APPENDIX – A

TO

SECTION – VII

(Employer's Requirements)

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CHAPTER – 1

SCOPE OF WORKS

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1 Project Particulars

Particular	Description
Design and Engineering	
Plant AC Capacity	100 MW
Minimum DC Capacity	126 MWp
Cell / Module Technology	Mono-crystalline
Origin of Cell / Module Manufacturer	Open
Solar Inverter/Power Conditioning Unit Type	String
Design life of PV Power Plant	25 years
O&M Period	10 years
Site Location and Water Body / Land Details	
Location	Getalsud Reservoir
Coordinates	23° 27’ 25” N, 85° 32’ 33” E
Village	Getalsud
Taluk	Ormanjhi/Angada
District	Ranchi
State	Jharkhand
Owner of Project	Solar Energy Corporation of India Limited
Ownership of Water Body & Land	Jharkhand Government
Owner of Water Body & Land	Water Resources Department, Jharkhand
Electrical Interconnection	
Interconnection Voltage Level	132 kV
Interconnection Point	Bay -111 & Bay-112 of 132/33 kV IRBA GSS (JUSNL) Short Circuit Levels: 132 kV Bus: 31.5 kA/s 33 kV Bus: 25 kA/3 sec 132 kV Switching Scheme - Double Bus Single Breaker Scheme

Plant End Power Transformer (132/33 kV) Capacity	2 x 50 MVA
Transmission Line from Plant till Interconnection Point	132 kV Double Circuit with ACSR ZEBRA Conductor Protection Scheme at Power Evacuation Switchyard at Plant End: Over Current Earth Fault Protection alongwith Distance Protection and other required protection schemes
Access	
Nearest Urban Area	Ranchi (30 km)
Nearest Highway	SH-1: Ranchi – Purulia (10 km)
Nearest Railway Station	Tatisilvai (20 km)
Nearest Domestic Airport	Birsa Munda Airport (40 km)
Performance Parameters	
Performance Ratio (PR) at 132 kV side of Plant Substation	84.4%
Capacity Utilization Factor (CUF) at 132 kV side of Plant Substation	22.6%
Other Details	
Construction Water	To be arranged by the Contractor. (Water usage from the reservoir requires prior approval from the Water Resources Department, prior to commencement of construction activity)
Construction Power	To be arranged by the Contractor (Permission form JBVNL for construction power shall have to be obtained prior to commencement of construction activities at site)
Bathymetric Survey Report	Carried Out by SECI (2020) – Excerpts from the Report enclosed as Annexure M

2 Brief Scope of Works

Scope of Supply & Work includes all design & engineering, procurement & supply of equipment and materials, 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 of 100 MW (AC) Floating Solar Photovoltaic Power Plant and performance demonstration on turnkey basis at Getalsud Reservoir, Jharkhand and 10 (ten) years comprehensive operation and maintenance from the date of Operational Acceptance.

All works shall be executed as per Technical Specifications given in Chapter – 2 of Appendix – A to Section – VII. Chapter – 3 of Appendix – A to Section – VII lays down Special Technical Conditions with reference to site specific design requirements. However, in case of any conflict in requirements between Chapter – 2 and Chapter – 3, Chapter – 3: Special Technical Conditions shall have precedence.

The details of Project location and reservoir are provided below:

S. No.	Description	Data
1	Name of Dam	Getalsud Reservoir
2	Co-ordinates	23° 27’ 25” N, 85° 32’ 33” E
3	Owner of Dam	Water Resources Department, Govt. of Jharkhand
4	Type of Dam - Multipurpose / Irrigation / Power generation	Drinking water requirements of Ranchi, Industrial Requirements and Power Generation
5	Storage Capacity overt the Years	**Designed Storage Capacity (1971)** – 288.63 million cubic metres at FRL 590.09 m **Revised Storage Capacity (2001)** – 267.57 million cubic metres at FRL 590.09 m **Hydrographic Survey (2020) –** 232.95 million cubic metres at FRL 590.09 m
6	Full Reservoir Level (FRL)	590.09 m
7	Minimum Drawdown Level (MDDL)	584.30 m
8	Dead Storage Level (DSL)	579.12 m
9	Maximum Depth at FRL	29.2 m
10	Area of reservoir	3475 Ha
11	Source of water	Subarnarekha River

12	Silt Level / Sedimentation report (If any)	The sedimentation rate of the reservoir was estimated to be 0.702 MCM/year by the Central Water Commission, Govt. of India (2001). Total height of silt column was estimated to be around 1.602 m from the reservoir bed as of 2020.
13	Usable Reservoir Area	Approx. 172 Ha
14	Flood occurrence in past years	As per the information gathered from the reservoir authorities, since its commissioning, no major flood has occurred.
15	Highest water level of reservoir	In the year 1998 – 590.09m (Reached FRL) In the year 2006 – 590.40m (Crossed FRL) In the year 2017 – 590.49m (Crossed FRL)
16	Possible Floating Solar PV (FSPV) Power Plant location	On the storage reservoir
17	Water flow velocity at tentative project location	Maximum velocity value shall be considered after performing flood routing studies using software simulations or hydraulic model study to derive flow path and critical velocities. Additionally, water current velocity shall be measured at upstream and downstream of proposed site for at least 30 days using suitable Acoustic Doppler Current Profiler (ADCP) /Current Meter. The velocity measurements should be undertaken at surface, at half of the water depth, and at 0.5 m above the reservoir bed.
18	Statutory approvals required for setting up of the project.	1. Consent from the JUSNL /JBVNL for the evacuation of the power generated by Floating Solar Grid Interactive Floating Solar Power Projects. 2. Consent to establish the project during construction and consent to operate the project after the commissioning of the plant from Jharkhand Pollution Control Board (JPCB) 3. Approval of the Electrical Inspectorate, Government of Jharkhand for commissioning of the transmission line and the Floating Solar power project installed at the Project Site. 4. Certificate of Commissioning of the Floating Solar Grid Interactive Power Project issued by JBVNL.

		5. SNA/JREDA registration certificate, if required. 6. Permission from all other statutory and non-statutory bodies required for the Project. 7. Clearance from Department of Forest, Ecology and Environment, if required.
19	Water body approvals, agreement and charges, if any	Consent/ Approval shall be sought from Water Resources Department, GoJ before construction

Note: *All works shall be executed as per Technical Specifications given in Chapter – 2 of Appendix – A to Section – VII.*

The Reservoir Level details of Getalsud reservoir has been attached as Annexure-G.

