degreasing	Acid base cold degreaser	Major	Chemical	One sample daily	Sp. Gravity 1.1 to 1.2, ph Value 2 to 3	Vendor Records	√	x	x	x	Record review
463	ii	Pickling - Acid & Iron content	Lab test	Major	Chemical	One sample daily	Acid Content-Concentration 18% to 4% min, Sp. Gravity 1 to 1.3 Iron Content -120g/litre (max)	Vendor Records	√	x	x	x	Record review
464	iii	Rinsing	pH meter	Major	Chemical	One sample daily	Rinsing water ph value 5 to 7	Vendor Records	√	x	x	x	Record review
465	iv	Pre-fluxing in ZnCl solution - Specific gravity, pH	pH meter	Major	Measurement	One sample daily	Sp Gr - 1.10 to 1.26 pH - 3 to 5	Vendor Records	√	x	x	x	Record review
466	v	Pre-heating	Pyrometer	Major	Measurement	One sample daily	Above 50^0 C	Vendor Records	√	x	x	x	Record review
467	vi	Dipping - Zinc bath temperature, Imersion & withdrawl time	Continuous recording & verification by Pyrometer	Major	Measurement	Hourly check	Zn bath temp - 440^0 C to 460^0 C Article to be immersed till reaction	Vendor Records	√	x	x	x	Record review
468	vii	Quenching	Plain water	Minor			Bath in plain water for cooling & Cleaning. Temp. Below 65°	Vendor Records	√	x	x	x	Record review
469	viii	Di-chromating	Di-chromate solution	Major	Chemical	One sample daily	strength of the solution to be maintained as 0.7 to 1% of sodium dichromate, temperature of solution should be less than 65°	Vendor Records	√	x	x	x	Record review
470		**Post Galvanizing**											
471	i	Surface Defects/Finish - Dross, Pimples, Black marks, Ash deposition	As agreed/ Required	Major	Visual	100%	IS 2633	Vendor Records	√	x	x	x	Record review Random samples to be inspected during
472	ii	Thickness of Zinc Coating	Alcometer	Critical	Measurement	3 samples per dip	As Per IS 4759 , 6745 , Minimum 80micron or as per spec.	Vendor Records	√	x	x	x	Record review Random samples to be measured during factory visit by Owner/PMC
473	iii	Mass of Zinc Coating		Critical	Chemical	1 sample per shift	As Per IS 6745	Vendor Records	√	x	x	x	Record review
474	iv	Uniformity of Zinc Coating (Preece Test)		Major	Chemical	1 sample per shift	No red stains after 4 dippings	Vendor Records	√	x	x	x	Record review/ Sample test if deemed necessary
475	v	Adhesion of Zinc Coating (Pivote Hammer Test/ Knife Test)		Major	Physical	1 sample per hour	No Removal or lifting in areas between hammer impression/coating should not peel off. As per IS 2629	Vendor Records	√	x	x	x	Record review Random samples to be inspected during factory visit by Owner/PMC. Sample test if deemed necessary
476		**Proto Assembly**											
477	i	Proto Assembly check - Fitment, Dimensions, Alignment, Overall Stability	Prototype of one mounting table with	Critical	Physical/ Measureemnt	100%	Cut lengths of all members, Fitment (dia. of holes, end security, c/c distance between holes etc. shall be checked for correctness wrt permissible tolerence through in postion ispection of assembled proto), Fasteners (bolts, nuts and washers), Cleats, Gussete plates shall be as per Approved drawing/ specifications. The proto assembly shall be checked for overall stability for design verification of various conenctions and col. support system.	IR	√	x	x	x	The general quality of fabrication and galvanization of members, straightness of members, overall stability of prototype etc. shall be checked for design verification. Any suggestions for design changes etc. shall be properly recorded in the inspection report for implimentation in mass production of MMS members
478		**Marking/ Packaging**											
479	i	Marking	As agreed/ Required	Major	Visual	100%	Aprroved drawing/ marking scheme	IR	√	x	x	x	Record review Random sample shall be checked during facroty visit by Vendor and SECI/ Owner representative

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480	ii	Packaging, Storing, Bundling, Handling	As agreed/ Required	Major	Visual	100%	As per IS-802. Packing of Column. Bracing, Rafters and Purlins shall be done by strapping. Packing of smaller items by wires or in gunny bags/ or as per approved procedure	IR	√	x	x	x	Separate packaging for different type of members like Col, Purlin, Rafter, Front/ rear/ diagonal bracings, fasteners, cleats etc. Small members shall be bundled with wire. Damage to galvanization and form (shape) of the member during handling and trasporting shall be controlled
481		**Site Installation**								x	x	x	
482	i	Receipt of materials and Checking as per packing list	As agreed/ Required	Critical	Visual	Random			√	x	x	x	
483	ii	Fabricated members - Dimensional Check	As agreed/ Required	Major	Visual	100%				x	x	x	
484	iii	Visual checks for defects/damages, rusting, pitting, galvanising etc.	As agreed/ Required	Major	Visual	Random	Tech. Specification, Approved Drawing & Method Statement.			x	x	x	
485	iv	Nut/Bolt/Washers	As agreed/ Required	Major	Measurement	100%				x	x	x	
486	v	Mounting of structures & Accessories - Coordinates, Levels, Fitment, Alignment etc.	As agreed/ Required	Critical	Visual /Measurement	100%			√	x	x	x	
487	vi	Torque Checking - Daily calibration check, Bolt installation	As agreed/ Required	Major	Measurement	100%				x	x	x	
489	**35**	**Module Mouting - Pre Installation Check**			Visual	100%							
490	i	Check for site physical layout as per drawing / Design Specification		Major	Physical	100%				x	x	x	
491	ii	Check for Structure, Mounting readiness		Major	Physical					x	x	x	
493	**36**	**String Combiner Boxes (SCB) - Mouting - Pre Installation Check**											
494	i	Check for foundation readyness - location & coordinates, dimensions & levels, foundation bolts etc.		Major	Physical	100%				x	x	x	
496	**37**	**Inverter Panel**											
497		**Pre Installation**											
498	i	Check for site physical layout as per drawing.		Major	Visual	100%	Design Specification, Drawings, Manufacturer Manual Method Statement	SR	√	x	x	x	
499	ii	Ensure that no fouling with civil/structural		Major	Physical	Random				x	x	x	
500	iii	Check for Foundation readiness and level of foundation.		Major	Physical	100%				x	x	x	
502	**38**	**Burried Cables**					Design Specification, Drawings, Manufacturer Catalogue Method Statement (SWSEPC-MS-CAB-006)						
503	i	Cable Trench - Dimensions, alignment		Critical	Physical	100%	Design Specification, Drawings, Manufacturer Catalogue Method Statement	SR		x	x	x	
504	ii	Sand filling before cable laying, sand filling after cable laying, placing of precast concrete slabs/ bricks, backfilling with soil		Major	Visual	100%				x	x	x	
586													
587													
588													
589													
590													
591													

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Sr.No.**	**Activity & Operation**	**Instruments**	**Class of Check**	**Type of Check**	**Quantum of Check**	**Reference Documents & Acceptance Standard**	**Format of Record**	**D*** (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	**Cheking Agency**			**Remarks**
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		**M'fr/ Supplier or Sub-Contractor**	**EPC Contractor**	**SECI or Owner**	
592			**LEGEND**: D * Records, indentified with "Tick" (√) shall be essentially included by supplier in QA documentation.							**DOC. NO.**: SECI - XXX - XXX -XXX - FQP & MQP - 001 **REV**: 0			
593			**Legend to be used:**										
594			**Class # : A** = Critical, **B**=Major, **C**=Minor										
595			**Format of Record** # : **SR**=Site Register, **TR**=Lab Test Report, **IR**=Inspection Report, **MTC**=Manufacturer's Test Certificate										
596			All **MTC'**s shall be correlated with batch of material supply, Tech specs and drawings										
597			**Category 'A'** - Sub-contractor/ sub-vendor, EPC Vendor, SECI/ Owner										
598			**Category 'B'** - Sub-Contractor/ Sub-Vendor, EPC Vendor, SECI										
599			**Category 'C'** - Sub-Contractor/ Sub-Vendor										
600										**Reviewed By**	**Approved By**		**Approval Seal**
601			This document shall be read in conjunction with Tech. Specifications and Drawings										

Annexure – G

Pile Test Methodology

1.0 GENERAL

This specification deals with the testing of bored cast in situ piles by the application of an axial load or force. It covers vertical piles tested in compression (i.e. subjected to loads or forces in a direction such as would cause the pile to penetrate further into the ground) and vertical piles tested in tension/ pull-out (i.e. subjected to forces in a direction such as would cause the piles to be extracted from the ground).

2.0 DEFINITIONS

Compression pile: A pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.

Tension pile: A pile which is designed to resist an axial force such as would cause it to be extracted from the ground.

Initial Test pile (or test pile): A pile installed before the commencement of the main piling works or specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimension and load capacity

Kentledge: The dead weight used for applying a test load on pile

Reaction system: The arrangement of kentledge, piles, anchors or rafts that provide a resistance against which the pile is tested.

Maintained load test: A load test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.

Failure load test: a load test applied to an initial test pile. Maximum test load for this test should not normally be less than 250% of the estimated safe load capacity worked out as per static formula for estimation of pile capacity, but the possibility of failure load test carried well beyond 300% of the predicted working load should not be ruled out if otherwise specified. This test serves as a design check and confirmation or validation of safe load capacity of working piles through field test

Ultimate load capacity: the max load which a pile or pile cap can carry before failure of ground (when soil fails by shear as evidenced from the load settlement curve) or failure of the pile

Allowable or safe load: the load on a pile derived by applying a factor of safety on ultimate load capacity of pile as determined by load test.

Working load: design load to be carried by the working pile without exceeding the allowable settlement requirement

3.0 SAFETY PRECAUTIONS

General

While casting the test pile, conducting the test and dismantling the test pile after the test is complete, the contractor shall follow all applicable precautions, statutory provisions and directions of Engineer for maintenance of safe working conditions, and shall in addition make such other provisions as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

The Contractor shall be responsible for the design of the reaction system (e.g. kentledge or reaction piles/ground anchors, foundation of the kentledge system etc.) As required, the design of the reaction system including the design calculations shall be endorsed by the Chartered Engineer registered with Institution of Engineers, India, who will be responsible for the safety of the whole reaction & testing system and fulfill the Health & Safety Acts.

Personnel

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

Kentledge

Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any beams or other supporting structures in such a manner that there will not be any differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it from falling apart, or becoming unstable because of deflection of the supports.

The weight of kentledge shall be at least 1.2 times m or e than the maximum test load and if the weight is estimated from the density and volume of the constituent materials, an adequate factor of safety against error shall be considered. The Contractor shall take all reasonable steps to ensure that sufficient excess load capacity is at all times available for the uninterrupted execution of a load test.

Reaction Piles and Ground Anchors

Where tension piles or ground anchors are used (subject to approval of the Engineer), the Contractor shall ensure that the load is correctly transmitted to all the tie rods or bolts. The extension of rods by welding shall not be permitted unless it is known that the steel will not be reduced in strength by welding. The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.

The reaction piles or ground anchorages shall be so designed that they will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles or anchorages shall be placed in the specified positions, and bars, tendons or links shall be aligned to give a stable reaction in the direction required.

Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable up to the maximum test load to be applied. Means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure or any other cause that might constitute a hazard to personnel. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum workingpressure without possible leaking.

The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.

4.0 MATERIALS AND LABOUR

The Contractor shall supply all labor, materials and other equipment necessary for the performance, recording and measurements of the test loads and settlement including the supply and placing in position of kentledge used in the tests. The Contractor shall subsequently dismantle and remove all the material and equipment used.

Throughout the duration and operation of the test loading the Contractor shall place competent men to operate, watch and record the test.

5.0 INITIAL TEST PILES

In order to confirm the design type, size, length and load capacity of pile through field tests, the Contractor shall install and test specially installed initial piles in advance of the main piling operation for *working piles*. The locations, sizes, lengths, test loads and instrumentation required for the initial piles shall be submitted by the contractor for approval before start of the work.

Initial piles shall be installed within the same plant and in a similar manner as that to be used in the construction of the working piles.

All initial test piles shall be instrumented in accordance with that indicated in the drawings and specification. After testing, the Contractor shall be responsible to hack away the initial test pile if it is obstructing the construction of other foundation works.

6.0 MEASURING DEVICES

Load measuring devices shall be calibrated before and after each series of tests, whenever adjustments or replacements are made to the devices or at the intervals recommended by the manufacturer of the equipment. All measuring equipment and gauges shall be calibrated together. Certificates of calibration from an approved laboratory shall be supplied to the Engineer for acceptance.

The Contractor's proposed method of measuring the movement of pile heads and load shall be submitted to the Engineer for approval.

7.0 SUPERVISION

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use. Load testing shall be carried out in the presence of the Engineer or Engineer's Representative.

8.0 LOADING TEST PILES

The rate of application of the test load is specified in the specification for general guidance. The rate of application and removal of the load may be altered or modified solely by the Engineer. Unless otherwise decided by the Engineer the load steps and duration are as indicated in approved Test Procedure.

9.0 READINGS

Take readings of time, load and settlement and record immediately before and after the application of each load increment or decrement, or as directed by the Engineer. A minimum of another two readings shall be recorded at intermediate intervals.

10.0 INSTALLATION OF A TEST PILE

Inclusive Works

The works for the load tests shall include the construction and subsequent demolition of all necessary pile caps to the contractor's design which shall be subjected to the Engineer's approval.

Notice of Construction

The Contractor shall give the Engineer at least 48 hours' notice prior to commencement of casting of any initial test pile.

Method of Construction

Each initial test pile shall be constructed in a manner similar to that to be used for the construction of the working pile, and by the use of similar equipment and materials. Any variation will only be permitted with prior agreement.

Extra reinforcement and concrete of increased strength shall be provided as required in the shaftsor initial piles as per approved design of test piles to this effect.

Boring Record

For each initial test pile which is to be tested, a detailed record of the conditions experienced during boring shall be made and submitted daily, not later than the next working day. Where the Engineer requires soil samples to be taken or in-situ tests to be made, the Contractor shall present the results without delay. All submission shall also include a scan copy (in PDF format) to be emailed to the Engineer's office.

Concrete test cubes

At least 1 sample (six test cubes) shall be made from the concrete used in the initial test pile If a concrete pile is extended or capped for the purpose of testing, a further 1 sample (six test cubes) shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with IS: 516

The pile test shall not start until the compressive strength of pile concrete is established equal or greater than the design strength through tests on the test cubes. As a general rule the pile test shall be carried out after 28 days of casting the pile without special permission for early testing obtained from Engineer.

Pile Head for Compression Test

For a pile that is tested in compression, the pile head or cap may be formed as required to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement-measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

The pile cap shall be concentric with the test pile. The joint between the cap and the pile shall have a strength equivalent to that of the pile.

Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at maximum expected settlement, load is not transmitted to the ground except through the pile.

Pile Connection for Tension Pile

For a pile that is tested in tension, means shall be provided for transmitting the test load axially to the pile.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load which is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

11.0 REACTION SYSTEMS

Compression Tests

Compression tests shall be carried out using kentledge only. Unless instructed, approved or specified by the Engineer, tension piles, ground anchors or otherwise specially constructed anchorage shall not be used.

Where kentledge is to be used, it shall be supported on cribwork, disposed around the pile head so that its center of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer in writing only. The kentledge may consist of concrete blocks, steel piles etc., but must be of uniform size so that weight of the kentledge can be easily calculated.

Tension Tests

Tension tests shall be carried out using compression piles or rafts constructed on the ground. The use of inclined reaction piles, anchors or rafts is not precluded, subject to agreement. In all cases the resultant force of the reaction system shall be co-axial with the test pile.

Spacing

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3m.

The center-to-center spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2m whichever is the greatest.

Where a pile to be tested has an enlarged base (under reamed pile), the same criterion shall be applied with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall be closer to the base of the test pile than one and half of the enlarged base diameter.

Where vertical reaction piles penetrate deeper than the test pile, the center-to-center spacing of the reaction piles from the test pile shall be not less than five times the diameter of the test pile or the reaction piles whichever is the greatest unless the base capacity of the test pile is less than 20% of the total ultimate capacity.

Where ground anchorages are used to provide a test reaction for loading in compression, no section of fixed anchor length transferring load to the ground shall be closer to the test pile than three times the diameter of the test pile. Where the pile to be tested has an enlarged base the same criterion shall apply with regard to the pile shaft, with the additional requirement that no section of the fixed anchor transferring load to the ground shall be closer to the pile base than a distance equal to the base diameter.

Adequate Reaction

The size, length and number of reaction piles or the area of the rafts, shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

Care of Piles

The method employed in the installation of any reaction piles or rafts shall be such as to prevent damage to any test pile or working pile.

Working Piles as Reaction Piles

The Contractor shall not use working piles as reaction piles.

Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

Pile caps and Structural Elements

Temporary pile caps and other structural elements forming part of the reaction system proposed by the Contractor shall be designed and built by the Contractor, and to the approval of the Engineer. The cost of building and demolishing such pile caps and structural elements shall be borne by the Contractor.

12.0 EQUIPMENT FOR APPLYING LOAD

General

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The rams or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the test. The contractor shall prepare sufficient spare steel plate to drop or raise the jack after each sequence of test after the pile had settled with allowed tested total settlement of pile.

Jack Capacity

The total capacity of the jacks shall exceed by 50% or more the required maximum test load, thereby avoiding heavy manual pumping effort when nearing maximum load and minimizing the risks of any leakage of oil through the seals.

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained load test.

The length of stroke of a ram shall be sufficient to cater for deflection of the reaction system under load plus a deflection of a pile head up to 15% of the pile shaft diameter unless otherwise specified.

13.0 MEASUREMENT OF LOAD

Load Measurement Procedure

The load shall be measured by a load measuring device and by a calibrated pressure gauge included in the hydraulic system. The technical specifications of the load cell and pressure gauge shall be submitted to the Engineer prior to the test. The load cell and pressure gauge shall be of appropriate range of the testing load. Reading of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used. The pressure gauge readings are required as a check for gross error. The pressure gauge shall have been recently calibrated.

The load measuring device may consist of a proving ring, load measuring column, pressure cell, vibrating wire load cell or other appropriate system. The load cells or proving ring shall be calibrated immediately prior to the test and a certificate shall be submitted to the Engineer.

A spherical seating shall be used in conjunction with any device that are sensitive to eccentric loadings; care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in axial length in order to achieve the best possible stability. The Contractor shall pay attention to details in order to ensure that axial loading is maintained.

Any increment of load shall not be allowed to fall below 1% of the specified load.

The Engineer's agreement shall be obtained in writing prior to any modification of this procedure.

Calibration of Load Measuring Devices

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together.

Certificates of calibration performed by an NABL accredited testing laboratory shall be supplied to the Engineer prior to carrying out the load test.

Measurement of Settlement

Settlement shall be measured by use of a reference beam or wire supported independently of the test pile, reaction pile or piles supporting reaction loads. Settlements shall be measured to the nearest 0.1mm for reference beams or 0.5mm of reference wires. A precise optical level shall also be used to check movements of the reference frame against an independent datum. The reference beam supports shall be located at least 3m from the test pile, reaction pile or piles supporting reaction loads. The reference beams or wires shall be protected from the effects of temperature changes. Construction equipment and persons not involved in the test shall be kept well clear to avoid disturbance of the measuring system. Pile driving or similar operations will not be permitted in the vicinity of the test unless the Engineer is satisfied that the measuring system will not be affected.

Deflections shall be precisely measured by min. two dial gauges placed diagonally opposite on the pile head with sensitivity of 0.01mm to give useful information on pile bending as well as axial movement. These dial gauges shall be firmly attached to the reference beams (datum beams), so that the plungers are parallel to the pile axis. The plunger points shall bear onto reference plates by means of machined plates or glass slides attached to the pile head. The reference plates shall be equidistant from the center of the pile, diametrically opposite, and carefully aligned so that they are perpendicular to the pile axis in order that sideways movements do not produce any axial components.