3 Design and Engineering

3.1 Contractor shall prepare the detailed design basis report (DBR) along with relevant standards (with respective clause description), PERT Chart and MDL. Contractor shall submit a copy of the same to Employer for review and approval prior to detail engineering.

3.2 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 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.

- Category-I: Approved
- Category-II: Approved subject to incorporation of comments. Re-submit for approval after 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)

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

- Solar insolation data and basis for generation
- Flood routing study, Water flow path and critical velocity studies using software simulations or hydraulic model study
- 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 structures/ components, Floats, Anchoring mechanisms, 33 kV switchgears & other interfacing panels
- Test reports (for type, routine and acceptance tests)
- Relay setting charts
- Design calculations and design templates for Floats, Anchoring and Mooring mechanism
- Shadow analysis
- Concrete mix design report for different grades of concrete to be used for construction
- Bathymetric survey report including topographical survey data in digital format (Excel file) and Contour plan of the area.
- Geotechnical (on-shore & off-shore) and Geophysical (off-shore) investigation reports
- Array/ Plant Layout
- GA, & detail drawings for architectural, civil, structural and RCC works for the entire project which shall include various buildings and facilities like office cum master control room (MCR), roads, Foundation and plinth for Open installations for LCR/ ICR (as applicable), Weather protection canopy/ shed over open equipment installations, Sewerage, Water supply & module washing system networks, Security room & watchman cabin(s), Fire protection system, Boundary & transformer yard fencing, MMS structure & foundation works etc.
- Transmission line drawings and erection plans as per DISCOM/ STU guidelines

- Environment and Social Impact Assessment (ESIA) survey & study of the Transmission Line route and implementation of the Environment and Social Management Plan (ESMP) as per Annexure M.
- 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) drawings/documents

3.4 Estimation of the plant generation based on Solar Radiation and other climatic conditions prevailing at site.

3.5 Design of associated civil, structural, electrical & mechanical auxiliary and plumbing systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for civil, structural, RCC and plumbing & sanitary works, roads and drainage etc. including analysis & design input file, 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 not covered above but required for engineering of all facilities within the periphery shall 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.

4 Procurement and Supply

The equipment and materials for Grid Interactive Floating Solar PV Power Plant with associated system shall include but not limited to the transit insurance, receipt, unloading, storage, erection, testing and commissioning of all supplied material for the following:

4.1 Adequate capacity of solar PV modules with minimum DC capacity as mentioned in Clause 1 of Scope of Works.

4.2 PV Module Floating Platform – Floating system along with anchoring and mooring

system for mounting PV modules, inverters, cable trays and other associated equipment.

4.3 Power Conditioning Units (string inverters) of appropriate rating along with mounting structure suitable for installation on PV Module floating platform.

4.4 Transformer Floating Platform – Floating system along with anchoring and mooring system for mounting of LT Switchgear panels, inverter duty transformers, Gas Insulated Switchgears and other associated equipment.

4.5 AC Combiner Box / LT Switchgear panels of appropriate rating with adequate number of inputs for pooling of power from inverter to inverter duty transformer suitable for installation on transformer floating platform.

4.6 DC Cables of appropriate size and rating along with straight/Y-connectors, ferrules, conduits, cable trays, cable ties and other materials required for cable laying and termination at both the ends.

4.7 AC Cables (LT & HT) of appropriate size and rating along with cable termination kits, ferrules / tags, conduits, cable floats, cable trays, cable ties and other materials required for cable laying and termination at both the ends.

4.8 Inverter transformers of appropriate rating suitable for installation on transformer floating platform.

4.9 33 kV Gas Insulated Switchgears including Vacuum Circuit Breakers, Current Transformers, Voltage Transformers, Relays and other accessories for complete protection of inverter transformer feeders suitable for installation on transformer floating platform.

4.10 33 kV Switchgear panels (with one spare) including Vacuum Circuit Breakers, Current Transformers, Voltage Transformers, Relays and other accessories for complete protection of GIS feeders suitable for installation in Main Control Room.

4.11 Two nos. of 132/33 kV 50 MVA Power Transformers and associated equipment.

4.12 Nitrogen Injection Fire Protection System for power transformers.

4.13 132 kV Switchyard including Circuit Breakers, Disconnectors, Instrument Transformers, Surge Arrestors, Control & Relay Panels other associated equipment for complete protection. Over Current Earth Fault Protection alongwith Distance Protection and other required protection schemes shall be provided at the 132/33kV Power Evacuation Switchyard at Getalsud Dam Site.

4.14 ABT meters with all necessary metering rated CTs and PTs at 132 kV side of Plant Substation as per CEA Metering Regulations 2006 as amended time to time and state

metering code.

4.15 132 kV Double Circuit Transmission Towers, Conductors, Insulators and associated accessories along with 24 fibre (24F) Optical Ground Wire (OPGW) cables from Plant Substation to Interconnection point as per STU specifications.

Note: *The Contractor shall construct the line after Joint Detailed Survey of Transmission Line Route Jointly Verified by the representatives of SECI and JUSNL. Supervision Charges payable to JUSNL shall be borne by SECI.*

4.16 Fibre Optic Terminal Equipment (FOTE) at the 132/33kV Power Evacuation Switchyard at Plant End as per specifications provided.

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

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

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

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

4.21 Communication cables including end terminations and other required accessories.

4.22 Supervisory Control and Data Acquisition (SCADA) and Energy Management system for remote monitoring/control of plant facilities.

4.23 Data Acquisition System and communication infrastructure to transfer real time data to SLDC, JUSNL as per the specifications of SLDC wing and as per grid connectivity approving authority.

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

4.25 Lightning Protection System for entire plant area including both off-shore and on-shore installations.

4.26 LED luminaries with diffuser for indoor and outdoor illumination (off-shore and on-shore), lighting poles, distribution boxes and power supply cables along with required conduits, fittings, etc.

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

- Pyranometers – Two in Horizontal Plane for GHI and two in inclined plane for GTI – Minimum 4 (Four) Nos.
- Ultrasonic Anemometer (wind speed and direction) – 2 (two) no.
- Temperature Sensor (ambient and module surface) – 3 (three) nos.
- Power source to the all sensors wherever required

- Data Logger

4.28 Water Quality Monitoring System (Two nos.) with all necessary hardware and software required for real-time monitoring of water temperature, pH, Electrical Conductivity and Dissolved Oxygen via SCADA.

4.29 Water Flow Monitoring System (one no.) for measurement of surface water current velocity and wave parameters with all necessary hardware and software for real-time monitoring via SCADA.

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

4.31 Fire detection and fire protection system in buildings/containers and switchyard.

4.32 Materials and accessories, which are required for satisfactory and trouble-free operation and maintenance of the above equipment like module cleaning system, supply of spares for all equipment, supply of tools and tackles etc.

4.33 Testing instruments as specified.

4.34 Mandatory spares as specified in Annexure – E.

4.35 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 Float Structure and interconnection of PV Modules.

5.2 Installation, Testing and Commissioning of solarinverters/Power conditioning Unit on PV Module floating platform.

5.3 Installation, Testing and Commissioning of AC Combiner Boxes / LT Switchgear Panels, Inverter Transformers and Gas Insulated Switchgears on Transformer floating platform.

5.4 Laying of AC cables from inverters to AC Combiner Boxes / LT Switchgear Panels along with termination at both the ends, as applicable.

5.5 Laying of AC cables from AC Combiner Boxes / LT Switchgear Panels to inverter transformers along with termination at both the ends, as applicable.

5.6 Laying of 33 kV AC cables from inverter transformer to Gas Insulated Switchgears along with termination at both the ends.

5.7 Laying of 33 kV AC cables from Gas Insulated Switchgears (Transformer Floating Platform) to 33 kV Switchgear Panels (Main Control Room) along with termination at

both the ends.

5.8 Installation, Testing and Commissioning of 33 kV Switchgear Panels inside Main Control Room.

5.9 Installation, Testing and Commissioning of 132/33 kV Power Transformers and 132 kV Switchyard Equipment.

5.10 Installation, Testing and Commissioning of Nitrogen Injection Fire Protection System for Power Transformers.

5.11 Installation, Testing and Commissioning of ABT meters with all necessary metering rated CTs and PTs at Plant Substation as per CEA Metering Regulations 2006 as amended time to time and state metering code.

5.12 Installation, Testing and Commissioning of 132 kV Double Circuit Transmission Line from Plant Substation to Interconnection point.

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

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

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

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

5.17 Installation, Testing and Commissioning of SCADA and Energy Management System along with suitable communication system for interfacing PCU, Transformer, GIS, HT 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.

5.18 Installation, Testing and Commissioning of Telemetry System for communication of Plant Data to the Transmission System Operator as per Central Electricity Authority (Technical Standards for Communication System in Power System Operations) Regulations, 2020.

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

5.20 Installation of lightning protection system for entire plant facilities.

5.21 Installation of indoor & outdoor illumination (off-shore and on-shore) system including all required accessories and laying of power supply cables.

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

5.23 Installation, Testing and Commissioning of Water Quality Monitoring System and Water Flow Monitoring System and associated equipment.

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

5.25 Installation of fire detection and fire protection system for buildings/containers and switchyard.

5.26 Pre-commissioning checks and tests for all equipment.

5.27 Synchronization and Commissioning of plant.

5.28 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

6.1 Conducting topographical survey of on-shore portion of the plant area including submission of contour drawings.

6.2 Conducting hydrographic survey of 'Maximum Permissible Plant Area' provided in 'Annexure-I: Available Reservoir Area with Contour Details' and submission of contour drawings and survey report.

6.3 Conducting geo-technical and geo-physical investigation of 'Maximum Permissible Plant Area' provided in 'Annexure-I: Available Reservoir Area with Contour Details' and submission of survey reports.

6.4 Conducting geo-technical investigation of on-shore portion of the plant area including submission of contour drawings and survey report.

6.5 Earthwork for site levelling & grading including dozing and rolling off the ground as required to make it fairly flat and well compacted for construction of Main Control Room and Substation, etc.

6.6 General clearing of plant site and TL corridor by cutting of any vegetation & shrubs including disposal of waste material.

6.7 Construction of Main Control Room.

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

6.9 Construction of one security room at Main Gate and one security cabin near water body approach path.

6.10 Construction of perimeter boundary wall and main gate for plant area on-shore (approximate dimensions – 133 m x 76 m).

6.11 Foundation for 132/33 kV Plant Substation equipment.

6.12 Construction of fence for transformer yard and switchyard (on-shore).

6.13 Construction of PV Module floating platform including floating system, anchoring and mooring system.

6.14 Construction of Transformer floating platform including floating system, anchoring and mooring system.

6.15 Construction of floating fence around off-shore portion of the plant.

6.16 Suitable arrangement for water shall be ensured to cater day-to-day requirement of drinking water and permanent water supply for module cleaning and other needs of the power plant during entire O&M period.

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

6.18 Construction of storm water drainage & sewage network including rain water harvesting mechanism (on-shore).

6.19 Construction of water tanks, plumbing network for drinking water and cleaning of PV Modules.

6.20 Construction of foundation and/or mounting structure for Weather Monitoring Station (on-shore) and associated civil works.

6.21 Foundation for Lighting poles, CCTV poles and other equipments.

6.22 Foundation for 132 kV double circuit transmission towers from Plant Substation to Interconnection point.

6.23 Construction of approach path (RCC/Steel framed structure) to facilitate movement of personnel and equipment from the reservoir bank to the floating platform provided for access to the boat/vessel. This floating platform shall be located where adequate water depth is met at MDDL for the movement of boat/vessel and shall be suitably anchored.

6.24 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 approvals as and when, as necessary for setting up of a solar power plant including CEIG/ CEA, connectivity, power evacuation, Railways, Port Trust authorities etc. (as applicable) as per the suggested guidelines.

7.1.1 All statutory approvals/permissions and/or No Objection Certificates (NoC) etc. from the DISCOM for obtaining connectivity at the substation as per Project Particulars provided above.

7.1.2 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.

7.1.3 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.

7.2 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, after operational acceptance of the plant till final acceptance or culmination of the O&M period, 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 prepare and send Forecasting and Scheduling generation reports as per extant regulations (SERC/CERC) for Forecasting, Scheduling, Deviation Settlement Mechanism and related matters. 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, equipment rooms, roads, vehicular parking, tool room, stores room, equipment, clean, green and in 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 (MTBF) and mean time to restore (MTTR) at the culmination of penultimate year under O&M period.