Before stacking up of the Kentledge or construction of the reaction piles / ground anchors, the preparation of the pile head shall be carried out and the reduced level of the pile head surveyed and recorded.

Initial Zero Load Readings

Before the first increment of test load is applied, all gauges shall be read at 30 minutes intervals over a period of 12 hours under zero load to determine the effect of variable site conditions on the test pile. Air temperature shall be recorded with each set of readings. The test set- up shall be exactly as during the test proper, with the loading jack in position but clear of the loading frame.

14.0 MEASURING MOVEMENT OF PILE HEADS

Maintained Load Test

In a maintained load test, movement of the pile head shall be measured by one of the primary systems and one of the secondary systems described in this section.

Primary System

An optical or any other leveling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readingsto be made within an accuracy of 0.5mm. A scale attached to the pile or pile cap may be used instead of a leveling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed, so that any one datum point can be re-established in case it is inadvertently demolished. Each datum point shall be situated so that only one setting of the level is needed.

No datum point shall be affected by the test loading or other operations on the Site. Where

another method of leveling is proposed, this shall be agreed in writing.

Independent Reference Frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance fromthe test pile, kentledge support cribs, reaction piles, anchorages and rafts that movements of the ground in vicinity of the equipment do not cause movement of the reference frame during the test which will affect the required accuracy of the test.

Observations of any movements of the reference frame shall be made and a check shall be made of the movement of the pile head relative to an external datum during the progress of the test. Supports for the reference frame shall be placed not less than three test pile diameters or 2 meters, whichever is the greater, from the center of the test pile, and not less than 1 metre from the nearest corner of the kentledge support crib.

The measurement of pile movement shall be made by min. 2 dial gauges equally spaced around the pile and equidistant from the pile axis. Dial gauges shall be rigidly mounted on the reference frame and bear on surfaces which are normal to the pile axis and fixed to the pile cap or head.

Alternatively, the gauges may be fixed to the pile and bear on surfaces on the reference frame. The dial gauges shall have a travel of 50mm and shall be accurate to 0.01mm.

The reference frame shall be protected from direct sunlight, wind and rain.

Secondary Systems

Reference Wire

A reference wire shall be held under constant tension between two rigid supports founded as in the method used for the primary Reference Frame system. The wire shall be positioned against a scale fixed to the pile and the movement of the scale relative to the wire shall be measured.

Observations of any movements of the supports of the wire shall be made or a check shall be made of the movement of the pile head as in the method used for primary Reference Frame systems. Readings shall be taken to within an accuracy of 0.5mm.

The reference wire shall be protected from direct sunlight, wind and rain.

Other Methods

The Contractor may propose and implement any other suitable and adequate method of measuring the movement of pile heads subject to the prior agreement of the Engineer.

Instrument Calibration

Prior to carrying out the load test, the Contractor shall submit to the Engineer the calibration certificates of dial gauges performed by NABL accredited testing laboratory.

Night Readings

The entire test area shall be adequately lighted up during the night to facilitate taking readings.

15.0 PROTECTION OF TESTING EQUIPMENT

Protection from Weather

Throughout the test period, all equipment for measuring load and movement shall be protected from direct exposure to sunlight, wind and rain.

Prevention of Disturbance

Construction equipment and persons who are involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

16.0 SUPERVISION

Notice of Test

The Contractor shall give the Engineer at least 24 hours of notice prior to commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test as required under the section headed 'Presentation of Results' in this specification shall be available for inspection by the Engineer.

17.0 TEST PROCEDURE

Failure Load Tests (Initial Tests)

Failure Load Tests shall be performed following maintained load procedure on initial piles designated by the Engineer at the commencement of the contract to verify the design parameters used and to confirm the lengths of subsequent working piles. The initial test piles shall be the only ones made in the first instance, and the load tests carried out prior to the installation of any other piles. Piling works shall not commence until after the failure load test results have been analyzed, and upon instruction by the Engineer.

The provisional number of Failure Load Test shall be as agreed subject to min. of 3 numbers of tests under each type (compression or tension). The locations of initial test piles shall be so chosen to properly represent the total plant site and shall be subject to the approval of the Engineer. However, the Engineer reserves the right to alter the number of tests subject to the nature of subsoil conditions encountered and the pile system adopted vis-a-vis the method of installation, material and plant usage.

The test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load taken as 100%. In case of any variation with respect to approved pile test procedure, the approved procedure shall have the precedence.

LOADING CYCLES FOR INITIAL TEST PILES

Load Stage (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till the movement of the pile top is not more than 0.2mm/hour or until 2 hours have elapsed, whichever is earlier, subject to min. 1 hour	
20		
40		
60		
80		
100		
120		
140		
160		
180		
200		
220		
250	24 hr. (after application of max. test load)	The vertical loading (shall be continued till one of the following takes place Compression: (a) The applied load reaches 250% of estimated safe load or (b) Max. settlement of pile exceeds 10% of diameter in case of uniform diameter pile and 7.5% of bulb diameter in case of under reamed pile. Pull out: (a) The applied load reaches 250% of estimated safe uplift load or (b) until the load displacement curve shows a clear break (downward trend).
200	01 Hour	
150	01 Hour	
100	01 Hour	
50	01 Hour	
0	01 Hour	

The test schedule for compression test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

The procedure for tension pile tests shall be exactly as described in this section for compression pile test; for tension test, the words “settlement” and “rebound” should be read a s “displacement” in the column “action to be taken after Load Stage.”

For failure load tension pile test, the Contractor shall provide adequate reinforcement in the test pile to carry the ultimate tension load.

All loading and unloading operations shall take place during the day. Pressure gauge readings shall be recorded at each load increment or at each decrease in load. During waiting periods at various loading stages, all readings shall be recorded after the load has been applied and before the commencement of next loading stage. Take readings at 15-minute intervals at 100%, 200% and 250% of working load.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

Working Load Test on Working Piles

A number of working load tests on 0.5 % of the total working piles shall be carried out at test load of 1.5 times the working load on piles to be designated by the Engineer, and in accordance with IS:2911 or as specified in Tech Specifications. In case of discrepancies the provision of this specification and Tech Specifications the Tech Specifications shall take precedence. The Contractor shall submit a detailed proposal of load tests to the Engineer, and shall obtain his approval in writing before carrying them out the test. On completion of the test, the Contractor shall submit to the Engineer the test results, including graphs showing load and settlement versus time and settlement versus load.

The provisional number of working load tests to be carried out shall be as specified in Tech. specifications. The Engineer may reduce the number of tests if a consistent high quality of workmanship and pile material is well established and if the nature of soil conditions encountered does not vary substantially, Conversely, the Engineer reserves the right to increase the number of tests either to verify the quality of workmanship and pile material or in response to variable subsoil conditions.

Unless otherwise specified by the Engineer, the test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load, taken as 100%:

LOADING CYCLES FOR WORKING PILES

Load (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till the movement of the pile top is not more than 0.2mm/hour or until 2 hours have elapsed, whichever is earlier, subject to min. 1 hour	
20		
40		
60		
80		
100		
120		
140		
150	24 hr. (after application of max. test load)	The vertical loading shall continue till one of the following takes place

		Compression: (a) The applied load reaches 150% of the safe load or (b) max. settlement of the pile exceeds 12mm Pull out: (a) The applied load reaches 150% of the safe load or (b) total settlement reaches 12mm
115	01 Hour	
75	01 Hour	
35	01 Hour	
0		

(NOTE: Pull out test on routine (working) pile shall be carried out only in case it is found be necessary to conduct the same based on construction quality and the soil strata variation observed during working pile installation or any other reason as found necessary by the engineer.
While conducting the routine test for pull out, it shall be ensured that the displacement is within elastic deformation of the pile during the test as observed from initial failure test graph or 8mm whichever is early).

The test schedule for compression or pull-out test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

The procedure for working load tension pile tests shall be exactly as described in this section for compression pile tests; for tension test, the words "settlement" and "rebound" should be read as "displacement" in the column "action to be taken after Load Stage".

All loading and unloading operations shall take place during the day. Minimum three (3) sets of readings shall be taken in each loading stage: one set each at the beginning, middle and end of each loading or unloading stage. When a test load is maintained for more than 30 minutes, readings shall be taken at maximum half-hourly intervals thereafter unless otherwise specified by theEngineer.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

18.0 ABANDONMENT OF PILE TEST

Test shall have to be discontinued if any of the following occurs:

- faulty jack or gauge,
- instability of kentledge,
- improper setting of datum, or
- unstable Bench Marks or Scales,
- measuring instruments used are found to have been tampered with by anyone,
- pre-jacking or pre-loading before commencement of the test.
- Insufficient steel plate to compensate for settlement of the pile after each sequence of loading (shall allow up to 150mm settlement).

Should any test be abandoned due to any of the above causes, the Contractor shall carry out further tests to the Engineer instructions after rectification of the errors.

19.0 PRESENTATION OF RESULTS

Results to be Submitted

A written summary to the Engineer within 24 hours (or unless otherwise directed) of the test, which shall give:

(i) For each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

(ii) Load vs Settlement curve.

The completed schedule of recorded data (hard & softcopy) as described hereunder in this section shall be submitted to the Engineer within seven days of completion of the test in the format generally, as specified in IS: 2911 (part 4) and approved by the Engineer.

Schedule of Recorded Data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

General

* Site location
* Contract identification
* Proposed structure
* Name of EPC Contractor
* Name of Piling Contractor & Testing Agency
* Name of SECI/ Owner Engineer
* Name of EPC Contractor's Engineer
* Name of Testing Agency/ Piling Contractor Engineer
* Data of test

Pile Details

All piles

* Identification (no. and location)
* Position relative to adjacent piles
* Brief description of location (e.g. in marshy land, rocky area, high water table etc.)
* Existing Ground level at pile location
* Head level at which test load is applied
* Type of pile (e.g. bored cast in situ, pre-cast driven etc.)
* Compression or tension
* Shape and size of cross-section of pile (diameter), position of change in cross-section (in case of under reamed pile – the position and dimensions of the bulb)
* Shoe or base details
* Head details
* Length in ground
* Level of toe

Installation Details

* Test cube results
* Design grade of concrete
* Reinforcement
* Whether construction under water

Test Procedure

* Weight of kentledge.
* Tension pile, ground anchor or compression pile details
* Plan of test arrangement showing position and distances of kentledge support, rafts, tension orcompression piles and reference frame to test pile
* Jack capacity
* Calibration certificates of pressure gauges and dial gauges
* Method of load measurement
* Method(s) of penetration or uplift measurement
* Proof test by maintained loading
* Relevant dates and times

Test Results

* In tabular form
* In graphical form: log P plotted against log S (only for Failure Load Tests), load plotted against settlement (or uplift load and settlement or uplift) plotted against time,
* Ground heave

Site Investigation

* Site Investigation report reference number and coordinate or grid reference
* Nearest Borehole reference

20.0 COMPLETION OF A TEST

Measuring Equipment

On completion of a test, all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in future tests or removed from the Site.

Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in future tests or removed from the Site.

Ground Anchors and Temporary Piles

On completion of a Failure Load Test, temporary pile and ground anchors shall be cut off below ground level, removed from the Site and the ground made good with approved material.

The pile cap, if formed in concrete, shall be broken up and removed from the Site. If the pile cap is made of steel, it shall be cut off and either stored so that it is available for use in further tests or removed from the Site.

Initial Test Pile

Test piles which are not to be incorporated into the permanent works shall be broken down to 2m below ground level or as required, and the ground backfilled to the original level with approved material. For test piles which are to be incorporated into the permanent works, the pile head shall be made good or extended to the cut off level

1.0 GENERAL

This specification deals with the testing of bored cat in situ piles by the application of a lateral load or force. It covers vertical piles tested under lateral load (i.e. subjected to loads or forces in a horizontal direction such as would cause the pile to displace laterally under the action of horizontal load or force)

2.0 DEFINITIONS

Initial Test pile (for failure load test): a pile installed before the commencement of the main piling works or specific part of the Works to assess the load carrying capacity of the pile. This pile tested to its ultimate load capacity or to twice it's estimated safe load.

Reaction system: the arrangement of piles, pedestals, or rafts that and loading system to provide a resistance against which the pile is tested.

Ultimate bearing capacity: the load at which the resistance of the soil becomes fully mobilized.

Allowable load: the load which may be safely applied to a pile after considering its ultimate bearing capacity, negative skin friction, pile spacing, overall bearing capacity of the ground below and allowable settlement. Allowable load is load defined as per IS: 2911 (part 2).

Working load: designed load to be carried by the working pile without exceeding the allowable lateral displacement requirement (5mm unless specified otherwise

3.0 SAFETY PRECAUTIONS

General

While casting the test pile, conducting the test and dismantling the test pile after the test is complete, the contractor shall follow all applicable precautions, statutory provisions and directions of Engineer-in-charge for maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

The Contractor shall be responsible for the design of the reaction system (e.g. reaction piles, reaction pillars, installation of loading jack system etc.). As required, the design of the reaction system including the design calculations shall be endorsed by the Chartered Engineer registered with Institution of Engineers, India, who will be responsible for the safety of the whole reaction & testing system and fulfill the Health & Safety Acts.

Personnel

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

Reaction Piles/ Reaction Pedestals

Where reaction pile or reaction pedestal are used (subject to approval of the Engineer), the Contractor shall ensure that the load is correctly transmitted to the test pile.

The reaction pile or pedestal shall be so designed that it will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles or anchorages shall be placed in the specified positions, and bars, tendons or links shall be aligned to give a stable reaction in the direction required.

Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable up to the maximum test load to be applied. Means shall be provided to enable dial gauges to be read from a position clear of the test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure or any other cause that might constitute a hazard to personnel. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum test pressure without possible leaking.

The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.

4.0 MATERIALS AND LABOUR

The Contractor shall supply all labour, materials and other equipment necessary for the performance, recording and measurements of the test loads and settlement including the supply and placing in position of the reaction system used in the tests. The Contractor shall subsequently dismantle and remove all the material and equipment used.

Throughout the duration and operation of the test loading the Contractor shall place competent men to operate, watch and record the test.

5.0 INITIAL TEST PILES

In order to confirm the load bearing capacity of the design pile the Contractor shall install and test specially installed initial piles in advance of the main piling operation for installation of working piles. The locations, sizes, lengths, test loads and instrumentation required for the initial piles shall be submitted by the contractor for approval before start of the work.

Initial piles shall be installed with the same plant and in a similar manner as that to be used in the construction of the working piles.

All initial piles shall be instrumented in accordance with that indicated in the drawings and specification. After testing, the Contractor shall be responsible to hack away the initial test pile if it is obstructing the construction of other foundation works.

6.0 MEASURING DEVICES

Load measuring devices shall be calibrated before and after each series of tests, whenever adjustments or replacements are made to the devices or at the intervals recommended by the manufacturer of the equipment. All measuring equipment and gauges shall be calibrated together. Certificates of calibration from NABL approved laboratory shall be supplied to the Engineer for acceptance.

The Contractor’s proposed method of measuring the movement of pile heads and load shall be submitted to the Engineer for approval for start of load test.

7.0 SUPERVISION

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use. Load testing shall be carried out in the presence of the Engineer or

Engineer's Representative.

8.0 LOADING TEST PILES

The load steps and duration as per IS: 2911(Part-4) are given in the specification for guidance. The rate of application and removal of the load may be altered or modified solely by the Engineer. Unless otherwise decided by the Engineer the load steps and duration are as indicated in approved Test Procedure.

9.0 READINGS

Take readings of time, load and settlement and record immediately before and after the application of each load increment or decrement, or as directed by the Engineer. A minimum of another two readings shall be recorded at intermediate intervals.

10.0 INSTALLATION OF A TEST PILE

Inclusive Works

The works for the load tests shall include the construction and subsequent demolition of all necessary pile caps to the contractor's design which shall be subjected to the Engineer's approval.

Notice of Construction

The Contractor shall give the Engineer at least 48-hour notice prior to commencement of casting of any initial test pile.

Method of Construction

Each initial test pile shall be constructed in a manner similar to that to be used for the construction of the working pile, and by the use of similar equipment and materials. Any variation will only be permitted with prior agreement.

Extra reinforcement and concrete of increased strength shall be provided as required in the shafts or initial piles as per approved design of test piles to this effect.

Boring Record

For each initial test pile which is to be tested, a detailed record of the conditions experienced during boring shall be made and submitted daily, not later than the next working day. Where the Engineer requires soil samples to be taken or in-situ tests to be made, the Contractor shall present the results without delay. All submission shall also include a scan copy (in PDF format) to be emailed to the Engineer's office.

Concrete test cubes

At least 1 sample (six test cubes) shall be made from the concrete used in the initial test pile If a concrete pile is extended or capped for the purpose of testing, a further 1 sample (six test cubes) shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with IS: 516

The pile test shall not start until the compressive strength of pile concrete is established equal or greater than the design strength through tests on the test cubes. As a general rule the pile test shall be carried out after 28 days of casting the pile without special permission for early testing obtained from Engineer.

Pile Connection for Lateral Test

For a pile that is tested under lateral load, means shall be provided for transmitting the test load horizontally to the pile along its center line.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load which is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

11.0 REACTION SYSTEMS

Lateral load Test shall be carried out using reaction pile or pedestal constructed on the ground. The reaction pile or pedestal shall be designed for adequate strength and shall be founded firmly in to the ground. In all cases the resultant force of the reaction system shall be co-axial with the diametrical axis of test pile.

Spacing

The distance of the vertical reaction pile/ pedestal from the test pile shall be not less than one and half time the diameter of the test pile or the reaction pile or 1m whichever is the greatest.

Where a pile to be tested has an enlarged base (under reamed pile), the same criterion shall be applied with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall becloser to the base of the test pile than one and half time the enlarged base diameter.

Where vertical reaction pile penetrates deeper than the test pile, the center-to-center spacing of the reaction pile from the test pile shall be not less than two and half times the diameter of the test pile or the reaction pile whichever is the greatest.

Adequate Reaction

The size, length and number of reaction piles/ pedestals or reaction beam if so provided shall be adequate to transmit the maximum lateral test load to the ground in a safe manner without movement or influence on the test pile.

Care of Piles

The method employed in the installation of any reaction piles/ pedestals or beam shall be such as to prevent damage to any test pile or working pile.

Working Piles as Reaction Piles

The Contractor shall not use working piles as reaction piles.

Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

Pile caps and Structural Elements

Temporary pile caps and other structural elements forming part of the reaction system proposed by the Contractor shall be designed and built by the Contractor, and to the approval of the Engineer. The cost of building and demolishing such pile caps and structural elements shall be borne by the Contractor.

12.0 EQUIPMENT FOR APPLYING LOAD

General

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The rams or jacks shall be arranged in conjunction with the reaction system to deliver a lateral load to the test pile. The complete system shall be capable of transferring the maximum load required for the test. In case the test load is applied by jack located between the reaction and the test pile, the full load imposed by the jack shall be taken as the lateral resistance of each pile. If the load is applied by installation of two jacks placed diametrically opposite at 45^0 inclinations with respect to the axis of the test pile the value of net applied test load along the test pile axis shall be worked out accordingly.

Jack Capacity

The total capacity of the jacks shall exceed by 50% or more the required maximum test load, thereby avoiding heavy manual pumping effort when nearing maximum load and minimizing the risks of any leakage of oil through the seals.

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of load test.

The length of stroke of a ram shall be sufficient to cater for deflection of the reaction system under load plus a deflection of a pile head up to 15% of the pile shaft diameter unless otherwise specified.

13.0 MEASUREMENT OF LOAD

Load Measurement Procedure

The load shall be measured by a load measuring device and by a calibrated pressure gauge included in the hydraulic system. The technical specifications of the load cell and pressure gauge shall be submitted to the Engineer prior to the test. The load cell and pressure gauge shall be of appropriate range of the testing load. Reading of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used. The pressure gauge readings are required as a check for gross error. The pressure gauge shall have been recently calibrated.

The load measuring device may consist of a proving ring, load measuring column, pressure cell, vibrating wire load cell or other appropriate system. The load cells or proving ring shall be calibrated immediately prior to the test and a certificate shall be submitted to the Engineer.