8.11 Availability of vehicles for Employer/ his authorized representative staff during construction and O&M period as per requirement may be ensured, failing which Employer shall have full right for alternate arrangement at the risk & cost of the contractor.

8.12 The contractor shall be responsible for all the required activities for the successful running, committed energy generation & maintenance of the Solar Photovoltaic Power Plant covering:

- Deputation of qualified and experienced engineers and technicians at the facility.

- Deputation of Security personnel for the complete security of plant.
- Successful running of Solar Power Plant for committed energy generation.
- Co-ordination with STU/SLDC/other statutory organizations as per the requirement on behalf of Employer for Joint Metering Report (JMR), furnishing generations schedules as per requirement, revising schedules as necessary and complying with grid requirements.
- Monitoring, controlling, troubleshooting maintaining of logs & records, registers.
- Furnishing generation data monthly to Employer 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
- Quarterly visual inspection of floats, anchoring and mooring system and other off-shore installations using underwater drone videography & photography. The drone shall have low-light 4K UHD camera.
- Replacement of Modules, Invertors/PCU's and other equipment as and when required during the O&M period without additional cost to Employer

8.13 Continuous monitoring of 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.

8.14 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.

8.15 The period of Operation and Maintenance will be deemed to commence from the date of completion of performance demonstration/Operational acceptance 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.

8.16 All the equipments 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.

8.17 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.

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. in a log book.

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

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.

9.9 The Contractor shall, at his own expense, deploy required number of suitable work boats (minimum two) along with trained manpower at all times for seamless Operation & Maintenance of FSPV plant.

9.10 In addition to above, the Contractor shall, at his own expense, deploy one passenger boat with minimum seating capacity of 10 (ten) along with life jackets throughout the O&M period.

10 Security Services

10.1 The contractor has to arrange proper security system including deputation of security personnel at his own cost for the check vigil for the Solar Power Plant for the complete scope of works including complete O&M period.

10.2 The security staff may be organized to work on suitable shift system; proper checking & recording of all incoming & outgoing materials vehicles shall be maintained. Any occurrence of unlawful activities shall be informed to Employer immediately. A monthly report shall be sent to Employer on the security aspects and scheduling of security personnel at site.

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.

CHAPTER – 2

TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

DISCLAIMER:

1. Though adequate care has been taken while preparing the Bidding documents, the Bidders/Applicants shall satisfy themselves that the document is complete in all respects. Intimation of any discrepancy shall be given to this office immediately. If no intimation is received from any Bidder within twenty (20) days from the date of notification of NIT/ Issue of the NIT documents, it shall be considered that the NIT documents are complete in all respects has been received by the Bidder.
2. Solar Energy Corporation of India Limited (SECI), the EMPLOYER, reserves the right to modify, amend or supplement this NIT documents including all formats and Annexures.
3. While this bidding documents have been prepared in good faith, neither EMPLOYER or its authorized representatives nor their employees or advisors make any representation or warranty, express or implied, or accept any responsibility or liability, whatsoever, in respect of any statements or omissions herein, or the accuracy, completeness or reliability of information, and shall incur no liability under any law, statute, rules or regulations as to the accuracy, reliability or completeness of this bidding documents, even if any loss or damage is caused by any act or omission on their part.
4. The specifications mentioned for all the equipment which include Solar modules, PCU, combiner boxes, DC cables, module mounting structures, transformer, CT, PT, LT/ HT cables, interfacing panels, switch gears & other associated equipment etc., to complete the power generation and evacuation to the designated substation, in the present bidding documents are for the **reference** only. It is subject to revise/ alter as per the design/ planning/ good engineering practices etc., to be carried out by the selected bidder, to the satisfaction of the EMPLOYER or its authorized representatives. It is advised that the bidders must satisfy himself with the prevailing site conditions before design/ plan. The design must be optimized as per the site conditions and directed to achieve the maximum output from the installed capacity at all times. Moreover, the components not separately mentioned, but are required to complete the plant for operation is also included in the scope of bidder and shall be vetted by the EMPLOYER or its authorized representatives.

Place:

Date:

(Signature)
Name and Designation of bidder

A Design Philosophy

1 The main objective of the design philosophy is to construct the plant with in-built Quality and appropriate redundancy to achieve high availability and reliability with minimum maintenance efforts. In order to achieve this, the following principles shall be adopted while designing the system.

1.1 Adequate capacity of SPV modules, PCUs, Junction boxes etc. to ensure generation of power as per design estimates. This will be done by applying liberal de-rating factors for the array and recognizing the efficiency parameters of PCUs, transformers, conductor losses, system losses, site conditions etc.

1.2 Use of equipment and systems with proven design and performance that have high availability track records under similar service conditions.

1.3 Selection of the equipment and adoption of a plant layout to ensure ease of maintenance.

1.4 Strict compliance with approved and proven quality assurance (QA) systems and procedures during different stages of the project, starting from sizing, selection of make, shipment, storage (at site), during erection, testing and commissioning.

1.5 Proper monitoring of synchronization and recording, to ensure availability of power to the grid.

1.6 The plant Data Acquisition and control system should be designed to ensure high availability and reliability of the plant to assist the operators in the safe and efficient operation of the plant with minimum effort.

1.7 It should also provide the analysis of the historical data and help in the plant maintenance people to take up the plant and equipment on predictive maintenance.

1.8 System design shall have intelligent protection mechanism which may include very fast responsive microprocessor-based relays etc., so that any disturbance from the grid will not cause any damage to the equipment of the Solar Power Plant.

2 The basic and detailed engineering of the plant shall aim at achieving high standards of operational performance especially considering following:

2.1 SPV power plant should be designed to operate satisfactorily in synchronization with the grid within permissible limits of high voltage and frequency fluctuation conditions. It is also extremely important to safeguard the system during major disturbances, internal and external surge conditions while ensuring safe operation of the plant.

2.2 Module Mounting Structures shall be designed for stability under design wind load

conditions specified in this document while optimizing energy generation.

2.3 Shadow free plant layout to ensure minimum losses in generation during the day time.

2.4 Higher system voltage and lower current options to be followed to minimise ohmic losses.

2.5 Selection of PCUs with proven reliability and minimum downtime. Ready availability of requisite spares.

2.6 Careful logging of operational data / historical information from the Data Monitoring Systems, and periodical analysis of the same to identify any abnormal or slowly deteriorating conditions.