A spherical seating shall be used in conjunction with any device that are sensitive to eccentric loadings; care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in their length in order to achieve the best possible stability. The Contractor shall pay attention to details in order to ensure that lateral loading is properly maintained.

Any increment of load shall not be allowed to fall below 1% of the specified load.

The Engineer's agreement shall be obtained in writing prior to any modification of this procedure.

Calibration of Load Measuring Devices

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together.

Certificates of calibration performed by an NABL accredited testing laboratory shall be supplied to the Engineer prior to carrying out the load test.

Measurement of Deflection/ Displacement

Deflection/Displacement shall be measured by use of a reference/datum beam supported independently of the test pile, reaction pile or piles supporting reaction loads. Settlements shall be measured to the nearest 0.1mm A precise optical level shall also be used to check movements of the reference frame against an independent datum. The reference beam supports shall be located at least 3m from the test pile, reaction pile or piles supporting reaction loads. The reference beam shall be protected from the effects of temperature changes. Construction equipment and persons not involved in the test shall be kept well clear to avoid disturbance of the measuring system. Pile driving or similar operations will not be permitted in the vicinity of the test unless the Engineer is satisfied that the measuring system will not be affected.

Deflections shall be precisely measured by min. two dial gauges of 0.01 mm sensitivity spaced at 300 mm and kept horizontally one above the other on the test pile and the displacement interpolated at cut-off level from similar triangles where cut-off level is unapproachable. For approachable cut-off level one dial gauge placed diametrically opposite to the jack shall directly measure the displacement. The dial gauge shall be firmly attached to the reference beam (datum beam), so that the plungers are perfectly horizontal and are aligned along pile axis. One of the methods for keeping the dial gauge on pile surface is to chip off uneven concrete on the side of the pile and to fix a piece of glass 20 to 30 mm square. The dial gauge tips shall rest on the central portion of the glass plate.

Initial Zero Load Readings

Before the first increment of test load is applied, all gauges shall be read at 30 minutes intervals over a period of 3 hours under zero load to determine the effect of variable site conditions on the test pile. Air temperature shall be recorded with each set of readings. The test set- up shall be exactly as during the test proper, with the loading jack in position but clear of the loading frame.

Instrument Calibration

Prior to carrying out the load test, the Contractor shall submit to the Engineer the calibration certificates of dial gauges performed by NABL accredited testing laboratory.

Night Readings

The entire test area shall be adequately lighted up during the night to facilitate taking readings.

14.0 PROTECTION OF TESTING EQUIPMENT

Protection from Weather

Throughout the test period, all equipment for measuring load and movement shall be protected from direct exposure to sunlight, wind and rain.

Prevention of Disturbance

Construction equipment and persons who are involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

15.0 SUPERVISION

Notice of Test

The Contractor shall give the Engineer at least 24 hours of notice prior to commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test as required under the section headed 'Presentation of Results' in this specification shall be available for inspection by the Engineer.

16.0 TEST PROCEDURE

Failure Load Tests (Initial Tests)

Failure Load Tests shall be performed on initial piles designated by the Engineer at the commencement of the contract to verify the design pile capacity the initial test piles shall be the only ones made in the first instance, and the load tests carried out prior to the installation of any other piles. Piling works shall not commence until after the failure load test results have been analyzed, and upon instruction by the Engineer.

The provisional number of Failure Load Tests shall be as agreed subject to min. of 3 numbers. The locations of initial test piles shall be so chosen to properly represent the total plant site and shall be subject to the approval of the Engineer. However, the Engineer reserves the right to alter the number of tests subject to the nature of subsoil conditions encountered and the pile system adopted vis-a-vis the method of installation, material and plant usage.

The test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load taken as 100%. In case of any variation with respect to approved pile test procedure, the approved procedure shall have the precedence.

LOADING CYCLES FOR INITIAL TEST PILES

Load (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till rate of lateral displacement of pile head is less than or equal to 0.1mm/per 30 minutes subject to min. 30 minutes.	
20		
40		
60		
80		
100		
120		
140		
160		
180		
200		
220	12 hr from start of first stage loading	
250	12 hr from start of first stage loading	Test loading shall continue till one of the following take place (a) Max. test load reaches 250% of the safe load or (b) Total lateral displacement reaches 18mm.
200	10	
150	10	
100	10	
50	10	
0	0	

(NOTE: Unloading stages stated above are indicative and shall be per approved test procedure)

LOADING CYCLES FOR ROUTINE TEST PILES

Load %	Time of Holding the Load (Minutes)	Remarks
0		
20		
40		
60		
80		
100		Test load shall be carried out till one of the following takes place (a) Max. test load reaches the safe load or (b) till the total displacement is less than 5mm
75	10	
50	10	
25	10	
0		

The test schedule for Lateral Load test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

For failure load test, the Contractor shall provide adequate reinforcement in the test pile to carry the ultimate lateral load.

All loading and unloading operations shall take place during the day. Pressure gauge readings shall be recorded at each load increment or at each decrease in load. During waiting periods at various loading stages, all readings shall be recorded after the load has been applied and before the commencement of next loading stage. Take readings at 15-minute intervals at 100% and 200% of working load.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

17.0 ABANDONMENT OF PILE TEST

Test shall have to be discontinued if any of the following occurs:

- faulty jack or gauge,
- improper setting of datum, or
- unstable Bench Marks or Scales,
- measuring instruments used are found to have been tampered with by anyone,
- pre-jacking or pre-loading before commencement of the test.

Should any test be abandoned due to any of the above causes, the Contractor shall carry out further tests to the Engineer instructions after rectification of the errors.

18.0 PRESENTATION OF RESULTS

Results to be Submitted

A written summary to the Engineer within 24 hours (or unless otherwise directed) of the test, which shall give:

(i) For each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

(ii) Load vs Settlement curve.

The completed schedule of recorded data (hard & softcopy) as described hereunder in this section shall be submitted to the Engineer within seven days of completion of the test in the format generally as specified in IS: 2911 (part 4) and approved by the Engineer.

Schedule of Recorded Data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

General

* Site location
* Contract identification
* Proposed structure
* Name of EPC Contractor
* Name of Piling Contractor & Testing Agency
* Name of SECI/ Owner Engineer
* Name of EPC Contractor's Engineer
* Name of Testing Agency/ Piling Contractor Engineer
* Data of test

Pile Details

All piles
* Identification (no. and location)
* Position relative to adjacent piles
* Brief description of location (e.g. in marshy land, rocky area, high water table etc.)
* Existing Ground level at pile location
* Head level (cut-off level) at which test load is applied
* Type of pile (e.g. bored cast in situ, pre-cast driven etc.)
* Shape and size of cross-section of pile (diameter), position of change in cross-section (in case of under reamed pile – the position and dimensions of the bulb)
* Shoe or base details
* Head details
* Length in ground
* Level of toe

Installation Details

* Test cube results
* Design grade of concrete
* Reinforcement
* Whether construction under water

Test Procedure

* Max. test load
* Reaction pile details
* Plan of test arrangement showing position and distances of reaction piles and reference frame to test pile
* Jack capacity

* Calibration certificates of pressure gauges and dial gauges
* Method of load measurement
* Method(s) of lateral displacement measurement
* Proof test by maintained loading
* Relevant dates and times

Test Results

* In tabular form
* In graphical form: log P plotted against log S (only for Failure Load Tests), load plotted against settlement
* Ground heave

Site Investigation

* Site Investigation report reference number and coordinate or grid reference
* Nearest Borehole reference

19.0 COMPLETION OF A TEST

Measuring Equipment

On completion of a test, all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in future tests or removed from the Site.

Temporary Piles/ Pedestals

On completion of the Load Test, temporary pile shall be cut off below ground level, removed from the Site and the ground made good with approved material.

The pile cap, if formed in concrete, shall be broken up and removed from the Site. If the pile cap is made of steel, it shall be cut off and either stored so that it is available for use in further tests or removed from the Site.

Initial Test Pile

Test piles which are not to be incorporated into the permanent works shall be broken down to 2m below ground level or as required, and the ground backfilled to the original level with approved material. For test piles which are to be incorporated into the permanent works, the pile head shall be made good or extended to the cut off level

Annexure – H

Operation & Maintenance Agreement

1 CONTRACTOR'S OBLIGATIONS

1.1. **Services**

During the Term of the Contract, the Contractor shall perform the services in accordance with the Operation and Maintenance Scope of work as described in Annexure-1 (Scope of Work for Operation and Maintenance) (hereafter the "Services"), and also in accordance with the other conditions as prescribed related to the operational performance under Section - VII of the Bid Document.

1.2. The Contractor shall be deemed to have allowed correct and sufficient O&M Price to cover all its obligations under the Contract and to have allowed the necessary resources to enable it to perform the Services to the standards and in the manner required. The Contractor's failure to acquaint itself with or assess any applicable condition shall neither relieve it from the responsibility for performing its obligations under the Contract nor entitle the Contractor to any additional costs or any other relief.

1.3. To the extent the Contractor reasonably believes that it is necessary to enhance the overall performance or safety of the Plant, the Contractor may propose changes and improvements to the Plant [(including the software included with respect thereto)]. The Contractor shall ensure that no modification of any equipment, change of software settings or any other alteration of equipment shall:

(i) cause a negative impact on the performance of the safety and reliability of the Plant;
(ii) adversely impact the Warranties;
(iii) adversely affect the warranties provided by the Contractors under the Contract;
(iv) conflict with the requirements under the contract; or
(v) bypass any protective equipment.
(vi) Violates any National/International Trade & IPR laws.

1.4. Any proposed modifications/changes shall not be carried out without the approval of the original equipment manufacturer and the Employer and in accordance with Performance Standards, and Technical Specifications. The Employer shall be notified of the proposed modifications along with reasons and technical note for such modifications, changes, alterations, etc., and after the modifications are carried out in accordance with the contract, an alterations activity report is to be shared with the Employer.

1.5. The Contractor shall, while rendering the Services, observe and comply with all the Applicable Laws, Good Solar Industry Practices, Ministry of New & Renewable Energy (MNRE), Ministry of Power (MoP), CEA, CERC, GRID India, SLDC/RLDC, Local DISCOM & TRANSCO, CTU guidelines and Performance Standards pursuant to the contract. The Employer shall have the right to, to the extent applicable to Services rendered by the Contractor, conduct monthly audit on Applicable Laws, health, safety and environment and all other relevant compliances. The Contractor shall provide all necessary access and supporting documents during audit which are applicable to the same. However, such audits will be planned well in advance in coordination with the Contractor, without affecting the site operation plan.

1.6. The Contractor shall provide and make available as necessary, all such skilled, experienced and qualified labour and other competent personnel as are required to perform the Services the Contractor shall ensure that its Personnel hold and continue to maintain all qualifications and licenses as required under Applicable Law to allow its Personnel to lawfully undertake performance of the Services and carry out the Contractor's other obligations under the contract. For works/services being performed on a continuous basis, the O&M Price shall be deemed to include and the Contractor shall obtain all required Government Approvals and bear any costs related thereto (including any shift or permitted overtime working, allowances, wage orders, night shift differentials, etc.).

1.7 The Contractor shall ensure that all its Personnel deployed for providing the Services have undergone adequate safety training and are appropriately skilled, qualified and experienced in performing the Services for solar farms of a similar size, scope and complexity as the Plant. The Contractor shall be responsible for all matters relating to labor relations, working conditions, training, employee benefits, safety programs and related matters pertaining to its Personnel. The Contractor shall at all times have full supervision and control over its Personnel and shall at all times maintain appropriate order and discipline among its Personnel.

1.8 Contractor shall be solely liable for and, at its sole cost and expense, arrange for the response, reporting, removal, transportation, disposal, investigation, cleanup or other remedial action (in all cases by licensed, insured, competent and professional contractors in a safe manner and in accordance with Applicable Laws) for any hazardous substances/waste existing at, in, on or under the Project.

1.9 The Contractor shall ensure availability of such Consumable Parts, Spare Parts, and Contractor's Equipment as may be necessary for the performance of the Services. The Contractor shall ensure that such Contractor's Equipment does not interfere with the operational or structural integrity of the Plant

1.10 The Contractor shall make available to the Employer the Reference Documents set forth in the Reference Documents and shall also provide the Employer with updates and revisions to the Reference Documents to the extent such updates and revisions are necessary and applicable to the performance of the Services. The Contractor shall provide the Employer with a latest version of update available of all the Reference Documents at the time of termination of the contract.

1.11 The Contractor acknowledges and agrees that other contractors of the Employer may be present at the Plant and it shall cooperate with such other contractors to allow the performance of its and their respective obligations to occur concurrently.

1.12 The Contractor shall through relevant agencies, if applicable, promptly investigate all accidents, damage or destruction, diagnosis, assessment of any potential consequential effects, estimating cost of repair, arranging for any remedial action required, making of any claims under the insurance policies and co-operating with and making reports required by the Employer or insurers.

1.13 The Contractor shall ensure that any Warranties provided under the Project Contracts are not invalidated or adversely affected by any act or omission of the Contractor during the period of such warranties.

1.14 The Energy Management System (EMS)/ Power Plant Controller (PPC) and SCADA system shall be connected with the Plant and the Contractor shall make arrangements to provide monthly reports from the SCADA system. The Contractor shall arrange to connect the Plant to the SCADA system operating at the Site enabling the remote operation of the Plant by the Contractor and to provide access to information pertaining to the Plant to the Employer's Representative at Site and SLDC/RLDC. The Employer may collect the data generated by the SCADA system in respect of the Plant from the Contractor.

1.15 Upon the expiry or earlier termination of the contract, the Contractor shall arrange to provide and install an additionally extended terminal from the SCADA system at the Site to enable the Employer to continue to access data relating to the Plant, at no Additional Cost and upon such terms as may be mutually agreed between the Parties at such time of expiry or earlier termination of the contract as the case may be.

1.16 The Contractor shall further provide support for the operation and maintenance of any Employer installed scope including any third-party support as may be required by any relevant Government Authority.

1.17 The Contractor shall notify and communicate to the Employer about any condition which may cause any malfunction or failure in the Project.

2. FUNCTIONAL GUARANTEES/WARRANTIES

2.1. Technical and Functional Performance Guarantee

2.1.1 The Contractor shall be responsible for meeting the performance guarantee of the Plant Facility as described in the contract.

2.1.2 In case of failure to meet the functional guarantees as described in section 2.1.1 above, the Contractor shall be liable to pay applicable Liquidated damages as described in the Bid Document and represented in Annexure-2 of this document.

2.2. <u>General Repair Warranty</u>

2.2.1. All repairs and replacements performed by the Contractor pursuant to the contract, shall cover a warranty for defects in materials and workmanship for the entire terms of O&M contract.

2.2.2. The Contractor shall disassemble, repair or, replace and reinstall any defective Equipment parts and/or re-perform any defective work covered by this warranty, at no cost or expense to the Employer.

2.2.3. In the event that Contractor replaces Parts that failed during the final year of the Term in accordance with its obligations under the Contract, Contractor hereby warrants to Employer that the replacement Parts installed in the Plant Equipment during such period shall not fail due to a defect for one (1) year following the date of installation of such replacement Parts; provided that in no event shall any such warranty extend beyond earlier of (i) the period that is one (1) year following the expiration of the Term or (ii) the date of any termination of the contract for reasons other than attributable to Contractor. During such period, if the contract is not in effect for any reason other than being terminated by Employer for cause, Contractor's obligation will be limited to supplying all needed Parts on to the Site delivered basis. For the avoidance of doubt, this Clause may survive the termination or expiry (as the case may be) of the contract for a period of one (1) year.

2.2.4. During Defect Liability Period if any repair and replacement are done, then the warrantee of the equipment shall be extended from the data of such repair and replacement to the period of original equipment warrantee w.r.t. that replaced component.

2.2.5 Any latent defect which may not come to knowledge or discovered in the course of normal inspection/operation during two years from the operational acceptance but, may arise within a period of 5(five) years from expiry of warranty period of two years, shall be under warranty by free replacement/rectification.

2.2.6 The acceptance of the equipment by employer shall in no way relieve contractor of his obligations under the contract.

2.3. <u>Guarantee of compliance in relation to Curtailment Plans (acoustic or other curtailment plans)</u>

The Employer may communicate to the Contractor any curtailment plans either linked to acoustic requirements; load management, or Applicable Law, the ("**Curtailment Plans**").

The Contractor shall ensure compliance with all Curtailment Plans provided by the Employer in accordance with Performance Standards and Technical Specifications. If either the Contractor or the Employer detects a variation with respect to the Curtailment Plans or in noise emission the Contractor will, at its own expense, characterise the problem, isolate the source of the problem and propose solutions to solve the problem to Employer (at the Employer' expenses in all cases other than cases where it's ascertained that the deviation was caused by a non-respect of the obligations under the contract).

2.4. <u>Grid Connection and balance of electricity commitments</u>

The Contractor acknowledges that to allow the Employer to inject the energy generated by the Plant Facility to the Grid and be eligible for the full tariff under the PPA, the Plant and the Contractor must comply with the requirements prescribed by Applicable Law, Good Solar Industry Practices, Performance Standards and the Grid documents and that failure to comply with such requirements may cause the Employer to either: (i) not be able to collect the tariff energy injected; and/or (ii) be subject to penalties payable to the Grid operator and/or the DISCOM and/or the power purchaser and/or any Government body. The Contractor therefore undertakes to diligently comply the requirements referred to Grid Connection and balance of electricity commitments, as prescribed under the Grid documents as provided by or on behalf of the Employer from time to time (or of which the Contractor otherwise becomes aware), and/or with the reasonable requests of the Employer associated with the compliance therewith.

3. PERFORMANCE STANDARDS

3.1 Contractor shall perform its obligations under the contract in compliance with the contract and otherwise, as applicable, in accordance with the following order of precedence (collectively, the "Performance Standards") as from time to time in force:

3.1.1 the Applicable Laws, and the requirements from the Grid Operator/SLDC/RLDC;

3.1.2 the Permits and all the related documents;

3.1.3 the terms of the contract;

3.1.4 the functional Guarantee;

3.1.5 the Reference Documents including the manufacturers recommendations;

3.1.6 Employer's health and safety manuals and procedures and ESMP;

3.1.7 the Site Regulations;

3.1.8 the Equator Principles and the Equator Principles Requirements;

3.1.9 Good Solar Industry Practice;

3.1.10 Any relevant and reasonable instructions issued by the Employer, relevant to the scope of the contract, to the Contractor at least 15 days before the implementation of such instructions without any cost to the Contractor.

3.1.11 The terms of insurances directly relating to the Project and

3.1.12 Comply with all operation and maintenance obligations as set out under the PPA or do anything which results in a breach of the Employer's obligations under the PPA.

3.2 If there is any inconsistency between the Performance Standards, [it shall be interpreted in the order of precedence listed above provided that(i) the application of a Performance Standard does not derogate, breach, contradict, obstacle or circumvent the application of a Performance Standards appearing above such standard in the above order of precedence, and, in addition, (ii) provided that this such application does not cause a breach of Performance Standards or the Parties shall discuss and agree upon the manner in which such conflict shall be resolved.

3.3 Notwithstanding any other provision in the contract, the Contractor shall have no responsibility or obligation:

(a) to save and to the extent that the Contractor is required to do so pursuant to the provisions of Additional Services, to ensure that the Plant complies with the requirements of Applicable Law, Permits, if and to the extent that the same are introduced or amended following the Commencement Date; or

(b) subject to Additional Services, to ensure that the Plant or the Plant (as a whole or in part) complies with any noise or acoustic emissions requirements under Applicable Laws Permits.

Without prejudice to the foregoing, the Contractor is required to comply with the quality of supply limits determined in accordance with the Applicable Law and the Contractor will be deemed to have knowledge of its content.

3.4 The Contractor shall not do or omit to do anything in the performance or discharge of its obligations or the exercise of its rights under the contract or in breach of the contract, which would cause any breach of any of the terms of the Supply Contract, Works Contract, the Applicable Law, the Permits or the terms of any Permits or the Direct Contract, and should the Contractor be in breach of the Performance Standards, it shall, on demand of the Employer, indemnify the Employer against any direct Losses arising from a breach of this Clause by the Contractor, always subject to the aggregate liability cap of the Contractor (except as otherwise agreed herein).

3.5 If the Contractor is aware of a conflict between any of the above requirements, it shall inform the Employer accordingly and the Parties shall discuss and agree upon the manner in which such conflict shall be resolved.

4. **EXCLUSIONS**

4.1. General

(a) Force Majeure events as per GCC

4.2. The rights of the Contractor under Exclusions shall only apply to the extent that the Excluded Risk Event has caused actual delays or substantial interference to the performance of the Contractor’s obligations under his Contract, which could not have been mitigated by the Contractor’s best efforts, and to such portions of Contractor’s obligations directly affected by such delays or interference.

4.3. Notification of Excluded Risk Event

To the extent Contractor has actual knowledge of any loss or damage to the Plant caused by or arising from an Excluded Risk Event, it shall give Employer immediate notice of the same and provide a written report to Employer within five (5) Business Days; and the employer and Contractor shall be mutually agreed upon within (30) business day. However, that any failure of Contractor to provide such notice shall not waive, prejudice or otherwise affect the other provisions in Exclusions, except to the extent that the failure to timely notify Employer results in any additional damage or loss to the Plant. Notwithstanding the foregoing, in case of delay to provide the aforementioned notice, the Contractor shall be liable towards the Employer for any additional damage or loss caused by the delay to notify the Employer.

5. ADDITIONAL SERVICES

5.1. Employer may, with respect to the Plant, request that Contractor perform work, provide services, or supply other equipment or parts, not included within Services for the successful operation of the plant for the duration of this O&M Agreement. Any such requested service or supply that the Parties mutually agree to in writing shall, subject to any specific terms and conditions agreed with respect to such service or supply, be an "**Additional Service**".

6. SERVICE PERSONNEL

6.1. Contractor shall provide the Services and any Additional Services to be performed on Site using a sufficient number of suitably skilled, qualified and experienced (including any licensing, certifications or training required by Applicable Laws or the local transmission system operator) and adequately equipped and properly trained Personnel and/or Subcontractors, all appropriately skilled and experienced in their respective trades or occupations as may be reasonably necessary to fulfil its obligations hereunder in relation to the Services and Additional Services

6.2. The Employer may request the Contractor to remove (or cause to be removed) any Person or Subcontractor employed on the operation of the Plant, including the Contractor's Representative if applicable, who:

(i) engages in material or persistent misconduct or lack of reasonable care;

(ii) carries out duties incompetently or negligently;

(iii) fails materially to conform with any provisions of the Contract;

(iv) engages in conduct which is prejudicial to safety, health or the protection of the environment or in violation of any related Performance Standards or Applicable Laws;

(v) engages in conduct which might reasonably result in a breach of any provision of the contract and threaten public health, safety or security.

6.3. The Employer shall give notice to the Contractor of the same giving reasons and request the Contractor to replace such Personnel with a suitable candidate. The Contractor shall then as soon as reasonably possible but no later than seven (7) days upon receiving such notice from the Employer, Contractor will look in to the facts and claims of the case in all sincerity and deploy the required actions with the notice to the Employer.

6.4. Contractor shall have full supervision and control over its Personnel at the Site and shall maintain appropriate order and discipline among such personnel and shall cause any Subcontractor to maintain similar standards with respect to such Subcontractor's personnel at the Site.

6.5. The Contractor shall be responsible for all matters relating to labour relations, working conditions, training, employee benefits, employee drug testing in accordance with the Contractor's standard drug testing policy, safety programs and related matters pertaining to its employees and other Personnel engaged by the Contractor. The Contractor shall at all times have full supervision and control over its employees and other personnel engaged by it and shall at all times maintain appropriate order and discipline among its Personnel and shall cause any Subcontractor (or any subcontractor appointed by such Subcontractor) to maintain similar standards with respect to such Subcontractor's or any subcontractor appointed by such Subcontractor) employees and Personnel.

6.6. The Employer shall have the right, acting reasonably and following prior notification, to require the Contractor to remove from the Site any employee or Personnel of the Contractor or any of its Subcontractors (or any subcontractor appointed by such Subcontractor) engaged in activity which presents a risk of injury to persons or property at the Site.

7. SAFETY PRECAUTION

7.1 During performance of the Services, Contractor shall:

7.1.1 comply with the safety standards and any safety procedures established by Contractor and same shall be approved by employer after the Commencement Date;

7.1.2 take all precautions required by Applicable Laws or Site Regulations, or otherwise according to the Performance Standards, for the health and safety of Contractor, its Affiliates and Subcontractors in the performance of the Services and any other Persons with temporary or perpetual access to the Site; [provided that the foregoing shall not limit Employer's responsibility for the safety of the Site as provided in Safety Precautions.

8. CONSUMABLES, SPARE PARTS, TOOLS AND EQUIPMENT

8.1 During the Term, Contractor shall provide equipment Spare Parts and Consumables and Tools, all as part of the Services and without Additional Cost to the Employer in accordance with the contract. Unless otherwise specified in the contract, the Contractor shall provide the Employer with an initial Spare Parts inventory. At the end of the Term or upon termination of the contract, the Supplier will replenish the equal quantity of the Spare Parts and Consumables and Tools as provided during the start of Contract.

8.2 <u>Consumables and Tools</u>

Contractor shall supply Consumables and Tools to the extent required for performance of the Services. All Consumables provided by Contractor in the performance of its Services, shall be compatible with the applicable requirements of the Reference Documents and Applicable Laws.

8.3 <u>Equipment and Spare Parts</u>

Contractor shall supply Equipment and Spare Parts to the extent required for its performance of the Services and to maintain its obligations thereunder. The Contractor has the right to use renovated Equipment and Spare Parts. If the Contractor intends to use any refurbished Major Components, it will seek prior written approval from the Employer. Contractor's right to procure and use renovated / refurbished Spare Parts is subject to: (i) standards of good workmanship and Good Industry Practice; (ii) compliance with the applicable requirements of the Reference Documents; (iii) the Spare Part(s) are of the type being replaced or of another type insofar as same does not invalidate any applicable Type Certification of the Equipment (iv) the same warranty as equivalent new parts in terms of scope, nature and duration, (v) being renovated in conformity with the original equipment manufacturer's standards, and (v) being listed in the monthly maintenance report when used (track record of the Part).All such renovated/refurbished parts will be allowed by Employer only for any long lead items and also considering uninterrupted generation from the Project. However, the contractor shall immediately reinstate and order new items in order to replace the refurbished items provided for emergency purposes.

8.4 <u>Inspection of Replaced Parts</u>

Contractor shall give to the Employer seven (7) days' notice of the time when the Replaced Part is being transported to the Site. Contractor shall permit Employer to inspect, at Employer's sole cost and expense, any Part which is removed and replaced by a Spare Part pursuant to Consumables, Spare Parts, Tools and Equipment (such Part, a "Replaced Part"); provided however, any such inspection:

a) must not include physical alteration or disassembly of such Replaced Part; and

(ii) must not result in any material increased costs to Contractor or delay Contractor in the performance of its obligations under the contract or any Contract with, or warranty from, its Subcontractors, unless Employer agrees to cover such material increased cost.

8.5 Tools and Equipment

Contractor shall furnish its service personnel with such tools, instruments, or materials tools and equipment and equipment as are necessary to perform the Services (the "**Contractor's Equipment**").

8.6 Prices of Consumables, Spare Parts and Contractor's Equipment

Subject to GST, Taxation & Import Duties, the O&M Price payable to Contractor under the contract shall include (in addition to other components included in such Price) the Costs of any and all Equipment, Consumables, Spare Parts and Contractor's Equipment required in connection with the performance of the Services.

8.7 Risk of Loss or Damage to Consumables, Spare Parts and Contractor's Equipment

Contractor shall:

b) be responsible at its own cost for the safe transportation and delivery to Site and adequate storage; of all Consumables, Spare Parts, and Contractor's Equipment, in each case, required for the carrying out of the Services;

(ii) bear the risk of loss and damage to all such Consumables and Spare Parts during transportation to the Site and, thereafter up to the date of their incorporation by Contractor into the Plant; and

(iii) at all material times bear all risk in any and all Contractor's Equipment on or off the Site and whether remaining separate or temporarily attached to the Plant.

8.8 Title

Contractor shall retain title to any and all Contractor’s Equipment on or off the Site and whether remaining separate or temporarily attached to the Plant until transfer of Title occurs. Title to any Spare Part (or other Part) or Consumables provided by Contractor pursuant to the contract shall pass to the Employer upon:

c) incorporation by Contractor in the Plant free and clear of any Lien; or

(ii) in the case of Additional Services, the date (if later) on which payment is made in full for such Spare Part or Consumable.

Title to any Replaced Part shall vest in Contractor upon such replacement, except if the Parties agree differently from time to time. In case of Additional Services, Employer shall retain title to any Replaced Part.

9. COMMUNICATION AND REPORTING

During the Term, Contractor shall exchange information and reports on daily, weekly, monthly, quarterly and annual basis:

9.1 Monthly Reports

Contractor shall provide Employer with the Monthly Performance Report by no later than the fifth (5th) day from the end of each month.

9.2 Emergency Notices

Upon obtaining actual knowledge thereof, Contractor shall promptly notify Employer verbally (with written notice to follow within three (3) Days) of any emergency or other hazardous condition or occurrence that Contractor reasonable believes could cause an immediate threat to the safe operation of the Plant and/or the safety of Persons.

If, by reason of an emergency arising in the course of, as a result of or otherwise in connection with and during the performance of the Services, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Plant, the Contractor must immediately perform that work, provided that, Contractor shall have no obligation to perform such portions of the protective or remedial work which would be in violation with the Performance Standards, be a material breach of the contract or would cause a threat to the safety of Persons or property or would otherwise not be reasonably practicable or possible; and provided further, that Contractor shall have no obligation to retrofit or upgrade the Plant except if otherwise agreed.

Without prejudicing the liability attributable to the Contractor for failure to comply with the provisions of the paragraph above, it is clarified that if the Contractor does not perform the protective or remedial works referred to above immediately, the Employer may appoint a Replacement Contractor to perform such works. If the work (or parts thereof) which were performed or caused to be performed by the Employer is work which the Contractor was liable to do at its own expense under the contract, the costs incurred by the Employer as a result of appointing a Replacement Contractor shall be [substantiated to the Contractor on an open book basis and be] considered due and payable to the Employer and Invoices and Payment and Set Off shall apply. It is further clarified that the impact of Replacement Contractor's actions shall not be considered as an Excluded Risk Event.

9.3 Meetings

A representative of each of Contractor and Employer (the "**Representatives**") shall meet (either at the Site or alternatively at such other location as may be agreed between the Parties) at quarterly intervals or such other period as is agreed especially for the purposes set forth below:

(i) to discuss projected dates for performance of the Services and the Additional Services in the following quarter;

(ii) to discuss, the calculated Measured Average Availability of the Plant Facility for the past quarter under Annexure 2 [Functional Guarantees]; and

(iii) to review the Services and Additional Services performed in the past quarter.

9.4 Visitors Log Book

Contractor shall provide Employer with a log book for the Plant to record the identity and activity of all visitors to site. Such log book will be kept at the entry Gate location of Plant. The Contractor shall cause that all personnel and representatives of each Party or any third parties visiting the [site] shall be required to record their identity, the date, time and purpose of any visit to site, the nature of any work performed thereon and such other details for which log books may reasonably be used. It is clarified that the Contractor shall not permit unauthorised third party access to the Site unless such third parties have been authorised by the Employer, are required to inspect or access the Site in accordance with Applicable Law or for performance of Services. Copies of these logs shall be provided to the Employer within ten (10) Business Days following its written request. Contractor shall create a digital back up of such logs at least every month. The log book shall be in English only.

9.5 Annual Calendaring of Maintenance Services.

At the latest two (2) months after the beginning of commencement date, each year during the Term thereafter, the Contractor shall send to the Employer the projected dates and times for the immediately following period during which the Contractor shall perform the Maintenance/Preventive Services on the Plant, with the parties using reasonable efforts to minimize any Plant downtime during Operational Sunny periods (the "**Maintenance Services Calendar**". Such Maintenance Services Calendar may be postponed by the Employer for 5 business days); provided, that the Maintenance Services Calendar shall be developed in accordance with the Operating Manual and the terms of the contract. The dates and times in the Maintenance Services Calendar may be amended thereafter by mutual Contract of the Parties. For clarity, the Maintenance Service Calendar shall include a maintenance plan established in accordance with the Maintenance Manual.

9.6 Status Reviews

As reasonably required, or requested by the Employer, the Representatives shall meet to discuss and review (i) the information contained in the Monthly Performance Reports, (ii) the availability of the Plant, (iii) any technical issues which may have arisen with respect to the performance, availability or maintenance and servicing of the Plant Equipment, (iv) Maintenance Services and Repair Services performed during the preceding calendar month, (v) any and all failures by a Plant equipment, and (vi) Maintenance Services to occur during the next following a calendar month.

10. Contractor's Permits

Prior to the time in which such Permits are required in order to perform when the relevant Services and/or Additional Services, as applicable, are to be performed, Contractor shall obtain and maintain, as applicable, throughout the Term of the Contract all Permits (the "Contractor Permits") required by the Applicable Law, Good Solar Industry Practices, Performance Standards and Technical Specifications which should be issued in the name of Contractor or are otherwise attributable or necessary to the provision of the Services and/or Additional Services, other than such Permits as are required to be obtained by Employer pursuant to *Employer Permits*.

11. Contractor's Manager

On or prior to the commencement of the Term, Contractor shall designate a duly qualified and experienced person to manage and administer the Contractor's activities and shall provide notice thereof to the Employer, to act as its manager and coordinator of the contract on Contractor's behalf (the "**Contractor's Manager**"). The Contractor's Manager shall not have authority to amend or modify the contract or accept any commitment which would have an effect on the contract. In case the manager is on leave with prior intimation to employer, the deputy manager with equivalent qualification shall be provided at site by the Contractor

12. **Cooperation with other Subcontractors**

Contractor acknowledges and agrees that the Employer or Other Subcontractors of Employer may be present at the Site and agrees, at no cost or expense to the Employer, to reasonably cooperate with such Other Subcontractors to allow the performance of its and their respective obligations to occur concurrently. Employer shall inform the Other Subcontractors of the clear demarcation of Contractor's scope of work so as to ensure non-interference in such work and operations by Employer's Other Subcontractors.

13. **Reserved Rights**

13.1 Plant

To the extent Contractor believes, in its reasonable discretion, that it is necessary to enhance the overall performance or safety of the Plant, Contractor may propose to Employer changes and improvements to the Plant (including the software included with respect thereto) and implement such changes or improvements proposed after obtaining the prior written consent of the Employer; provided that such changes and/or improvements shall not (i) be in conflict with the Performance Standards**;** (ii) adversely impact the technical performance of the Plant or the safety of the Plant**;** (iii) adversely impact the Availability Warranty in Annexure 2 [Functional Guarantees] (iv) increase the cost of operating the Plant; (v) place the Employer in breach of the technical requirements of the Power Purchase Contract; (vi) impair or vitiate any obligations of the Contractor under the contract; (vii) adversely affect the Supply Contract Warranties and the Works Contract Warranties; or (viii) result in non-compliance with the Type Certificate**.**

13.2 The Contractor shall only have the right to implement such changes or improvements if it has received the prior written consent of the Employer and such changes and improvements are carried out at no cost to the Employer and in accordance with Reserved Rights.

14. CERTAIN NOTIFICATIONS BY CONTRACTOR

14.1 Contractor shall, upon obtaining actual knowledge thereof, promptly give the Employer notice of:

(i) any events or facts or observations that the Contractor believes could be reasonably likely:

(a) to have a material adverse effect on the operation of any of the Plant or the performance of the Employer's obligations under the contract; or

(b) to cause an immediate threat to the safe operation of the Plant (or any Plant therein) and/or the safety of Persons; provided that, in the case of this Clause, the Contractor shall provide immediate verbal notice of such event, fact or observation to the Employer with notice to follow within three (3) Business Days);

(ii) any actual or proposed event that the Contractor believes would be reasonably likely to have a material adverse effect on the operation of any of the Plant or the performance of either Party's obligations under the contract;

(iii) any (a) violation of Applicable Laws, or Permit, by the Contractor's agents, officers, directors, employees, representatives and Subcontractors, Employer or any Other Subcontractor; or (b) any notices of Liens (or claims of Liens) or investigations by Governmental Authorities related to the Plant;

(iv) any actual or contemplated change in Law that Contractor believes would be reasonably likely to have a material adverse effect on the operation of any of the Plant or the performance of either Party's obligations under the contract.

14.2 If the Contractor does not comply with its obligations under Certain Notifications by Employer, the Contractor shall, subject to Limitations of Remedies and Liability, indemnify the Employer for any loss the Employer may suffer as a consequence, including, without limitation, compensation pursuant to Employer's Obligations.

15. ASSIGNMENT AND SUBCONTRACTING

15.1 The Contractor shall not sublet, transfer or assign the contract or any part thereof without the prior written permission of Employer. The Contractor shall not subcontract any of the Services having a value of more than 30% of the Annual O&M Price of the concerned year, except upon the Employer's advance written approval of the subcontracting of such works. Such approval shall refer to the specific identity of the Subcontractor and to the scope and terms of the subcontract. In any event, the Contractor shall not subcontract all, or materially all of the Operation and Maintenance Services or the ultimate supervision of the performance of such services.

15.2 The Contractor agrees and acknowledges that any review, by approval of, or failure to approve, or rejection by the Employer as to any Subcontractor shall not relieve the Contractor of any of its obligations under the contract, and the Contractor shall be liable hereunder to the same extent as if any such Subcontract had not been entered into. The Contractor shall at all times ensure and cause the Subcontractors not to commit any act or omission which could release, void, impair or waive any guarantee or warranty on the Plant or any part thereof.

15.3 The Contractor shall supervise and direct the work of all Subcontractors and be fully responsible for the performance of the Subcontractors and to the methods, techniques, sequences and procedures of, and for coordinating the work of the Subcontractors and to the acts and omissions of all Subcontractors and their employees, directors, officers, advisors, agents and representatives, and those of their subcontractors ("Subcontractors' Parties). With regard to any Subcontract and Subcontractor's Parties, in particular, Contractor shall ensure that all wages, labor, health and safety and social related obligations are duly performed and timely discharged in accordance with Applicable Laws. It is agreed that if the responsibility of any such payments is transferred to the Employer pursuant to Applicable Law, the Employer shall have the right to adjust all such payments against the dues to the Contractor under the contract or otherwise recover the same from the Contractor under any other Contract. It shall be at Contractor's sole responsibility to ensure the payment and discharge of all its obligations with regard to the Subcontracts and shall indemnify the Employer and any Employer Indemnified Parties for any losses incurred by such parties in relation to the Subcontracts or to Subcontractor's Parties.

16. Inspection and Testing

16.1 The Contractor must provide the Employer, independent engineer, Grid Operator, Grid Administrator, and any other Contractor or Contractors employed by the Employer and their respective nominees, or other inspectors where required under the Applicable Law, the Permits, the Finance Documents and/or the Grid documents (collectively hereinafter referred to as the "**Project Parties**"), with access at any time to any place where the Services are being performed in order to inspect the progress and the manner of the Services, provided that the Employer (or its designated representatives) gives the Contractor twenty four (24) hours prior written notice.

16.2 The Project Parties and their respective nominees will have the right to examine and have access to documents relating to the Services.

16.3 The Contractor must carry out all tests and/or inspections of the Plant or Spare Parts in a lawful, professional, timely, safe and environmentally responsible manner as may be necessary to ensure the safe, reliable, efficient, and optimal operation of the Plant and in accordance with the Performance Standards, Applicable Laws and Good Solar Industry Practice. All these tests and inspections are to be carried out at the Contractor's expense, as part of Services.