2.7 The designed array capacity at STC shall be suitably determined to meet the proposed guaranteed generation output at the point of interconnection by the contractor in his bid. The contractor shall take care of first year degradation also by installing additional DC capacity as the CUF calculations will not factor the first-year degradation of the modules.

2.8 Each component offered by the bidder shall be of established reliability. The minimum target reliability of each equipment shall be established by the bidder considering its mean time between failures and mean time to restore, such that the availability of complete system is assured. Bidder's recommendation of the spares shall be on the basis of established reliability.

2.9 Bidder shall design the plant and equipment in order to have sustained life of 25 years with minimum maintenance efforts.

2.10 The work execution planning for supply, erection, commissioning and all other allied works for SPV Power Plant shall be such that it is completed within stipulated time from the date of order/ LOI/ NTP, whichever is later.

3 The specifications provided with this bid document are functional ones; any design provided in this document is only meant as an example. The Contractor must submit a detailed design philosophy document for the project to meet the functional requirements based upon their own design in-line with the above. The bidders are advised to visit the site and satisfy themselves before bidding.

4 All works shall be executed as per Technical Specifications given in Chapter – 2 of Appendix – A to Section – VII. Chapter – 3 of Appendix – A to Section – VII lays down Special Technical Conditions with reference to site specific design requirements. However, **in case of any conflict** in requirements between Chapter – 2 and Chapter – 3, **Chapter – 3: Special Technical Conditions shall have precedence**.

5 Approval of drawings and documents prepared by the Contractor:

All documents and drawings shall be submitted to the EMPLOYER in soft copies for review and approval. Drawing shall also be submitted in '*.dwg' format, if required. 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, as suitable, either soft or hard copies to the Contractor with category of approval marked thereon. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.

Category-I	Approved
Category-II	Approved subject to incorporation of comments. Re-submit for approval after 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).

The Contractor shall submit complete Master Document & Drawing list (MDL) to the EMPLOYER within 2 weeks after issue of LOA,. The MDL shall list all the Drawings & Documents envisaged for submission/ approval from the EMPLOYER and shall also have all the required information like drawing no (both vendor and EMPLOYER's drawing no), title, scheduled date of submission, actual date of submission and approval. The category of approval shall be decided mutually between Contractor and the EMPLOYER at the time of finalization of the MDL which shall be the basis for drawing & document approval process during project execution.

The construction shall be done only as per drawings approved under Category – I, II & IV. The EMPLOYER shall be kept updated with all proceedings and technical details during the course of design vetting of Floating unit and anchoring & mooring system.

B Electrical System

1 Photovoltaic Modules

1.1 Standards and Codes

Photovoltaic Modules shall comply with the specified edition of the following standards and codes or equivalent Indian Standards, wherever applicable.

Standard	Description
IEC 61215-1:2016 Ed.1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements
IEC 61215-1-1:2016 Ed.1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules
IEC 61730-1:2016 Ed.2	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
IEC 61730-2:2016 Ed.2	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
IEC 61701:2011 Ed.2	Salt mist corrosion testing of photovoltaic (PV) modules (Applicable for coastal and marine environment)
IEC 62716:2013 Ed.1	Photovoltaic (PV) modules - Ammonia corrosion testing (if applicable)
IEC TS 62804-1:2015 Ed.1	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon (under conditions of 85°C/85% RH for minimum 192 hours)

1.2 Technical Requirements

Parameter	Specification
Cell type	Mono-crystalline
Module Efficiency	≥ 20%
Rated power at STC	No negative tolerance is allowed
Temperature co-efficient of power	Not less than -0.4%/°C
Lamination	Glass-Glass with anodized aluminium frame
Application Class as per IEC 61730	Class A

1.3 Supplier Qualification Criteria

The PV Modules Supplier should have supplied minimum 5 GW capacity globally or 500 MW in India in the past 5 years as on last date of bid submission.

1.4 Component Specifications

1.4.1 The PV Modules glass panel:

(i) The PV Modules shall be glass-glass type, with minimum 2 mm glass thickness on each side. It shall be laminated using a laminator with symmetrical structure, i.e., heating plates on both sides.

(ii) The glass used shall have transmittance of above 90%.

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

Parameter	**Value**
Volume resistivity	> 1×10^{14} Ω.cm
Peeling strength with glass	> 40 N/cm

1.4.3 The sealant used for edge sealing of PV modules shall have excellent moisture ingress protection with good electrical insulation (Break down voltage >15 kV/mm) and with good adhesion strength. Edge tapes for sealing are not allowed.

1.4.4 The module frame shall be made of anodized Aluminium, which shall be electrically & chemically compatible with the structural material used for mounting the modules. It is required to have provision for earthing to connect it to the earthing grid.

1.4.5 The material used for junction box shall be UV resistant to avoid degradation during module life. The degree of protection of the junction box shall be at least IP 67. Minimum three number of bypass diodes and two number of IEC 62852/EN 50521 certified MC4 compatible connectors with appropriate length of IEC 62930/EN 50618 certified 4 sq.mm copper cable shall be provided. The cable length shall be in accordance with the PV Module wiring strategy and adequate to ensure that the cable bending radius standard is not exceeded.

1.4.6 Each PV Module shall be provided a RFID code which is embedded insidehe module lamination and must be able to withstand harsh environmental conditions. The RFID code data base shall contain the following information.

(i) Name of the manufacturer of PV Module

(ii) Name of the Manufacturer of Solar cells

(iii) Type of cell: Mono

(iv) Month and year of the manufacture (separately for solar cells and module)

(v) Country of origin (separately for solar cells and module)

(vi) I-V curve for the module

(vii) Peak Wattage, Im, Vm and FF for the module

(viii) Unique Serial No. and Model No. of the module.

(ix) Date and year of obtaining IEC PV module qualification certificate

(x) Name of the test lab issuing IEC certificate

(xi) Other relevant information on traceability of solar cells and modules as per ISO 9000 series.

RFID code scanner and database of all the modules containing the above information shall also be provided.

1.5 Warranty

1.5.1 PV modules must be warranted with linear degradation rate of power output except for first year (up to 3% including LID) and shall guarantee minimum 80% of the initial rated power output at the end of 25 years from the date of supply.