16.4 The Project Parties and their respective nominees are entitled to attend any test and/or inspection.

16.5 Whenever the Contractor is ready to carry out any test and/or inspection, the Contractor must give at least ten (10) days' advance notice to Employer of such test and/or inspection and of the place and time. The Contractor shall make its best efforts to obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Project Parties to attend the test and/or inspection.

16.6 The Contractor must provide the Employer with a report of the results of such test and/or inspection within five (5) days after the completion of that test or inspection in question.

16.7 If the Employer and/or any of the Project Parties fail to attend the test and/or inspection, or if it is agreed between the Parties that the Employer and/or any of the Project Parties will not attend, then the Contractor may proceed with the test and/or inspection in the absence of the Employer's and/or any of the Project Parties' inspector and provide the Employer with a report in the approved form of the results.

16.8 If any Spare Parts or the Plant fails to pass any test and/or inspection, the Contractor must either rectify or replace those Spare Parts or repair the Plant and promptly repeat the test and/or inspection upon giving notice.

16.9 The Contractor agrees that neither the performance of a test and/or inspection of Spare Parts or the Plant, nor the attendance by the Employer's and/or any of the Parties' inspector nor the issue of any test report will release the Contractor from any of its obligations under the contract.

16.10 <u>Inspection during the Term and at the End of the Term:</u>

During the Term, the Plant may be submitted to a general inspection performed by a Contractor selected by Employer:

16.10.1. Inspection during the Term
From time to time during the Term, but not more than once every year (being specified that any additional tests and inspections instructed by the Employer under this Clause will be for the Employer's account unless the tests or inspections were necessary as a result of the failure of the Contractor to fulfil its obligations under the contract);

16.10.2. End of Contract inspection: six (6) to twelve (12) months before the end of the Term, at the convenience of the Employer.

Subject to the Employer's reasonable advance notice as to the date of such inspection, Contractor is required to attend and assist the Employer and the designated inspector in performing such tests, without additional cost.

16.10.3. The final report shall be sent to the Contractor by the Employer and if any defect or damage found, same shall be rectified/replaced.

16.10.4. Without relieving Contractor from its obligations and without limiting Employer's ability to reasonably pursue the reliefs available to it, if applicable:

d) Contractor shall, promptly following receipt of the report, submit to the Employer (a) a recovery plan to remedy all breaches, defects and malfunctions detected in the report for which the Contractor is liable and shall perform such remedial actions without delay, and (b) provide detailed measures to be put in place to prevent such defaults from recurring;

(ii) if the Contractor fails to timely complete all remedial actions before the end of the Term, the Employer shall be entitled, at Contractor's cost and risk, to employ a Replacement Contractor to perform the works.

16.11 Employer Site Visit

16.11.1. If Employer decides to visit the Plant, Contractor shall provide personnel on the Site for mutual inspection with no additional cost to Employer. If the Contractor is reasonably unable to attend such visit for unexpected reasons and/or safety reasons, Contractor shall immediately inform the Employer. As the case may be, the Contractor shall reschedule a new visit within the next seven (7) days. Rescheduling of the visits thereof shall no occur more than once per year the Employer shall adhere to the HSE practices of the Contractor.

16.11.2. If, upon request of the Employer made in accordance with Employer Site Visit, the Contractor does not provide dedicated personnel for such visits, subject to the aforementioned rescheduling allowance, any downtime of Plant Equipment(s) to perform the inspections thereof shall be considered as unavailable for the purpose of availability calculation described in Annexure 2 [Functional Guarantees] [(however never exceeding eight (8) hours per given visit)]. Notwithstanding the foregoing, Employer may request that Contractor provide personnel on the Site for additional inspections as an Additional Service.

16.11.3. If, upon request of the Employer made in accordance with Inspection and Testing, for inspection of the Plant, the Contractor provides access to have services in the Plant Equipment examined available for inspection and Employer does not carry out such inspection, then any downtime of Plant Equipment(s) to perform the inspections thereof shall be considered as available for the purpose of availability calculation described in Annexure 2 [Functional Guarantees]

17. HAZARDOUS SUBSTANCES AND HAZARDOUS SITE CONDITIONS

17.1 Contractor shall not, nor shall it permit any other Person to bring any Hazardous Substances on the Site, other than Hazardous Substances to be used by Contractor or any Subcontractor in a manner that:

(i) does not violate any Applicable Laws, or Permits; and

(ii) is consistent in quantity and with Good Solar Industry Practices for operating and maintaining solar energy conversion plants, such as motor fuels, solvents and lubricants (collectively, “**Permissible Materials**”).

17.2 Contractor shall bear all responsibility and liability for:

(i) any Hazardous Substances that are not Permissible Materials belonging to the Contractor or present on site; or

(ii) the handling of, or failure to handle, Permissible Materials in violation of Applicable Laws or otherwise in any manner that constitutes negligence or willful misconduct by Contractor or any Subcontractor.

17.3 Contractor shall use Hazardous Substances in performance of the Services in accordance with the Performance Standards, Applicable Laws and Good Solar Industry Practices and shall not:

(i) utilize, or permit or cause any Subcontractor to utilize, on the Site such Hazardous Substances as are prohibited under Applicable Law from being used in India; or

(ii) import or use at the Site such Hazardous Substances as are prohibited under Applicable Law.

17.4 Contractor shall maintain a regularly updated log of all material safety data sheets for all hazardous substances used in connection with performance of the Services at or near the Site, which shall be available for Employer to review upon reasonable request. Contractor shall maintain an accurate record and current inventory of all hazardous substances used in performance of the Services at or near the Site, which record shall identify quantities, location of storage, use and final disposition of such hazardous substances.

17.5 Contractor shall arrange and agree for the disposal, transportation, reporting and certification (including provision of waste disposal vouchers and other certificates as required by Applicable Law or Permits) of Hazardous Substances, including waste disposal vouchers, brought onto and released at the Site by Contractor or its Sub Contractors, which are expected to include but not be limited to used oil, grease and ethylene glycol, to the extent required by Laws, in each case, by licensed, insured, competent and professional Contractors in a safe manner and in accordance with Laws. As between the Parties, Contractor shall be solely liable for any response, removal, investigation, clean-up or other remedial action required by any Laws related to any Contractor, 17.6 In the event Contractor encounters any Hazardous Substance or other hazardous conditions at the Site that are inconsistent with the Performance Standard or would reasonably be expected to impact the performance of Contractor's obligations hereunder, Contractor shall promptly report the condition to Employer. In such event, Contractor shall stop work and remove, or take other actions necessary to remedy the hazards associated with, any Contractor Hazardous Substances such that Contractor can resume work.

17.7 The Contractor shall indemnify and hold harmless the Employer against any fine, penalty or third-party Claim incurred as a result of non-compliance by the Contractor with the terms of the contract, Applicable Laws, Good Solar Industry Practice and more specifically, with its obligations under Hazardous Substances and Hazardous Site Conditions.

18. EMPLOYER'S OBLIGATIONS

During the Term, Employer shall perform the following obligations:

18.1 <u>Access</u>

18.1.1. On and from the Commencement Date, Employer shall provide the Contractor (and its Subcontractors) full, free and safe Access to the Plant for the purpose of enabling Contractor to fulfil its obligations under the contract.

Notwithstanding the foregoing, the Contractor shall be required to perform any works (including obtaining permits for such works) related to the Access to the Site required for the delivery of any Spare Parts, if so requested by the Employer in writing, on the Time to time Basis.

18.1.2. The Employer shall give to the Contractor and the Contractor's personnel unrestricted Access to the Site to enable Contractor and the Contractor's personnel to carry out all elements of the Services at any time from the Commencement Date until the end of the Term. Such Access shall include the provision by the Employer of:

(i) such keys or access codes as may be required by the Contractor to gain unhindered access to the Site (as the case may be);

(ii) Access to the access roads to and on the Site If there is any deviation, and such deviations are accepted by the transport contractor, then such deviations shall be accepted by the Contractor.

Notwithstanding anything else contained in the contract all Access to the Site and Plant is subject to the applicable site safety, security and environmental requirements and Applicable Law (and the Contractor should comply with the same). The Employer will have the right to limit Access or expel any Person off the Site in case of them not fulfilling the Emergency plan of the Site, the Emergency plan of the Plant Facility.

18.2 Employer's Permits

Contractor, on behalf of the Employer, shall obtain and maintain all Permits and any Permits required by Applicable Law to be obtained in the name of the Employer in order to (i) perform Employer's obligations under the contract and (ii) enable Contractor to lawfully access the Site at the point of entry to the Site and the Plant].

19. **SITE REGULATIONS**

Employer shall (directly or through a Subcontractor, advisor or agent) provide the Site Regulations and revisions thereof from time to time, and shall require the Other Subcontractors and their respective agents and employees to, (i) comply with the Site Regulations; and (ii) take all necessary precautions (as required by Applicable Law or otherwise) for the health and safety of all Persons (including Contractor's personnel) at the Site.

20. **CERTAIN NOTIFICATIONS BY EMPLOYER**

20.1 Employer shall, upon obtaining actual knowledge thereof, promptly give the Contractor, as soon as practicable, notice of:

20.1.1. any events or facts or observations that the Employer believes has determined that would:

(i) have a material adverse effect on the operation of any of the Plant or the performance of the Contractor's obligations under the contract; or

(ii) to cause an immediate threat to the safe operation of the Project (or any Plant therein) and/or the safety of Persons; provided that, in the case of this current Sub-Clause, the Employer shall provide as soon as possible verbal notice of such event, fact or observation to the other;

20.1.2. any (a) violation of Applicable Laws, including environmental Laws or the terms of any Permit, by Contractor or any Other Subcontractor or (ii) any notices of Liens (or claims of Liens) or investigations by Governmental Authorities related to the Project.

20.2 Failure to furnish notice pursuant to Certain Notifications by Employer shall not affect the Contractor's obligations to perform its obligations. Contractor.

21. **EMPLOYER 'S OWNERSHIP OF ENERGY, EQUIPMENT, SPARES AND PROJECT BENEFITS**

21.1 The Contractor acknowledges that ownership of the Energy or any benefits arising out of the operation of the Plant remains at all times, and in all circumstances with the Employer at all times and the Contractor has no legal or equitable title to or interest in the Energy or other benefit.

21.2 The ownership of all item supplied by the Contractor, including under Additional Services shall be transferred to the Employer at the end of the term of the contract:

(i) such items becoming a permanent part of the Plant against the mutually agreed payment by both the parties

21.3 The ownership of any item (not including Energy or benefits arising out of the operation of the Plant) supplied by the Contractor as part of the Services shall be transferred to the Employer upon such items becoming a permanent part of the Plant.

21.4 The Contractor agrees that any benefits, including any carbon credits, renewable energy certificates or similar royalty or credit that may arise as a result of having the Project undertaken belong to the Employer and the Contractor shall provide all reasonable assistance requested by the Employer in order to obtain such rights and benefits.

22. **PRICE AND PAYMENT**

22.1 <u>Total Annual O&M Cost</u>

Commencing on the Commencement Date and for the remainder of the Term, Employer shall, in consideration of the Contractor providing the Services and its prior receipt of an invoice with respect thereto, pay in accordance with Invoices and Payment to Contractor an annual O&M cost in INR in equal quarterly instalments at the end of every quarter for each year till 15 (Fifteen) years in the amounts set forth in and payable in accordance with Price Schedule No 5/SOR-5 [Schedule of Rates] of the bidding documents for the plant facilities. The yearly breakup of the Total O&M price shall be in line with the Price Schedule No 5/SOR-5.

Against the successful Operation and Maintenance of the entire Plant Facility payment will be released on quarterly basis at the end of every quarter for each year till 15 (Fifteen) years.

The O&M of the plant will commence from the date of Operational Acceptance of the plants.

The Contractor acknowledges that the Total Annual O&M cost forms the sole and exclusive consideration and reimbursement due to the Contractor for the performance of the services included under the Services and Spare Parts and that the Contractor shall not be entitled to any additional amount for their performance, for whatever reason, including, amount others due to increased costs, changes in applicable GST, customs or duties (including, without limitation those set forth in GST, Taxation and Import Duties below), and except as may be specifically provided in the contract.

22.2 Payment of amounts due to the Contractor:

Amount shall not be considered as due and payable and the period for the payment of any Price stipulated under the contract shall not commence until the Contractor has duly fulfilled and delivered all obligations and deliverables required from the Contractor until the date of submission of the invoice for the payment to the Employer with relation to such invoice and/or within the period for which the Price included in the invoice are due.

23. INVOICES AND PAYMENT

23.1 Contractor shall submit Goods & Service Tax (GST) compliant invoices to Employer for the amounts due under Total Annual O&M cost above and for any other amounts that may be due under the contract.

23.2 The Total Annual O&M Cost shall be invoiced by the Contractor quarterly against the completion of concerned quarter and each invoice may be submitted by Contractor no later than the day after the completion of the quarterly period in question and, subject to the terms of the contract, shall be paid by the Employer no later thirty (30) days from the date of submission of the invoice along with all other requisite documents (If so required). The Employer shall make payments by wire transfer to the bank account designated from time to time and owned by Contractor. The payment of any invoice shall be subject to the Contractor submitting to the Employer the Monthly Performance Reports.

23.3 Additional Services may, for purposes of this Invoices and Payment, be invoiced upon full and proper completion of each individual task and shall, subject to the terms of the contract be paid by the Employer within thirty (30) days from the date of submission of the invoice along with all other requisite documents (If so required).

23.4 VOID.

23.5 To the extent permitted by Applicable Laws, if the amount of an invoice is disputed by the Employer, the Employer shall be entitled to withhold payment of the disputed amount for the next invoice (or part thereof), until the dispute is resolved between the Parties under Law Dispute Resolution or otherwise. The Employer shall pay at the applicable time the undisputed amount of such invoice including any undisputed portion of the invoice item in dispute. Further, the Employer shall be entitled to withhold payment of any amount due to the Contractor, if, at the time, the Contractor is in breach of one or more of its material obligations in terms of the contract.

23.5.1. Subject to the provisions on the contract, the Contractor warrants that it has, and will be deemed to have, done everything that would be expected of a prudent, competent and experienced Contractor and in accordance with Good Solar Industry Practices in:

(i) assessing all risks which it is assuming under the Contract; and

(ii) ensuring that the **O&M Price** contain allowances to protect it against any of these risks eventuating,

and that it will not make a claim for an increase in the **O&M Price** if any of those risks eventuate.

23.5.2. Except for Liens arising out of a failure of the Employer to make any payment when due hereunder to Contractor or any other Person providing labour or services to the Project under Contract to the Employer, the Contractor acknowledges and agrees that it shall not file, claim or register any Liens and shall use its best efforts to prevent any Liens from being filed, claimed or registered by any Subcontractor or by any employee, or agent of the Contractor or Subcontractor, against the Services, Additional Services, the Plant as a whole or any part thereof, or any real or other property of the Employer, for any works done or any Services and/or Additional Services rendered under the Contract or any subcontract let by the Contractor and shall procure that all subcontracts contain undertakings to the like effect.

23.5.3. The Contractor shall indemnify the Employer against any loss, damage, cost or expense (including legal fees) of the Employer arising out of or in connection with any Lien being filed, claimed or registered as referred to Invoices and Payment.

23.5.4. The delay or failure of a party to pay any amounts due hereunder, or the withholding of any amounts which are claimed by a party to be due, shall not release the other Party from any of its obligations or liabilities under the contract.

24. SCADA, EMS

Contractor shall be required from time to time to update the SCADA and PPC/EMS software, as required for the ongoing adequate operation of the Plant Facility. Such updates shall also be provided to the Employer at no additional costs.

25. INSURANCE

25.1 Contractor ‘s insurance

The Contractor, at his own cost and expense, shall take out and maintain in full force and effect and shall cause its Subcontractors to take out and maintain in full force and effect, throughout the Term of the Contract and any extensions thereof, the following insurance policies from reputable insurers and shall provide the Employer with copies of the corresponding insurance certificates:

a) Covering physical loss or damage to the all plant facilities at the Site, with an extended maintenance coverage for the Contractor’s liability in respect of any loss or damage for the entire term of the contract.
b) Workers compensation insurance, as required by the Applicable Law and Contracts made with employees.

c) Group Medical Claim, Group Term Policy & Group Personal Accident Insurances covering the financial consequences cause by damage and loss arising from sickness, disease, injury or death of any person employed by the Contractor in respect of the services performed Automobile Public Liability insurance, as required by the Applicable Laws, for all vehicles and automotive equipment owned hired, rented, leased and non-owned by the Contractor and used in the performance of the Services.

d) Comprehensive General third-party liability insurance including product and contractual liability covering the financial consequences of the liability arising out loss or damage caused to third parties or to the employer as consequence of the performance of the services.

e) All other insurance like – transit insurance (Marine/ Cargo/ others as applicable), Construction All Risk, Erection All Risk, workmen compensation, fire, third party liability, insurance against Insurance against theft, fire, act of God, Contractor's Equipments, machinery breakdown policy, business interruption insurance, Property damage Insurance & Environmental risk insurance as required during the O&M period of the Plant shall be in the contractor's scope & shall borne by the Contractor.

The Service Provides shall ensure that under the aforementioned insurance policies, each of the insured has the ability to claim thereunder for a minimum period of three (3) months from the date of expiry of the insurance policies for any claims that arose prior to the expiry date.

The Employer shall be named as co-insured under all insurance policies taken out by the Contractor, except for the Third-Party Liability and Workers' Compensation Insurances, and the Contractor's Subcontractors shall be named as co-insureds under all insurance policies taken out by the Contractor, except for the Cargo, Workers' Compensation. All insurer's rights of subrogation against such co-insureds for losses or claims arising out of the performance of the Contract shall be waived under such policies.

Annual Status Report of Insurance Claims: The Contractor shall include the status of Insurance Claims made or required to be made during the year as part of the Annual Reporting Requirements.

25.2 Contractor's Insurance for the Plant Facility

The Contractor shall take out and maintain an insurance policy, seamlessly with CAR policy taken earlier during construction phase, preferably from same insurance company for the plant facility during the entire term of the contract

In the event of any incident or damage or loss that would be reasonably expected to result in an insurance claim, the Contractor shall:

e) Notify without delay to the Employer
f) Prepare and conduct all and any claims made under the policies effected by it, and all monies payable by any insurers shall be paid to the Contractor take all reasonable measures to mitigate the loss, its effects and to protect salvage.
g) Collaborate with Employer and the insurer and provide them with all information and documents they may request.
h) Arrange immediate reinstatement of the damage to the employer's satisfaction, without waiting for the settlement for the corresponding insurance claim.

i) Claim in pursuant to the contract to the insurance agencies, if the claim is accepted or rejected or not accepted or partly accepted by the insurance agency then it will not limit the contractor obligation in any case and also if any losses on account of this shall be in the scope of contractor.

25.3 General Insurance Requirements

25.3.1 The Contractor shall, provide copies of the corresponding insurance certificates mentioned above.

25.3.2 If the Contractor fails to effect or maintain any insurance policy required hereunder, or fails to produce copy of the corresponding insurance certificates**,** the Employer may (but as no obligation), without prejudice to any other right or remedy available to it under the contract, procure the insurance for the relevant coverage and/or pay the premiums due. Such payments shall be recoverable and deducted from the payments to be made to the Contractor by the Employer under the Contract. In the event if Contractor does not pay the premium, then the Employer may pay the premium however in such case the obligations of Contractor to undertake the coverage shall continue as envisaged, irrespective of premium being paid by Employer. The Premium if paid by the Employer shall be recovered from the Annual O&M Fees payable by the Employer to the Contractor.

25.3.3 The Contractor shall comply with the conditions stipulated in each of the insurance policies to be affected under the Contract and shall not make any alteration to the terms of any policy subscribed by it so it deviates from the requirements herein.

25.3.4 The Contractor must promptly notify to the Employer any notification received from an insurance company regarding any actual alteration to one of their policies.