1.5.2 The modules shall be warranted for minimum of 10 years from the date of supply against all material/ manufacturing defects and workmanship.

1.5.3 The above warranties shall be backed by third party insurance.

1.6 Approval

1.6.1 The Contractor shall provide Guaranteed Technical Particular (GTP) datasheet and Bill of Materials (BOM) of the module that is submitted for approval along with the datasheets of each component. The component datasheet shall contain all the information to substantiate the compliance for component specifications mentioned above.

1.6.2 The Contractor shall also provide test certificates corresponding to the standards mentioned above along with complete test reports for the proposed module. The tests should have been conducted at a test laboratory compliant with ISO 17025 for testing and calibration and accredited by an ILAC/IECEE member signatory. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted.

1.6.3 The BOM proposed shall be the subset of Constructional Data Form (CDF)'s of all the test reports.

1.6.4 The Contractor shall submit a detailed Manufacturing Quality Plan (MQP) for the PV Module with list of checks/tests performed during incoming material inspection, production, pre-dispatch and package.

1.6.5 The Contractor shall obtain the approval of the proposed module make & model prior to manufacturing/ inspection call.

1.7 Manufacturing and Inspection

1.7.1 The Contractor shall inform the module manufacturing schedule to the EMPLOYER at least 7 (seven) working days before the start of proposed schedule.

1.7.2 The EMPLOYER shall perform material inspection at the Manufacturer's factory before the start of proposed manufacturing schedule. Proof of procurement of components as per the approved BOM mentioning manufacturer name, manufacturing date and relevant test certificate shall be submitted during material inspection for verification.

1.7.3 The Manufacturing shall start only after the clearance by the EMPLOYER after the material inspection.

1.7.4 The cells used for module making shall be free from all defects like edge chipping, breakages, printing defects, discoloration of top surface etc. Only Class A solar cell shall be used.

1.7.5 The modules shall be uniformly laminated without any lamination defects.

1.7.6 Current binning of modules shall be employed to limit current mismatch of modules. Different colour codes shall be provided on the modules as well as pallet for identification of different bins.

Note: Current Bin size shall be proposed to the Employer for approval prior to manufacturing.

1.7.7 Pre-dispatch inspection of modules shall be performed as per the inspection protocol attached in Annexure – A.

1.8 Transportation, Handling, Storage and Installation

1.8.1 Transportation, handling, storage and installation of modules shall be in accordance with the manufacturer manual so as not to breach warranty conditions. The Standard Operating Procedure (SOP) for the same shall be shared by the Contractor prior to dispatch for approval.

1.8.2 It is required to construct a temporary platform (graded) while keeping the modules at least above the highest flood level. If the contractor scheduled/ planned to mount the modules immediately after the receipt at site, then the module shall be kept in

common storage area with proper arrangement.

1.8.3 Modules shall be dispatched in line with the Construction schedule. If Modules are dispatched ahead of schedule, following measures shall be undertaken:

i. Modules shall be covered with tarpaulin sheet. Alternatively, the Modules, properly stacked as per OEM recommendations, shall be stores under a temporary shed.

ii. Further, the temporary platform for keeping the modules shall be treated with anti-termite treatment.

2 Solar and DC Cables

2.1 Standards and Codes

Cable	From	To	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SCB	Copper/ XLPO	1.5 kV DC	IEC 62930 / EN 50618
DC Cable	SCB	PCU	Copper or Aluminium/ XLPE	1.5 kV DC	IS 7098 Part II
* Cable used for module interconnection shall also be referred to 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 should have marking of red line on black outer sheath.

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

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

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 IEC 62930/EN 50618 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. Cable terminations shall be made with connectors complying IEC 62852 / IS 16781. The connectors shall have degree of protection of IP 68.

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 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.

2.8.5 Solar cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits. The size of the conduit or pipe shall be selected on the basis of 40% fill criteria.

2.8.6 Solar/DC cables shall be laid on the waterbed from PV Modules/SCB to inverter, if placed on shore. There shall be one spare run of cable per inverter.

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

2.8.8 Cable Sealing System: Modular multi-diameter cable sealing system consisting of frames, blocks and accessories shall be installed where the underground and over ground cables enter or leave LCR/MCR enclosures/Buildings. Cable sealing system shall consist of multi-diameter type peel-able blocks of different sizes to suit the various cables. It should be simple, easy and quick to assemble & re-assemble the

cable sealing system. Solid blocks shall not be used on frame. Frames & stay-plate material shall be of galvanized steel and for compression, single piece wedge with galvanized steel bolts shall be used. 30% spare blocks on the frame shall be provided for expansion in future. Cable sealing system should have been tested for fire/ water /smoke tightness.

3 String Combiner Box (SCB)

The String Combiner Box (SCB) specifications mentioned in this section are applicable in case central inverter are employed. Please refer Appendix-A Section-VII: **Chapter-1 Scope of Works.**

3.1 Standards and Codes

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

3.2 Construction

3.2.1 SCB enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP67 and mechanical impact resistance shall be at least IK08.

3.2.2 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.

3.2.3 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.

3.2.4 DC switch disconnector of suitable rating shall be provided at SCB output to disconnect both positive and negative side simultaneously.

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

3.2.6 MC4 connector conforming to IEC 62852 or EN 50521 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.

3.2.7 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.

3.3 Warranty

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

3.4 Tests

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

4 Power Conditioning Unit/Solar Inverter

The Power Conditioning Unit (PCU) specifications mentioned in this section are applicable for both string & central inverters. Please refer Appendix-A Section-VII: **Chapter-1 Scope of Works** for the type of inverter acceptable.

4.1 Standards and Codes

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

Standard	Description
IEC 61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 62109-1 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
IEC 62109-2 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
IEC 61000-6-2 Ed.2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed.2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 62116 Ed.2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat

IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
IEC 60068-2-52:2017	Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution) Severity level 1
CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 and 2019 Amendment	

4.2 Supplier Qualification Criteria

The Inverter Supplier should have supplied minimum 5 GW capacity globally or 500 MW in India in the past 5 years as on last date of bid submission.

4.3 Technical Requirements

Parameter	**Specification**
Type	String/Central
Rated AC power	As per design
Maximum input voltage	1500 V
Rated AC output voltage	As per design
Tolerance on rated AC output voltage	+/-10%
Rated frequency	50 Hz
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.9 lag to 0.9 lead
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

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

4.3.2 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.