25.3.5 On occurrence of any loss covered by an insurance policy contemplated under *Insurance*, the Contractor shall, as soon as reasonably possible, notify to insurance companies for the policy subscribed by it. The Contractor shall also take any appropriate measure to mitigate the effects to the loss to the maximum extent possible. The Contractor shall assist any assessment mandated by the insurance companies.

25.3.6 The required coverages referred to and set forth in this Article 33 (*Insurance*) shall in no way affect or limit the Contractor's liability with respect to its obligations under the Contract.

25.4 The Contractor shall also arrange suitable insurance to cover following during the O&M Period:

a) **Machinery Breakdown**: Electrical & or machinery breakdown of any machinery or other equipment resulting in costly repairs or even replacement of the solar panel.

b) **Business Interruption**: Cover for period of operational downtime i.e., covering the cash flow of the solar business as a result of an insured peril, for example fire or storm damage, machinery breakdown or equipment failure.

c) **Property Damage**: The insurance should cover material damage due to external causes such as fire, theft, vandalism, sabotage, hail damage, snow load, lightning strike, overload, operational mistakes, clumsiness, negligence & theft.

d) **Employers Liability**: Provides cover against the risk of accident from usual workplace risks such as working at height & manual handling during construction & O&M period..

e) **Environmental Risk Insurance**: Environmental damage coverage indemnifies solar system owners of the risk of either environmental damage done by their development or pre-existing damage on the development site.

ANNEXURE-1

Scope of Work for Operation and Maintenance

i) The Contractor shall prepare the initial Annual Operating Plan for the Plant Facility and shall also indicate the proposed resources (manpower, material & machinery) that would be deployed for O&M.

ii) The Contractor shall be responsible for the smooth day-to-day operation of the Plant Facility.

iii) The Contractor shall provide necessary routine and preventive maintenance schedules of the plant for the Employer's approval and shall carry out all routine and preventive maintenance accordingly.

iv) The Contractor shall perform periodic overhauls and preventive maintenance required for the Plant in accordance with the recommendations of equipment manufacturers and as per the O&M manuals.

v) Contractor shall perform all break down maintenance and other maintenance in the Plant Facility. The Contractor shall be responsible for achieving the performance guarantee of the plant as indicated in the contract.

vi) The Contractor shall operate and maintain fire protection system and safety equipment for the plant.

vii) The Contractor shall do maintenance of electricity system including overhead lines in the Plant Facility area up to the Point of Common Coupling (PCC) to the grid at the site. Necessary co-ordination shall be made by the Contractor with STU/CTU, SLDC/RLDC and other agencies as may be required during the Operation and Maintenance term for smooth operation of the plant.

viii) Contractor shall work in coordination with the Employer or any Employer's designated party to optimize the Plant production.

ix) The Contractor shall provide required spare plant Equipment, Spare Parts, tools and tackles, consumables required for comprehensive operation and maintenance of the plant facility. The Contractor shall make arrangement to procure required spare parts, or equipment/s as required, overhauling of parts, tools and equipment, required to operate and maintain the Plant in accordance with the recommendations of individual original equipment manufacturer at his own cost. Cost of imported Equipment & spare parts, if any, shall be included in the O&M quoted cost. The List of Consumables, Spare Parts, tools and equipment shall be finalised in consultation with the Employer or Employer's representative. List of recommended spare parts shall be submitted by the Contractor at the beginning of services; however the complete recommended spares will be in the scope of contractor only. In case any equipment or spares is not listed in the mandatory spares list but is required vitally for the operation of the plant, then the same shall be procured and provided by the contractor without any additional cost.

x) It is the responsibility of the Service Provide to store the materials in appropriate stock yard or container at the site so as to ensure timely availability of the materials.

xi) The Contractor shall employ only such personnel who are adequately qualified and experienced for operating and maintaining such power generating sets. The Contractor shall ensure that such personnel are on duty at the plant at all times, 24 (twenty-four) hours a day and 7 (seven) days a week commencing from the Date of Operational acceptance.

xii) Contractor shall carry out all day-to-day operation and maintenance for the Plant Facility as set forth herein. Contractor shall perform the Work and supply all required spare parts in a prudent and efficient manner and in accordance with manufacturers and systems designers' specifications, the Annual Operating Plan for the Plant and all operation and maintenance manuals, all Indian applicable laws including environmental protection, pollution, sanitary, labour act, factory act, employment and safety laws, ("Government Rules") and Prudent Utility Practice. The contractor shall adhere to all labour laws which are applicable and as specified in the EPC contract document.

xiii) Contractor shall arrange necessary security staff for watch and ward of the Plant Facility round the clock at his own cost, the details of which shall be furnished along with the bid.

xiv) Contractor shall be responsible for:

- Maximizing plant capacity utilization,
- Reducing plant downtime,
- Optimizing the useful life of the equipment of the power plant.

xv) The Contractor shall maintain all accounting records regarding the facility in accordance with the generally acceptable accounting principles under the Laws of India.

xvi) The Contractor shall maintain accurate and up-to-date operating logs, records and monthly reports regarding operation and maintenance of the Plant facility (Such records shall be distinctly recorded for Solar PV Plant, in order to have clear data for assessment of any individual component of the Plant Facility) which shall include details of power output, other operating data, repairs performed and status of equipment. All such records to be maintained for a minimum of 60 (sixty) months after the creation of such record or data and for any additional length of time required by regulatory agencies with jurisdiction over the Parties. Upon expiry of term, the Contractor shall hand over all such records to EMPLOYER. However, EMPLOYER shall have access to all such records at any time. Generation and O&M reports should be made available to EMPLOYER on daily and monthly basis in required formats as well as the Quarterly and Annual Performance Reports shall be provided. Contractor shall provide communications as well as daily, weekly, monthly, quarterly and annual reports to the employer in the desired format as per the Contract with the Employer or Employer's Engineer.

xvii) The Contractor shall develop and implement plans and procedures including those for firefighting, maintenance planning, procuring and inventory control of stores and spares, plan to meet emergencies, plant safety and security; and such other facilities and systems as may be necessary to commence Contractor's ongoing responsibilities.

xviii) The Contractor shall provide copies of all necessary documents including the following:

- Operation and maintenance manuals shall be prepared and approval shall be accorded from Employer within three months from the date of Operational acceptance.
- Failure Analysis/history/trouble shooting details of all the Equipment
- Identification of Equipment needing preventive maintenance
- List of Vendors indicating name and addresses during operation and maintenance with credentials
- root cause analysis report for any major failure.
- Record of consumables / spare parts

xix) The Contractor shall be responsible for conveying following details to the Employer on daily basis as well as on monthly basis (by the end of 5th day of each month) by fax/ e-mail giving the detail of plant performance during previous month.

- Power generated at all Solar PV Plant
- Power fed to the grid
- Internal power loss and internal consumption
- Power consumption for captive use (if any)
- Reactive power consumption
- Downtime of Plant Facilities including Solar PV Plant and other infrastructure of the Plant facility.

xx) The Contractor shall be responsible for liasioning with statutory authorities–and local authorities in order to ensure smooth operation of the Power Plant.

xxi) Contractor shall provide constant remote surveillance to the Plant Facility

xxii) Contractor shall provide updates and revisions to Reference Documents, as and when applicable.

xxiii) Shall implement software updates to control and monitoring systems including EMS/SCADA in order to meet the plant facility operating requirement in consonance with the grid operations and in compliance with the grid codes as applicable during the operation.

xxiv) Duly and timely provide the Employer (or parties designated by the Employer) with all notifications required under the Contract including in particular such notifications set forth in Certain Notifications by Contractor;

xxv) Contractor shall provide access to the Employer to all data for the Plant Facility from the EMS including the SCADA system.

xxvi) Contractor shall at all times allow and provide Employer all necessary information for the operation of EMS including the SCADA system (with no notification or approval of access being required unless specifically and otherwise agreed to by the Parties) full, free, unconditional, safe and complete access to the EMS including the SCADA system. Contractor shall monitor and operate the Plant in accordance with the contract and shall ensure smooth operation of the plant.

xxvii) Provide the training to the Employer’s personnel in relation to the operation of the complete plant facility. Training shall be provided to the employer within 190 days before end the contract.

xxviii) Contractor shall provide the insurances prescribed in insurance. The Contractor shall, with [prior intimation of 5 Business Days] at regular business hours, allow persons duly authorized by the Employer including but not limited to the officials of the insurance company of the Employer, to inspect the Project and provide to such personnel, access to all information which is necessary for their inspection, and is reasonably requested by the Employer. All representatives of the Employer shall strictly adhere to the Applicable Laws and the Health, Safety and Environmental (HSE) practices of the Contractor as provided in the Reference Documents;

xxix) Contractor shall provide for the watch and ward of the Plant at all times during the Term. The watch and ward deployment plan shall take care of comprehensive Project level security and the Contractor shall take necessary steps to prevent sabotage, theft, vandalism and malicious damage of the assets comprising the Plant, and shall also coordinate and liaison with law enforcement authorities. The Contractor shall take all possible measures to keep the plant operational and secure.

xxx) Contractor shall Coordinate with SLDC/RLDC and other related entities/departments/local Panchayats as required for proper operation of the Plant Facilities. Also coordinate with relevant agencies for monthly Joint Meter Readings, meter testing, and any other requirements such as any audit or inspection by the government agencies or authorities, financiers, any designated third-party agency etc. for the Project operations.

xxxi) Contractor shall be responsible for appointing a Qualified Coordinating Agency at the Pooling Substation Level and shall be responsible for carrying out the forecasting and scheduling of the energy generation from the plant facility (In accordance with the Deviation Settlement Mechanism Regulations, as applicable). Scheduling given by the Contractor is such that no penalty is levied on the Employer due to any deviation of actual generation from scheduling beyond the allowed limit. If any penalty is imposed on the Employer due to such deviations beyond allowed limit the same shall be passed on to the Contractor and the recovery of the same will be done from the O&M Price payable to the Contractor.

xxxii) Water requirement for module cleaning arrangement and the cost for the same shall be borne by Contractor. The Contractor shall arrange for water on it's own, by ensuring ESIA norms.

xxxiii) Contractor shall be responsible to comply with all applicable National and International Standards as well as local statutory provisions related to Environmental Protection Regulations, Health and Safety requirement.

xxxiv) Contractor will be responsible for coordinating with the OEMs for securing warrantee conditions and services from OEMs as per the warrantee of each equipment, as well also for the Project insurance claims.

xxxv) Contractor shall carry out the performance monitoring for the Plant Facility on continuous basis and in case of any deviation, the Contractor shall perform the due diligence appropriately to find out the actual root cause of such deviation. Any test or inspection required such as thermal imaging, IV characteristics test etc. to analyse such deviation will be the responsibility of the Contractor. Thereafter the corrective action required to mitigate such deviation shall be undertaken by the Contractor without any additional cost.

xxxvi) Contractor shall be responsible for maintenance of all each and every civil infrastructure parts like Building, cable trench, fencing, drain, plumbing system fire-fighting system, CCTV system, security arrangement, road, earthing, any foundations, anti-weeding, clearing bushes in the solar field etc., as per the direction of employer's Engineering In-charge.

ANNEXURE-2

Functional Guarantees

1. Annual CUF Guarantee

A. In consideration for the payment of the O&M Price , from the Commencement Date until the end of the Term, the Contractor grants to the Employer Performance Ratio Guarantee on the terms and conditions set forth in the contract.

B. The Contractor guarantees of Plant Performance Ratio over the year committed herein over the O&M Period (“**Annual PR Guarantee**”) from the date of Operational Acceptance. In the event the PR is less than the Guaranteed PR, the Contractor shall immediately, upon demand, indemnify the Employer, as liquidated damages and not as penalty, amounts equivalent to estimated energy loss, subject to a maximum of seventy (70%) percent of the Total Annual O&M Contract Value.

C. Performance Ratio (PR) for Solar Plant shall be calculated as per the detailed procedure provided in Annexure A: FG Test Procedure. Towards the demonstration of Functional Guarantees under this O&M Agreement, the Annual PR shall be calculated as the mean of PR calculated on a monthly basis (over the total no. of days in the month) as per the procedure specified under Clause 2.1.4.2 therein (i.e. FG Test Procedure)

Annual PR = mean of monthly PR

D. Liquidated Damages for Shortfall in Annual PR for Solar PV Plant

If the Contractor fails to achieve annual guaranteed PR at the end of an Year, but PR achieved is not less than 5% from the guaranteed PR (eg, if guaranteed PR is 81%, and 76% >= PR achieved <= 81%), the Contractor shall be liable for liquidated damages to the Employer (amount to be deducted from the payment due towards O&M of the Plant under the Contract, as per below:

Liquidated Damages (LD) = (PR_g – PR_a)/0.05 x 0.7 x Annual O&M Contract Value

Where, PR_g = Annual PR Guarantee as per O&M Contract

PR_a = Actual PR achieved

Note:

(i) For the purpose of above calculation numerical value of the PR shall be considered with up to 3 significant decimal places. Eg. 0.811.

(j) The Invoices raised by the O&M Contractor during the year (when Annual PR has not been calculated), shall be paid by the Employer after deducting LD, if applicable, as per above formula, on the basis of average PR for the invoice period.

(ii) In case Annual PR guarantee is demonstrated by the O&M Contractor, any amount deducted as LD towards shortfall in PR during the year shall be reversed.

E. In case the Project fails to generate any power continuously for 1 month any time during the O&M period, apart from the force majeure and grid outages as certified by competent authority from STU/ CTU, it shall be considered as “an event of default”. In the case of default the entire Contract Performance Security will be forfeited.

F. Penalty during O&M period against breakdown of other Infrastructure of Plant Facilites that don 't affect the generation of power directly, such as but not limited to, civil infrastructure, water supply system/network, other Infrastructure developed by the Contractor as per Scope of Work for the Project (Section-VII: Scope of Works & Technical Specifications) and/or non-compliance with scheduled preventive maintenance activities shall be penalised @ Rs.1000/day, for non-compliance with PM Schedule (Initiation/Completion of Scheduled maintenance Activity as agreed under this Contract) beyond 48 hours. Cumulative value of such penalty shall be limited to 50% of Annual O&M Contract Value.

For the purpose of this Clause, the PM shall be inclusive of, but not limited to the following PM activities:

Item	Scope of Maintenance Activity	Periodicity
PV Arrays	Cleaning of PV Modules	A least 2 cycles per month
PV Arrays	Thermal Imaging of PV Modules	Once every year
Environmental/Corrosive Protective Coatings	White-washing/Application/Re-application of Distemper, Epoxy coatings	Once in every 2 years under the O&M Contract period, in consultation with the Owner
Roads and Access paths	Repair and maintenance of all roads – Access, Internal and Periphery roads, walkways as well as fences, gates, cable-trenches and outdoor equipment platforms.	Once every year prior to Monsoon season, in Consultation with the Owner
Water Supply Network	Repair and Maintenance of Water Supply Network including piping network, valves, pumps etc.	Once Every Year in Consultation with the Owner.
Periphery Lighting	Repair and maintenance of Peripheral Lighting including replacement of non-functional lighting fixtures, Junction Boxes, Conduits etc.	Once every Six Months
Rodent Entry Points	Application/re-application of Anti-rodent protection measures like PUF filling, sealant etc. at Checker/Gland Plates, Cable Entry Points (in PCU/SMU, Switchgear Panels, Buildings, Enclosures)	Once every Six Months

All bolted/tightened structures	Tightening/fastening of bolts that are exposed to winds/vibrations like MMS members/foundation bolts	Once every Year before onset of Windy season, in consultation with the Owner.
Enclosures of Equipment requiring Temperature and Dust Controlled environment for Normal Operation	Application/re-application of insulation/Dust-Filters/Temperature-control equipment at Enclosures/Buildings housing PCU, Switchgear	Once every Year, consultation with the Owner.
Weather Monitoring System	Calibration of Sensors/Measuring Instruments	As per the requirement to maintain valid calibration certificate
Entire Plant Facility	Oversight management of the hazardous/toxic materials including its handling and disposal as per Government of India Rules and environmental and safety assessments by a qualified Specialist	Once every Year, in consultation with the Owner.

Note : *The Contractor shall ensure intimation and submission of requisite Reports to the owner at least 15 days prior to initiation of maintenance action for the activity.*

G. Void

H. The Penalty specified on account of delays, and Liquidated Damages and on account of deviations in Functional Guarantees as above shall be assessed independent of each other.

I. **Limitation of Contractor's Liability under O&M Contract**: Except for the Contractor's indemnity obligations under this Contract, and except for actions or claims arising from gross negligence or intentional or wilful misconduct, Contractor's total liability to Employer for a given year shall not exceed the corresponding year's Value of O&M Contract.

Scheduling and Forecasting:

1. The Contractor shall be responsible for appointing a Qualified Coordinating Agency if required by concerned authorities at the Pooling Substation Level for scheduling and forecasting activity. Also, the contractor shall be responsible for carrying out the forecasting and scheduling of the energy generation from the plant facility (In accordance with the Deviation Settlement Mechanism Regulations, as applicable). Scheduling given by the Contractors is such that no penalty is levied on the Employer due to any deviation of actual generation from scheduling beyond the allowed limit. If any penalty arises due to DSM after adjusting the payable and receivable imposed on the Employer due to such deviations beyond allowed limit, the same has to be paid by the contractor separately. If the contractor fails to pay such penalty, then it shall be recovered from the contractor's payment to be done by Employer.

2. The deviation charges, as per applicable regulations, for the difference in units between scheduled and actual generation shall be recovered from the contractor on following basis.

2.1 In case of any deviation due to forecasting and scheduling error, Contractor shall bear the cost/Penalty.

2.2 In case of localized thunderstorm/sand storm, the Employer shall bear the deviation charges till the time period before which the revision of scheduling is not allowed, as per applicable regulation.

2.3 In case if there is a component/Machine/Inverter failure, the Employer shall bear the deviation charges on account of such failure till the time period block before which the revision of scheduling is not allowed, affected as per applicable regulation. The contractor shall bear the deviation charges due to such failure beyond such time period.