4.3.3 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.

4.4 Construction

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

4.4.2 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.

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

4.4.4 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.

4.4.5 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.

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

4.4.7 All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through protective conductor of appropriate size. DC negative terminal shall be grounded. In case DC negative grounding is not possible, appropriate anti-PID device shall be provided.

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

4.4.9 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 voltage

(iv) DC input current
(v) AC output power
(vi) AC output voltage (all the 3 phases and line)
(vii) AC output current (all the 3 phases and line)
(viii) Frequency
(ix) Power Factor

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

4.4.10 AC combiner box for string inverter configuration shall comply with Clause 7 of the Technical Specifications with exception of the following.

(i) Rated System Voltage – Inverter Output Voltage
(ii) IP Rating – IP 55
(iii) Metering System – Not required
(iv) CBCT – Not Applicable

4.5 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.

4.5.1 Standby Mode

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

4.5.2 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.

4.5.3 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.

4.6 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

4.7 Grid Support Functions

4.7.1 Active power regulation

The PCU shall be able to limit the active power exported to the grid based on the set point provided through PCU front control panel. The PCU shall also be able to automatically the limit the active power after an increase in grid frequency above a pre-set value. The ramp rate shall be adjustable during operation and start-up after fault. The applicability of the requirement shall be as per CEA regulation and compliance.

4.7.2 Reactive power control

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

4.7.3 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/absorb reactive power during the period of voltage dip/surge.

4.8 Warranty

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

4.9 Tests

4.9.1 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.

4.9.2 Routine Tests

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

5 Inverter Duty Transformer

5.1 Standards and Codes

Inverter duty transformer shall be Dry Type or Oil Type (with Synthetic Ester or Natural Ester insulating oil) and shall comply with the latest edition of the following standards and codes including amendments, as applicable. In case of Oil type transformer with Natural Esters, the Transformer shall be hermetically sealed.

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
IEC 61099 (Synthetic Ester)/ IS 16081 (synthetic Ester)	Insulating liquids — Specifications for unused synthetic organic esters for Electrical purposes
IEC 62770 /IS 16659 (Natural Ester)	Fluids for Electrotechnical Applications-Unused Natural Esters for Transformers and Similar Electrical Equipment
IS 3639	Fittings and Accessories for Power Transformers
IS 12063	Degree of protection provided by enclosures

CEA Regulations and other statutory regulations with any latest amendments
CBIP publication no. 295

5.2 Technical Requirements – Dry Type Transformers

Parameter	**Specification**
VA Rating	As per system design requirement
Voltage Ratio	33 kV / Inverter output voltage
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)
Winding	As per system design requirement
Frequency	50 Hz
Nos. of Phase	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement
Cooling	AN / AF
Tap Changer	OCTC, No. of steps shall be as per system requirement
Impedance at 75°C	As per Inverter Manufacturer requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)	
Top Oil	Not Applicable
Winding	As per IS 11171
SC withstand time (thermal)	2 second
Short Circuit Apparent power	As per system requirement
Termination	As per system requirement
Bushing rating	HV bushing – 36 kV LV bushing – 3.6 kV
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%.

5.2.1 Construction

5.2.1.1 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.

5.2.1.2 The transformer shall be housed in a metal protective housing having minimum degree of protection of IP 43 (Outdoor). Enclosure shall be of a tested quality sheet steel of minimum thickness 2 mm and shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

5.2.1.3 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.

5.2.1.4 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.

5.2.1.5 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.

5.2.1.6 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.

5.2.1.7 Neutral earthing shall be done as per system requirement. In case neutral is earthed, it shall be brought outside the cable box through bushing for connection to earth grid. If neutral is not earthed, it shall be brought to the cable box for testing purpose and covered by insulating cap.

5.2.1.8 Transformer shall have winding temperature sensors and Winding Temperature Indicator (WTI) with requisite set of remote signalling contacts for alarm and trip operations. There shall also be a provision for remote monitoring of winding temperature. WTI shall have accuracy of 1% or better.

5.2.1.9 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. 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.

5.2.1.10 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.

5.2.1.11 Bi-directional wheel/skids, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.

5.2.1.12 The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformer are deemed to be included in the contract without extra charges.

5.2.1.13 Fire-fighting system for inverter transformer of 10 MVA & above rating shall be provided in accordance with relevant CEA regulations as amended time to time.

5.2.2 Warranty

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

5.2.3 Testing and Inspection

5.2.3.1 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.

5.2.3.2 <u>Type Tests</u>

(i) Lightning impulse test as per IS 11171 / IEC 60076-11

(ii) Temperature Rise test as per IS 11171 / IEC 60076-11

5.2.3.3 Special Tests

(i) Short-circuit test as per IS 11171 / IEC 60076-11

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.

5.2.4 Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IS 2026 / 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 Withstand test
(viii) Induced voltage withstand test
(ix) Measurement of insulation resistance
(x) Partial discharge measurement

5.2.5 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

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.

5.3 Technical Requirements – Oil Type Transformer

Parameters	**Inverter Transformer**
VA Rating	As per system design requirement
Voltage Ratio	33 kV / Inverter output voltage

Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)
Type	1. Conventional Oil Type with Synthetic Ester Insulating Oil, or 2. Hermeticlly Sealed with Natural Ester Insulating Oil
Winding	As per system design requirement
Frequency	50 Hz
Nos. of Phase	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement
Cooling	ONAN
Tap Changer	OCTC, No. of steps shall be as per system requirement
Impedance at 75°C	As per Inverter Manufacturer requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)	
Top Oil	As per IS/IEC
Winding	As per IS/IEC
SC withstand time (thermal)	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
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

5.3.1 Construction – Oil Type Transformer with Synthetic Ester Oil

5.3.1.1 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

5.3.1.2 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.

5.3.1.3 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.

5.3.1.4 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.

5.3.1.5 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.

5.3.1.6 Neutral bushing of Inverter duty transformer shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker “For testing purpose only. Do not earth”.

5.3.1.7 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.

5.3.1.8 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.

5.3.1.9 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.

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

5.3.1.11 Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil.

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

5.3.1.13 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.

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

5.3.1.15 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.

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

5.3.1.17 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.