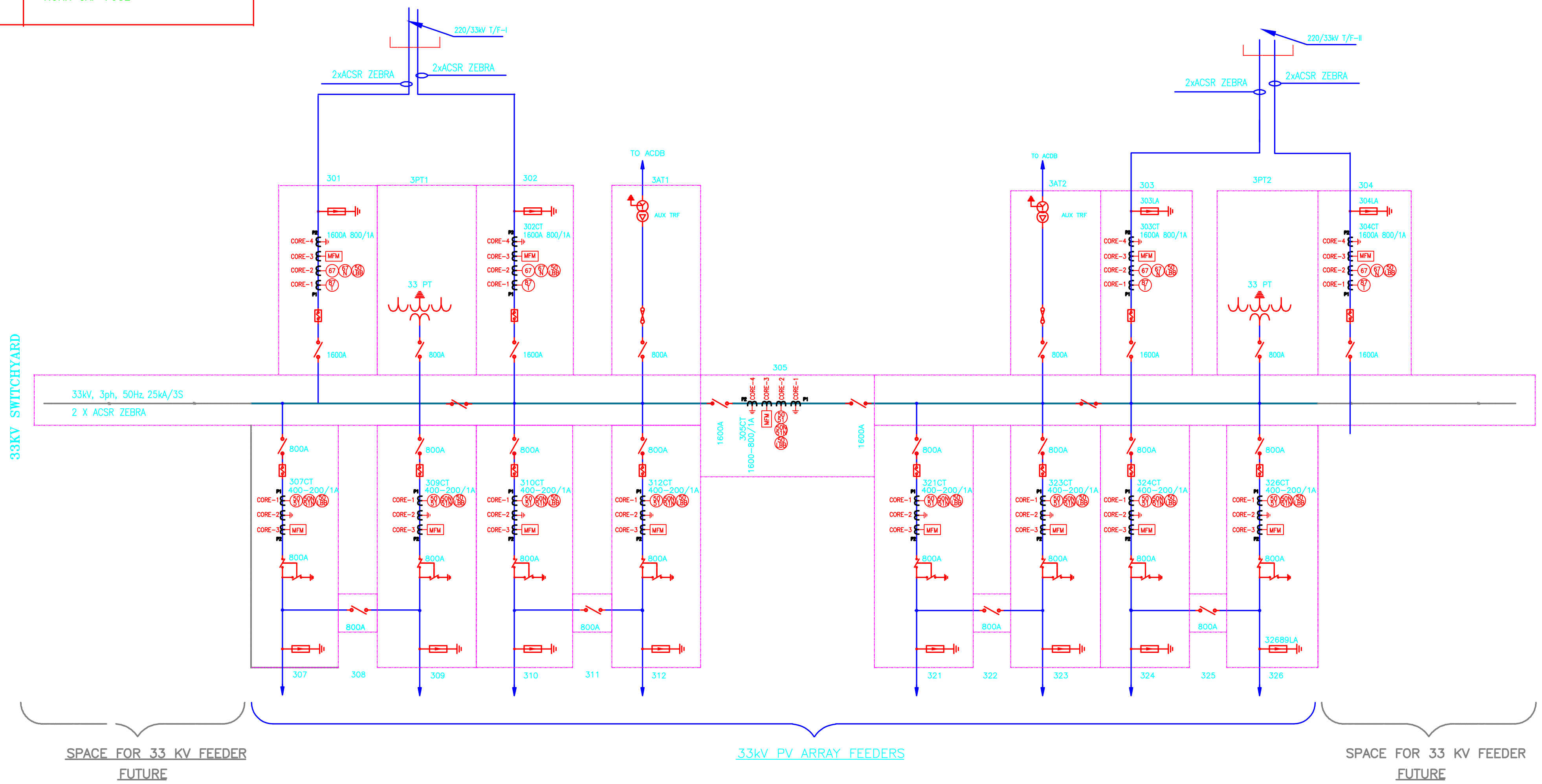
Appendices

1. **Reference Documents**

2. **Annual Preventive Maintenance Schedule**

LEGENDS:-

SYMBOL	DISCRIPTION
	CIRCUIT BREAKER
	LIGHTNING ARRESTOR
	ISOLATOR (DOUBLE BREAK) WITHOUT E/S
	ISOLATOR (DOUBLE BREAK) WITH E/S
	CURRENT TRANSFORMER
	COUPLING CAPACITOR
	POTENTIAL TRANSFORMER
	AUXILIARY TRANSFORMER
	HORN GAP FUSE



Note:

This drawing and the information contained herein represents the indicative schema of the Block Pooling Station.
Technical Data and specifications of components shall be finalized during detailed engineering in accordance with the Technical Specifications provided with the tender document.

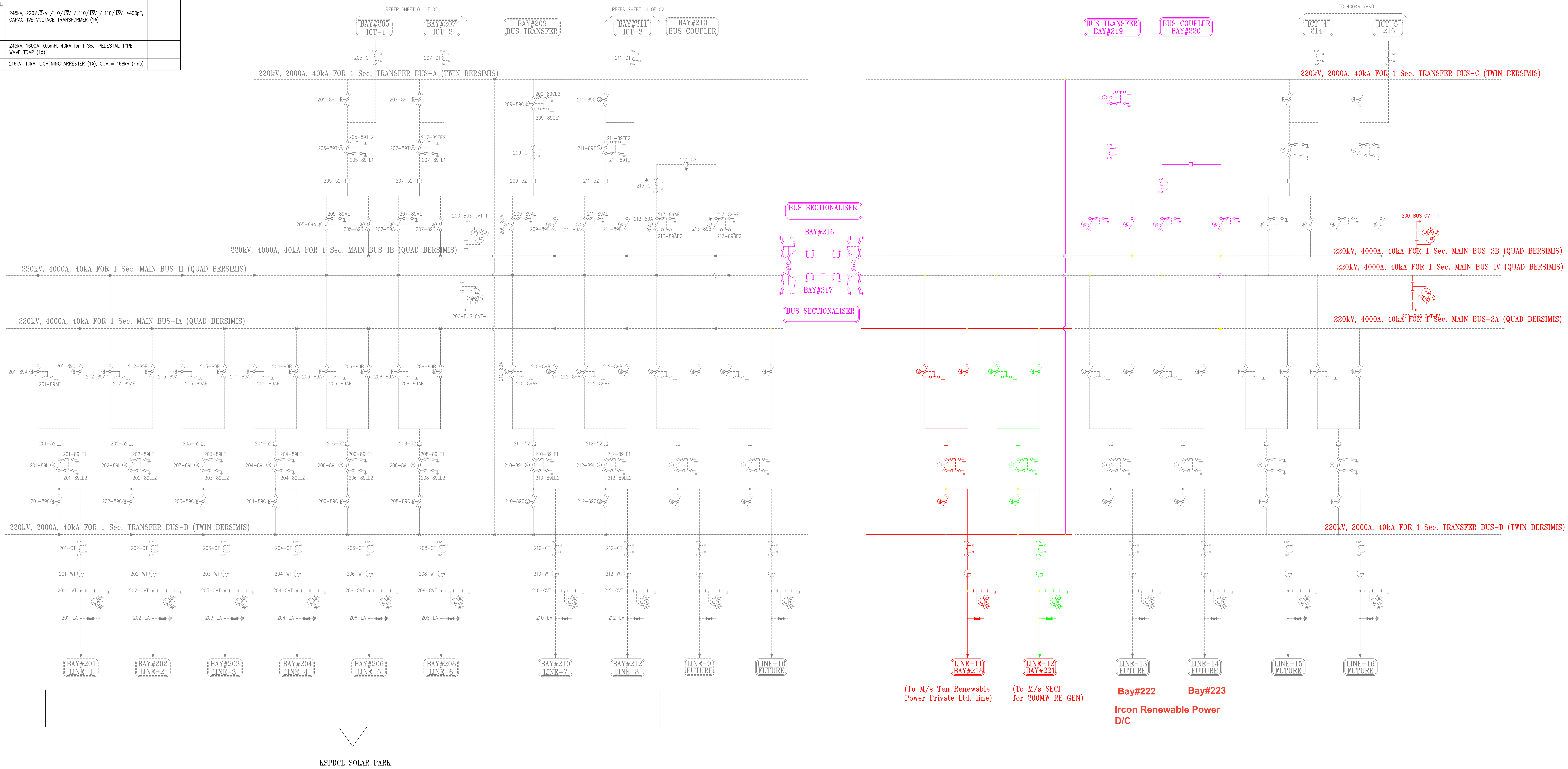
Drawing/Document Number		LOCATION	ANANTHAPURAMU, AP
		SUB STATION TYPE	PLANT END SUBSTATION
OWNER: Solar Energy Corporation of India Ltd. 6th Floor, NBCC Tower East Kidwai Nagar, New Delhi - 110023		VOLTAGE LEVEL	33KV
		Released for	PRELIMINARY
			ENGINEERING APPROVAL
Project: SECI CPSU 1 - 300MW - 33 kV SWITCHYARD, ANANTHAPURAMU, AP			CONSTRUCTION

Approved By

Scale	Paper Size	Sign.	Date	LOA No.:	
1:100mm	A2				
Responsible Dept. E&D	Drawn By			Document Type SINGLE LINE DIAGRAM	Document Designation
S	Created By			Title KEY & PROTECTION SLD 33 kV SWITCHYARD - PLANT END SS - SECI-1-CPSU - ANANTHAPURAMU, AP	Document Tree
	Approved By				Rev. 0 / Date of issue / Language EN / Sheet 01 of 01

BILL OF QUANTITY FOR 220kV EQUIPMENT:-

SYMBOLS	DESCRIPTION	QUANTITY
	245kV, 1600A, 3ø, 40kA FOR 1 Sec. SF6 CIRCUIT BREAKER	
	245kV, 2500A & 4000A, 3ø, 40kA FOR 1 Sec. SF6 CIRCUIT BREAKER	
	245kV, 1600A, 3ø, 40kA FOR 1 Sec MOTORIZED HORIZONTAL DOUBLE BREAK CENTER ROTATING TYPE, ELECTRICALLY GANGED ISOLATOR WITH TWO EARTH SWITCH	
	245kV, 1600A, 1ø, 40kA FOR 1 Sec MOTORIZED HORIZONTAL DOUBLE BREAK CENTER ROTATING TYPE, ELECTRICALLY GANGED ISOLATOR WITH ONE EARTH SWITCH	
	245kV, 1600A, 1ø, 40kA FOR 1 Sec MOTORIZED HORIZONTAL DOUBLE BREAK CENTER ROTATING TYPE, ELECTRICALLY GANGED TANDEM ISOLATOR WITHOUT ONE EARTH SWITCH	
	245kV, 2500A, 3ø, 40kA FOR 1 Sec MOTORIZED HORIZONTAL DOUBLE BREAK CENTER ROTATING TYPE, ELECTRICALLY GANGED ISOLATOR WITH TWO EARTH SWITCH	
	245kV, 1600A, CURRENT TRANSFORMER (1ø) WITH 120% EXTENDED CURRENT RATING	
	245kV, 1600A, CURRENT TRANSFORMER (1ø) WITH 150% EXTENDED CURRENT RATING	
	245kV, 220/√3kV /110/√3V / 110/√3V / 110/√3V, 4400pF, CAPACITIVE VOLTAGE TRANSFORMER (1ø)	
	245kV, 1600A, 0.5mH, 40kA for 1 Sec. PEDESTAL TYPE WAVE TRAP (1ø)	
	216kV, 10kA, LIGHTNING ARRESTER (1ø), COV = 168kV (rms)	

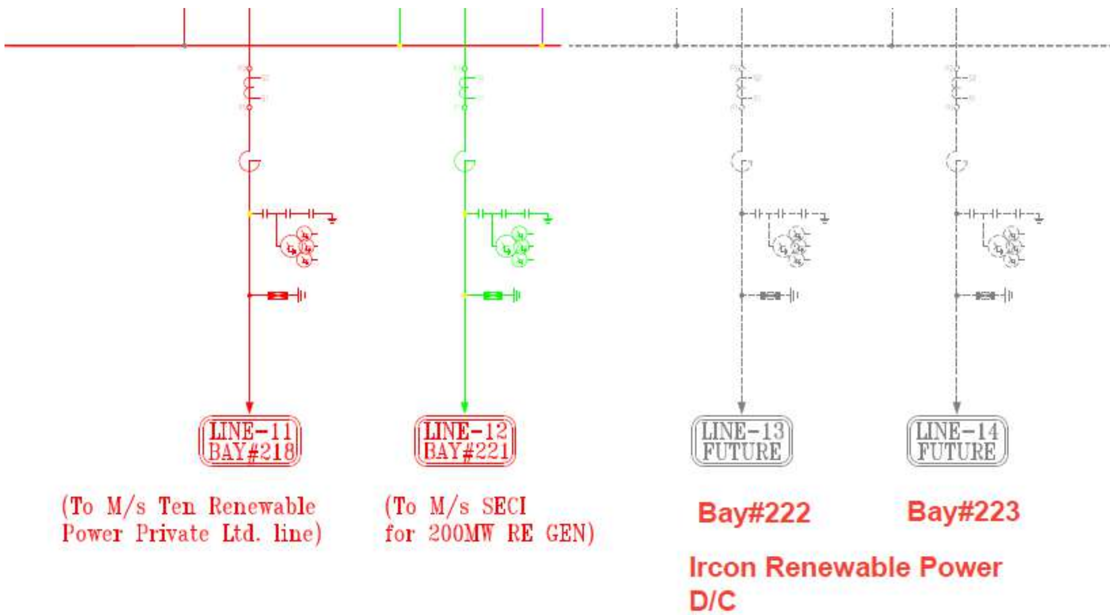


SINGLE LINE DIAGRAM OF 400/220KV TUMKUR (PAVAGADA) POOLING SUBSTATION

Annexure – L

220 kV Transmission Line Right of Way

CTU has allotted the 220 kV bays at Pavagada ISTS substation in the following order:



220kV Bay Allocation	
Bay No	**Developer**
218	Project Ten Renewable Power Pvt Ltd
221	SECI for 200MW RE GEN.
222	IRCON Renewable Power Ltd.
223	IRCON Renewable Power Ltd.

As per CTU's connectivity procedure of clause 6 "Considering *Right-of-Way near substation for termination of number of 400/ 220kV dedicated transmission lines, the connectivity grantees may coordinate among themselves for implementation of 400/ 220kV lines (as applicable) through multi circuit tower near the substation entry for about 2-3 kms stretches*".

The execution of bay no. 218 is being carried out by Project Ten Renewable Power Private Limited (PTRPPL), a Special Purpose Vehicle of Ayana Renewable Power Private Limited (ARPPL). The execution of bay no. 222 and 223 is being carried out by IRCON Renewable Power Limited (IRPL), a Joint Venture between IRCON International Limited (IIL) and Ayana Renewable Power

Private Limited (ARPPL). In order to implement 220 kV multi-circuit towers near the ISTS substation, SECI, in discussion with IRPL and ARPPL, proposes the following arrangement.

Multi circuit towers will be constructed by IRPL from for about 4# km (Tower AP-4) and double circuit tower for about 150# m (ISTS Substation Bay to Point-AP-16) as shown in Figure 1 and 2. Supply and installation of conductor, insulator string and associated hardware for the single circuit within the stretch of multi-circuit tower route and double circuit route shall be the responsibility of the BoS Contractor of SECI. Shutdown of other circuits of shared multi-circuit towers for stringing and/or hot line stringing at the shared multi-circuit towers shall also be the responsibility of the BoS Contractor of SECI.

From tower AP-4 till the plant pooling substation, the BoS Contractor of SECI shall construct 220KV transmission line with double circuit tower (with single circuit stringing), including Optical Ground Wire (OPGW). Necessary hardware required for joining this OPGW cable to the OPGW cable on the multi-circuit tower is also included. Right of Way (ROW) of double circuit tower from Point-S10 till the plant pooling substation shall be in the scope of the BoS Contractor of SECI. PTRPPL has agreed in-principle to provide ROW from Point-S3 to Point-S8 (~1.4#km) as shown in the Figure 1.

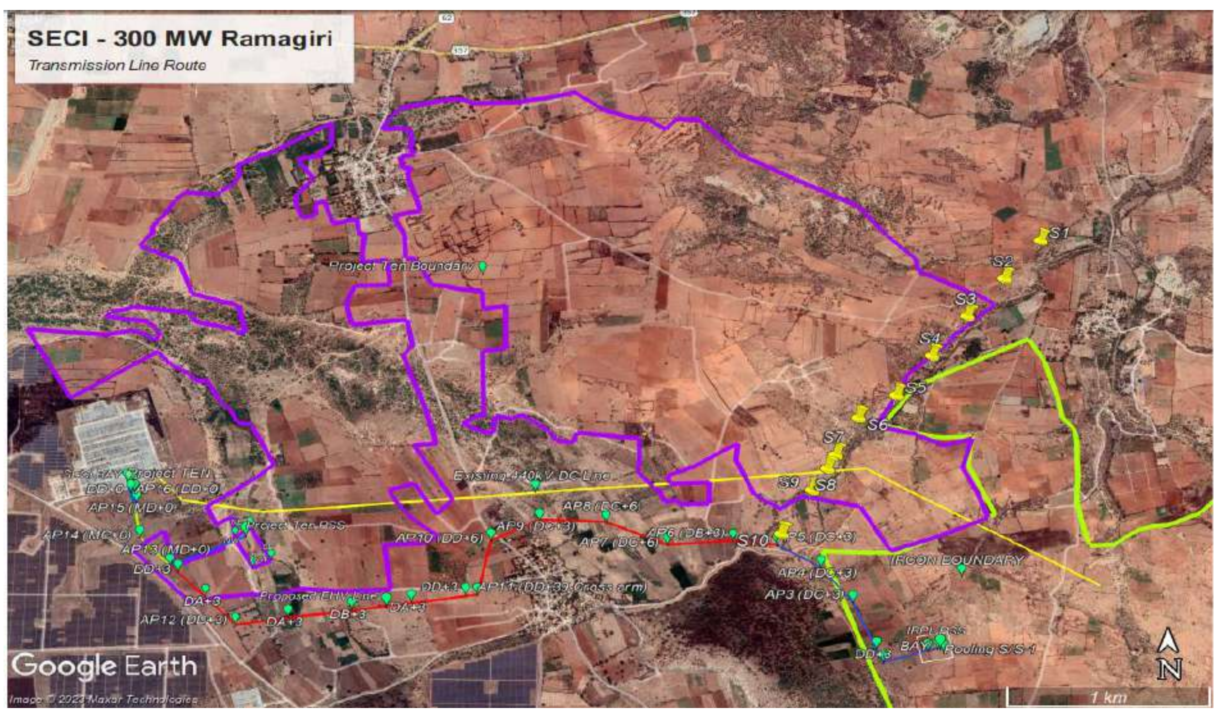


Figure 1: Transmission Line Tower Plan (Overall Route from Plant End SS to Interconnecting SS)

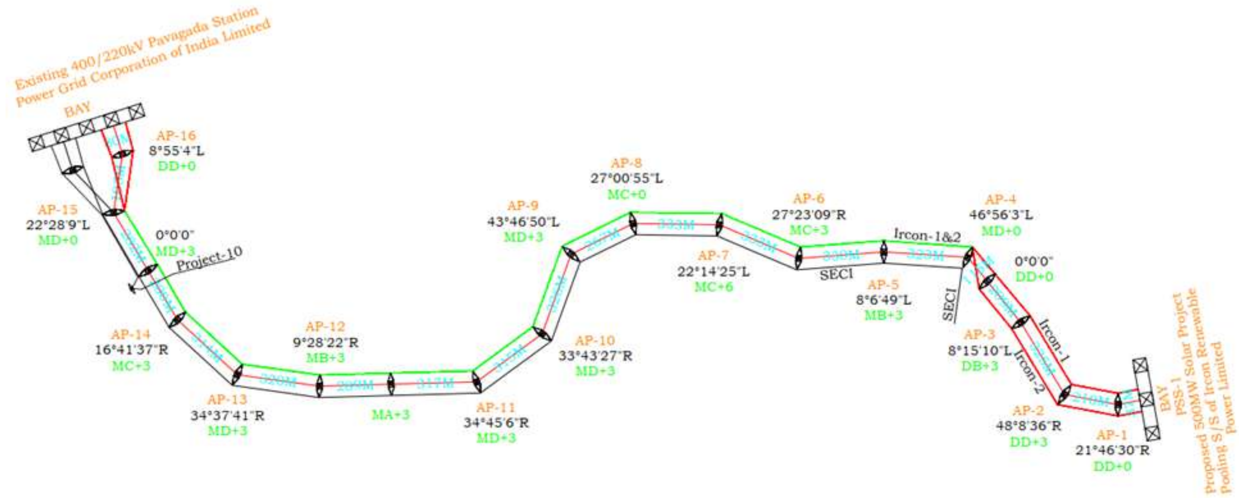
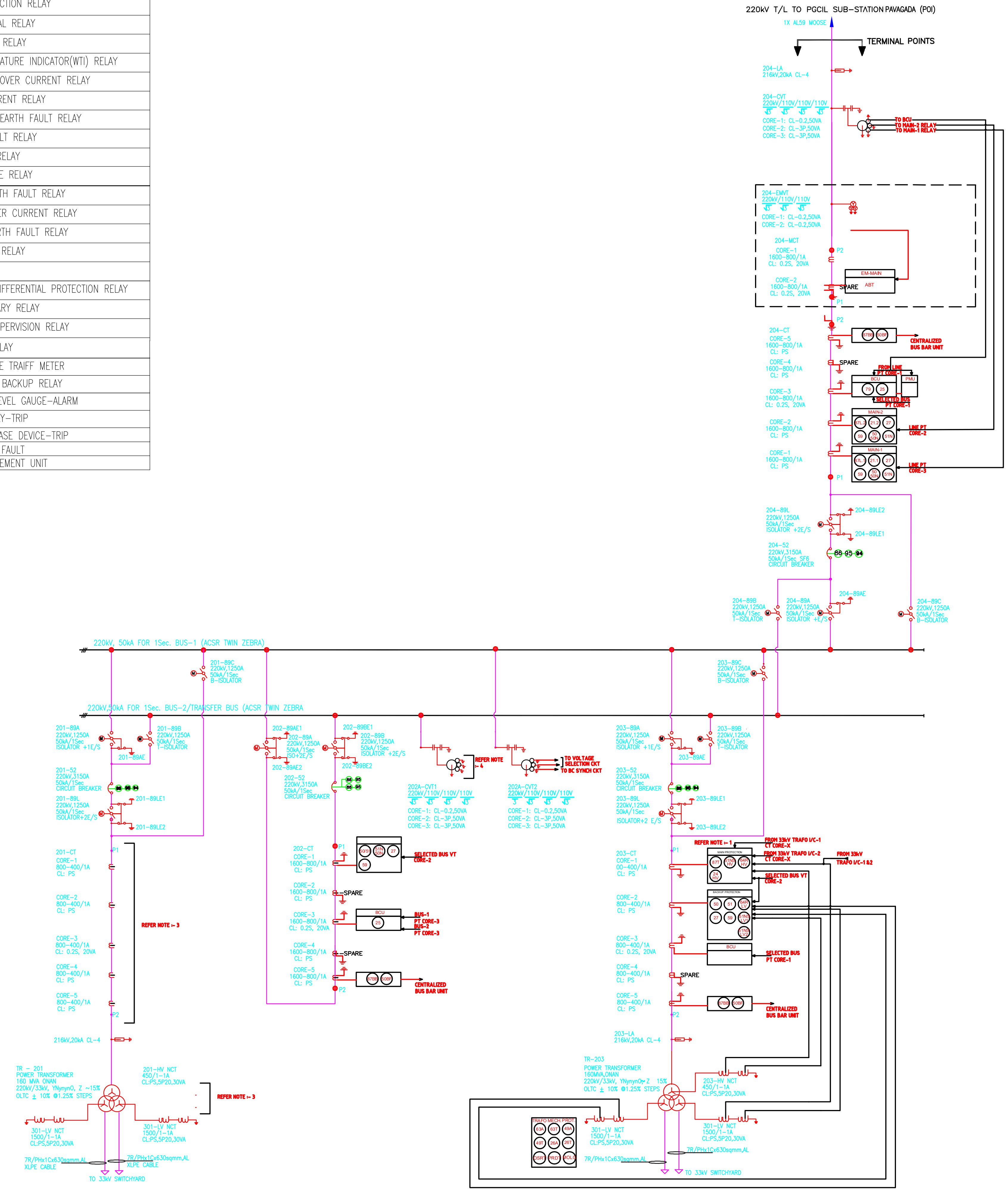


Figure 2: Transmission Line Tower Plan (M/C Portion)

- The distance indicated is indicative

LEGENDS :

SYMBOL	DESCRIPTION
21	DISTANCE PROTECTION RELAY
87L	LINE DIFFERENTIAL RELAY
27	UNDER VOLTAGE RELAY
49	WINDING TEMPERATURE INDICATOR(WTI) RELAY
50	INSTANTANEOUS OVER CURRENT RELAY
51	IDMT OVER CURRENT RELAY
50N	INSTANTANEOUS EARTH FAULT RELAY
51N	IDMT EARTH FAULT RELAY
59	OVER VOLTAGE RELAY
60	PT FUSE FAILURE RELAY
64R	RESTRICTED EARTH FAULT RELAY
67	DIRECTIONAL OVER CURRENT RELAY
67N	DIRECTIONAL EARTH FAULT RELAY
79	AC RECLOSING RELAY
25	SYNCH CHECK
87T	TRANSFORMER DIFFERENTIAL PROTECTION RELAY
94	TRIPPING AUXILIARY RELAY
95	TRIP CIRCUIT SUPERVISION RELAY
86	MASTER TRIP RELAY
ABT	AVAILABILITY BASE TRAIFF METER
LBB	LOCAL BREAKER BACKUP RELAY
MOLGA	MAGNETIC OIL LEVEL GAUGE-ALARM
OSRT	OIL SURGE RELAY-TRIP
PRDT	PRESSURE RELEASE DEVICE-TRIP
51NS	STANDBY EARTH FAULT
PMU	PHASOR MEASUREMENT UNIT



NOTES:-

1. PROTECTION AND INTERFACING SHOWN FOR BAY-203 SHALL BE ALSO APPLICABLE TO BAY-201
2. INTERFACING SHOWN FOR 202A-CVT2 SAME SHALL BE APPLICABLE TO 202A-CVT1.

This drawing and the information contained herein represents the indicative schema of the Plant Pooling Station.
Technical Data and specifications of components shall be finalized during detailed engineering in accordance with the Technical Specifications provided with the tender document.

SYSTEM PARAMETERS:-

DESCRIPTION	VALUE FOR UPTO 1000 MTR. ALTITUDE	
NOMINAL SYSTEM VOLTAGE (kV)	220	33
HIGHEST SYSTEM VOLTAGE (kV)	245	36
BASIC INSULATION LEVEL	950	170
FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 mSec)	1050	170
ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLATGE(RMS)	460	70
MAX. RADIO INTERFERENCE VOLTAGE FOR FREQUENCY B/W 0.5 MHZ & 2 MHZ. (MICROVOLTS AT 156 RMS)	1000	-
CREEPAGE DISTANCE (mm)	7595	900
SHORT CIRCUIT CURRENT (KA)	50	25
DURATION (s)	1	3
FREQUENCY	50HZ	
NO OF PHASEES	3	
SYSTEM NEUTRAL EARTHING	EFFECTIVELY EARTH	

MCT DATA FOR 220kV

S.NO	NO. OF CORE	REF. DESIGNATION	CORE NO.	APPLICATION	CURRENT RATIO	O/P BURDEN(VA)	CLASS
1.	2	204-MCT	1.	METERING	1600-800/1A	20	0.2S
			2.	METERING	1600-800/1A	20	0.2S

CT DATA FOR 220kV AIS

S. NO	DISCRIPTION	NO. OF CORE	REF. DESIG-NATION	CORE NO.	APPLICATION	CURRENT RATIO	O/P BURDEN (VA)	ISF (MAX)	ACCURACY CLASS	MIN KNEE POINT. VOLTAGE (V)	MAX. CT SECONDARY WNDG RESISTANCE AT HIGHEST RATIO	MAX. EXCITATION CURRENT (mA) AT KNEE POINT VOLTAGE AT HIGHEST RATIO
1.	FEEDER/LINE BAY (BAY NO: 204)	5	CT	1.	DIST. PROTN M1.	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
				2.	DIST. PROTN M2.	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
				3.	BCU	1600-800/1A	20	< 5 WITH	0.2S	-	-	-
				4.	(SPARE)	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
				5.	BUS BAR/LBB PROTECTION	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
2.	TRANSFORMER BAY (BAY NO: 201&203)	5	CT	1.	TRAFO. DIFF. PROTECTION	800-400/1A	-	-	PS CLASS	Vk =800-400	Rct = 8-4	25 ON 800/1 TAP 50 ON 400/1 TAP
				2.	BACKUP. PROTN.	800-400/1A	-	-	PS CLASS	Vk =800-400	Rct = 8-4	25 ON 800/1 TAP 50 ON 400/1 TAP
				3.	BCU	800-400/1A	20	< 5 WITH	0.2S	-	-	-
				4.	METERING	800-400/1A	-	-	PS CLASS	Vk =800-400	Rct = 8-4	25 ON 800/1 TAP 50 ON 400/1 TAP
				5.	BUS BAR/LBB PROTECTION	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
3.	BUS COUPLER BAY (BAY NO: 202)	5	CT	1.	BUS BAR/LBB PROTECTION	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
				2.	BACKUP. PROTN.	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
				3.	BCU	1600-800/1A	20	< 5 WITH	0.2S	-	-	-
				4.	PROTECTION (SPARE)	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP
				5.	BUS BAR/LBB PROTECTION	1600-800/1A	-	-	PS CLASS	Vk =1600-800	Rct = 8-4	25 ON 1600/1 TAP 50 ON 800/1 TAP

CT DATA FOR TRANSFORMER NEUTRAL

S. NO	DISCRIPTION	NO. OF CORE	CORE DESIG-NATION	CORE NO.	APPLICATION	CURRENT RATIO	O/P BURDEN (VA)	ISF (MAX)	ACCURACY CLASS	MIN KNEE POINT. VOLTAGE (V) AT LOWEST RATIO	MAX. CT SECONDARY WNDG RESISTANCE AT HIGHEST RATION	MAX. EXCITATION CURRENT (mA) AT KNEE POINT VOLTAGE AT HIGHEST RATIO
1.	HV SIDE BUSHING NCT	2		1.	RESTRICTED EARTH FAULT PROTECTION	450/1A	-	-	PS CLASS	500V	5	50 ON 400/1A TAP
				2.	SEF	450/1A	30	_	5P20	-	-	-
3.	LV SIDE BUSHING NCT	2		1.	RESTRICTED EARTH FAULT PROTECTION	1500/1A	-	-	PS CLASS	500V	15	50 ON 3000/1A TAP
				2.	SEF	1500/1A	30	_	5P20	-	-	-

CVT DATA FOR 220kV

S. NO	NO. OF CORE	REF. DESIGNATION	CORE NO.	APPLICATION	DESCRIPTION OF CORE (kV)	RATED OUTPUT (VA)	CLASS
1.	3	204-CVT 202A-CVT1 202A-CVT2	1.	METERING	$220/\sqrt{3}/0.11/\sqrt{3}$	50	0.2
			2.	PROTECTION	$220/\sqrt{3}/0.11/\sqrt{3}$	50	3P
			3.	PROTECTION	$220/\sqrt{3}/0.11/\sqrt{3}$	50	3P

EMVT DATA FOR 220kV

S. NO	NO. OF CORE	REF. DESIGNATION	CORE NO.	APPLICATION	DESCRIPTION OF CORE (kV)	RATED OUTPUT (VA)	CLASS
1.	2	204-EMVT	1.	METERING	$220/\sqrt{3}/0.11/\sqrt{3}$	50	0.2
			2.	METERING	$220/\sqrt{3}/0.11/\sqrt{3}$	50	0.2

BILL OF QUANTITY WITH LEGEND

220kV EQUIPMENTS BOQ (EXCLUDING SPARES)

SYMBOL	EQUIPMENT TAG	ITEM DESCRIPTION	QUANTITY (NOS)
	TR-201, TR-203	220/33kV, 160 MVA, TRANSFORMER	02
	201-89A,203-89A,204-89A	MOTORIZED ISOLATOR WITH SINGLE EARTH SWITCH, 3ϕ, 1250A, 50kA/1s MECHANICALLY GANGED	03
	201-89B,203-89B,204-89B	MOTORIZED T-ISOLATOR WITHOUT EARTH SWITCH, 3ϕ, 1250A, 50kA/1s , ELECTRICALLY GANGED	03
	201-89C,203-89C,204-89C	MOTORIZED ISOLATOR WITHOUT EARTH SWITCH, 3ϕ, 1250A, 50kA/1s , MECHANICALLY GANGED	03
	201-89L,202-89A,202-89B, 203-89L,204-89L	MOTORIZED ISOLATOR WITH +2 EARTH SWITCH, 3ϕ, 1250A, 50kA/1s , MECHANICALLY GANGED	05
	201-52,202-52,203-52 204-52	CIRCUIT BREAKER	04

BILL OF QUANTITY WITH LEGEND

220kV EQUIPMENTS BOQ (EXCLUDING SPARES)

SYMBOL	EQUIPMENT TAG	ITEM DESCRIPTION	QUANTITY (NOS)
	201-CT,202-CT,203-CT 204-CT	CURRENT TRANSFORMER 1Ø	12
	201-CVT,202A-CVT1 202A-CVT2	CAPACITIVE VOLTAGE TRANSFORMER 1Ø	09
	204-MCT	EB METERING CURRENT TRANSFORMER 1Ø 1600-800/1A	03
	204-EMVT	EB POTENTIAL TRANSFORMER 1Ø	03
	201-LA, 203-LA, 204-LA	1ϕLIGHTNING ARRESTER 216kV, 20kA, CL-4	09

Approved By

Drawing/Document Number

LOCATION ANANTHAPURAMU, AP
SUB STATION TYPE PLANT END SUBSTATION
VOLTAGE LEVEL 220/33KV

OWNER

Solar Energy Corporation of India Ltd.
6th Floor, NBCC Tower
East Kidwai Nagar, New Delhi - 110023

Released for: PRELIMINARY / ENGINEERING APPROVAL / CONSTRUCTION

Project
SECI CPSU 1 - 300MW - 33/220kV SWITCHYARD, ANANTHAPURAMU, AP

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INDICATIVE SCADA IO LIST

S No	Description		Signal Type	Signal	Unit	Alarm	SOE	Trend	Report
	220 kV Line Bay								
1	SF6 CB	Open/Close	DI	PF			Y		
2	SF6 CB	Auto Trip Operated/ Not Operated	DI	PF			Y		
3	SF6 CB Gas Pressure Low	SF6 Gas Pressure Low	DI	PF		Y			
4	CB L/R SWITCH	CB Local/Remote Mode	DI	PF			Y		
5	CB TRIP CIRCUIT SUPERVISION RELAY	Operated/Not Operated	DI	PF			Y		
6	CB TRIP CIRCUIT	Healthy/ Not Healthy	DI	PF			Y		
7	CB SPRING CHARGE	Charged/ Uncharged	DI	PF			Y		
8	CB D.C SUPPLY	Fail/ Not Fail	DI	PF		Y			
9	MASTER TRIP RELAY (86 RLY)	Operated/Not Operated	DI	PF		Y	Y		
10	MASTER TRIP RELAY RESET	Operated/Not Operated	DI	PF		Y			
11	Main -1 TRIP	Operated/Not Operated	DI	PF		Y			
12	Main -2 TRIP	Operated/Not Operated	DI	PF		Y			
13	OVER CURRENT/ EARTH FAULT (51N/ 50 RLY)	Trip/ Not Trip	DI	PF		Y			
14	OVER VOLTAGE/UNDER VOLTAGE (59/27 RLY)	Operated/Not Operated	DI	PF		Y			
15	DISTANCE RLY (21 RLY)	Operated/Not Operated	DI	PF		Y			
16	SYNCHRONISING RLY (25 RLY)	Fail/ Not Fail	DI	PF		Y			
17	BREAKER FAILURE RLY (50BF RLY)	Fail/ Not Fail	DI	PF		Y			
18	AC RECLOSING RELAY/AUTO RECLOSE RELAY (79 R	Operated/Not Operated	DI	PF					
19	ISOLATOR	Open/Close	DI	PF			Y		
20	EARTH SWITCH	Open/Close	DI	PF			Y		
	220 kV - Transformer Bay	**Signal**							
1	Tr. BUCHHOLZ RLY	Alarm - Bucchoz Relay Operation	DI	PF		Y			
2	Tr. PR REL VLV	Alarm - Pressure Release Valve	DI	PF		Y			
3	Tr. LO OIL LVL	Alarm - Low Transformer Oil	DI	PF		Y			
4	Tr. WNDG TEMP	Alarm - Transformer Winding Temperature High	DI	PF		Y			
5	Tr. WNDG TEMP	Alarm - Transformer Winding Temperature Breach/Trip	DI	PF					
6	Tr. OIL TEMP	Alarm - Transformer Oil Temperature High	DI	PF		Y			
7	Tr. OIL TEMP	Alarm - Transformer Oil Temperature Breach/Trip	DI	PF					
8	Tr. WNDG TEMP	Transformer Winding Temperature	AI	4-20MA	Deg C				

9	Tr. OIL TEMP	Transformer Oil Temperature	AI	4-20MA	Deg C				
10	Tr. TAP POSITION	Transformer Tap Position	AI	4-20MA					
11	TAP	Increase Tap Position	DO	110V DC			Y		
12	TAP	Decrease Tap Position	DO	110V DC			Y		
13	DIFFERENTIAL RELAY(87T)	Operated/Not Operated	DI	PF					
14	GROUND PROTECTIVE RELAY (64 HV)	Operated/Not Operated	DI	PF					
15	GROUND PROTECTIVE RELAY (64 LV)	Operated/Not Operated	DI	PF					
16	R PH VOLTAGE	R Pahse Voltage	SOFT AI		KV			Y	
17	Y PH VOLTAGE	Y Phase Voltage	SOFT AI		KV			Y	
18	B PH VOLTAGE	B Phase Voltage	SOFT AI		KV			Y	
19	R PH CURRENT	R Phase Current	SOFT AI		A			Y	
20	Y PH CURRENT	Y Phase Current	SOFT AI		A			Y	
21	B PH CURRENT	B Phase Current	SOFT AI		A			Y	
	220 kV - Bus Bar and Bus Coupler Bay								
1	ACTIVE POWER	Active Power Generated	SOFT AI		KW			Y	
2	REACTIVE POWER	Reactive Power Generated	SOFT AI		KVAR			Y	
3	ENERGY	Energy Injected	SOFT AI		KWH			Y	
4	SF6 CB CMD	Close Command	DO	110V DC			Y		
5	SF6 CB \CMD	Open Command	DO	110V DC			Y		
6	ISOLATOR	Open/Close	DI	PF			Y		
7	EARTH SWITCH	Open/Close	DI	PF			Y		
	Energy Meters								
1	Energy Exported in 15 min to GRID	Plant End ABT Meter	SOFT AI	RS485	MWh				Y

S No	Description		Signal Type	Signa l	Unit	Alar m	SO E	Trend	Report
	33 kV CB PANEL INCOMER FEEDER (FROM INVERTER TRANSFORMER)								
1	CB OPEN/CLOSE	VCB Open/ Close	DI	PF			Y		
3	CB IN REMOTE	VCB in Remote Mode	DI	PF			Y		
4	CB IN SERVICE	VCB in Service Mode	DI	PF			Y		
5	CB 86 OPERATED	VCB Master Trip Operated	DI	PF			Y		
6	CB TRIP CKT UNHEALTHY	CB Trip Circuit Unhealthy	DI	PF			Y		
7	CB SPRING CHARGED	VCB Spring Charged	DI	PF			Y		
8	CB PROTECTION TRIP	Protection Trip Operated	DI	PF			Y		
9	CB CONTROL SUPPLY HEALTHY	Control Supply Healthy	DI	PF			Y		
10	CB IN LOCAL	CB in Lcal Mode	DI	PF			Y		
11	CB IN TEST	CB in Test Mode	DI	PF			Y		
12	Tr. WNDG TEMP TRIP	Transformer Winding Temperature Tripped	DI	PF			Y		
13	Tr. WNDG TEMP ALARM	Transformer Winding Temperature Alarm	DI	PF		Y			
14	Tr. OIL TEMP TRIP	Transformer Oil Temperature Tripped	DI	PF			Y		
15	Tr. OIL TEMP ALARM	Transformer Oil Temperature Alarm	DI	PF		Y			
16	Tr. PRV TRIP	Pressure Release Valve Tripped	DI	PF			Y		
17	Tr. PRV ALARM	Pressure Release Valve Alarm	DI	PF		Y			
18	Tr. BUCHHOLZ TRIP	Buccholz Relay Tripped	DI	PF			Y		
19	Tr. BUCHHOLZ ALARM	Buccholz Relay Alarm	DI	PF		Y			
20	Tr. MOG TRIP	Magnetic Oil Gauge Trip	DI	PF			Y		
21	Tr. MOG ALARM	Magnetic Oil Gauge Alarm	DI	PF		Y			
22	R PH CURRENT	R Phase Current	SOFT AI	RS48 5	A			Y	
23	Y PH CURRENT	Y Phase Current	SOFT AI	RS48 5	A			Y	
24	B PH CURRENT	B Phase Current	SOFT AI	RS48 5	A			Y	
25	ACTIVE POWER	Active Power	SOFT AI	RS48 5	KW			Y	
26	REACTIVE POWER	Reactive Power	SOFT AI	RS48 5	KVA R			Y	
27	ENERGY	Energy Export	SOFT AI	RS48 5	MW H			Y	

28	CB CMD	CB Clode Command	DO	110V DC			Y			
29	CB CMD	CB Open Command	DO	110V DC			Y			