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

5.3.1.19 Insulating Oil

5.3.1.19.1 Synthetic Ester Insulating Oil shall conform to IEC 61099/ IS 16081. Tests for the standards should have been carried out at laboratories accredited by National Accreditation Board for testing and Calibration Laboratories (NABL) within 5 years prior to the date of opening of this tender.

5.3.1.19.2 Synthetic Ester Insulating Oil shall be K Class with net calorific value less than 32 MJ/kg as per IS13503.

5.3.1.19.3 Synthetic Ester insulating Oil shall be certified bio-degradable as per OECD 301 Test Method.

5.3.2 Construction: Hermetically Sealed Transformer with Natural Ester Oil

5.3.2.1 The transformer tank body shall be constructed with corrugated steel to withstand pressure variation due to oil expansion. The transformer shall be hermetically sealed by means of a nitrogen cushion and .

5.3.2.2 The Contractor shall ensure that the inverter transformer complies with all the requirements of inverter provided by the inverter manufacturer.

5.3.2.3 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.

5.3.2.4 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.

5.3.2.5 Transformer shall be provided with monitoring devices for detection of gas Internal over pressure and Oil over Temperature.

5.3.2.6 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.

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

5.3.2.8 Standard Accessories like bi-directional wheels/skids, Safety Valve, cover lifting eyes, transformer lifting lugs, jacking pads, terminal marking plates, two nos. of earthing terminals shall be provided. The accessories listed 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.

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

5.3.2.10 Insulating Oil

5.3.2.10.1 Natural Ester Insulating Oil shall conform to IS 16659:2017/ IEC 62770:2013. Tests for the standards should have been carried out at laboratories accredited by National Accreditation Board for testing and Calibration Laboratories (NABL) within 5 years prior to the date of opening of this tender.

5.3.2.10.2 Natural Ester Insulating Oil shall be K Class with net calorific value less than 32 MJ/kg as per IS13503.

5.3.2.10.3 Natural Ester insulating Oil shall be certified bio-degradable as per OECD 301 Test Method.

5.3.3 Warranty

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

5.3.4 Testing and Inspection

5.3.4.1 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.

5.3.4.2 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

5.3.4.3 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.

5.3.5 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

5.3.6 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 (not applicable for Hermetically Sealed Transformer)

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 at Contractor's expense.

6 Auxiliary Transformer

6.1 Standards and Codes

Auxiliary transformer 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 3639	Fittings and Accessories for Power Transformers
IS 12063	Degree of protection provided by enclosures
CEA Regulations and other statutory regulations with any latest amendments	
MoP Notification on Energy Consumption Standards for Star Labelled Distribution Transformer dated 12th January, 2009 and subsequent amendments	
BEE (Particulars and Manner of their Display on Labels of Distribution Transformers) Regulations, 2009 and subsequent amendments	

6.2 Technical Requirements

Parameter	Specification
VA Rating	As per system design
Voltage Ratio	As per system design
Duty, Service & Application	Continuous application (Outdoor/Indoor)
Winding	2
Frequency	50 Hz
Nos. of Phase	3
Vector Group & Neutral earthing	Dyn11
Tap Changer	OCTC, No. of steps shall be as per system requirement
Impedance at 75°C	As per system requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)	
SC withstand time (thermal)	2 second
Short Circuit Apparent power	As per system requirement
Termination	As per system requirement
Bushing rating	As per System requirements

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 applicable standards

6.3 Construction

6.3.1.1 Auxiliary 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.

6.3.1.2 The transformer shall be housed in a metal protective housing having minimum degree of protection of IP 55 (Outdoor). Enclosure shall be of a tested quality sheet steel of minimum thickness 2 mm and shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

6.3.1.3 Neutral earthing shall be done as per system requirement. In case neutral is earthed, it shall be brought outside the cable box through bushing for connection to earth grid. If neutral is not earthed, it shall be brought to the cable box for testing purpose and covered by insulating cap.

6.3.1.4 Transformer shall have winding temperature sensors and Winding Temperature Indicator (WTI) with requisite set of remote signalling contacts for alarm and trip operations. There shall also be a provision for remote monitoring of winding temperature. WTI shall have accuracy of 1% or better.

6.3.1.5 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. 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.

6.3.1.6 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.

6.3.1.7 Bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.

6.3.1.8 The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformer are deemed to be included in the contract without extra charges.

6.4 Warranty

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

6.5 Testing and Inspection

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

6.5.2 Type Tests (for transformer rating above 100 kVA)

The following type 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..

(i) Lightning impulse test as per IS 1180-1 or IS 11171 / IEC 60076-11

(ii) Temperature Rise test as per IS 1180-1 or IS 11171 / IEC 60076-11

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

6.5.3 Special Tests (for Transformer rating above 100 kVA)

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

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

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

(vi) 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.

6.5.4 Routine Tests

Each completed transformer shall be subjected to all the routine tests as per the latest edition of IS 1180-1 or IS 11171 / IEC 60076-11.

6.5.5 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

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 free of cost.

7 LT Switchgear

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

7.1 Standards and Codes

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

Standard/Code	Description
IS/IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IS/IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies

IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers
IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60947-5-1	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 62052-11	Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 11: Metering equipment
IS 694	Polyvinyl chloride insulated unsheathed-and sheathed cables/ cords with rigid and flexible conductor for rated voltages - up to and including 450/750V
IEC 61869	Instrument Transformers
IS 3043	Code of practice for earthing
IEC 60255	Measuring relays and protection equipment - Part 1: Common requirements

7.2 Technical Parameters

System Details	
Rated system voltage	415 V ± 10%, 3 Phase, 4 wire, Neutral Solidly Earthed
Rated frequency	50 Hz ± 5%
System fault current	As per system requirement
Air Circuit Breaker (ACB)	
Type	Air break
Rated Current	As per system requirement
Rated Ultimate Short-Circuit Breaking Capacity & Rated Service Short-Circuit Breaking Capacity	As per system fault current
Rated short-time withstand current duration	1s
Moulded case circuit breaker (MCCB)	
Rated Voltage	415 V

Release	Thermal-Magnetic/Microprocessor
Rated current	As per system requirement
Poles	4 poles
Rated insulation level	690 V
Rated Ultimate Short-Circuit Breaking Capacity & Rated Service Short-Circuit Breaking Capacity	As per system fault current
Rated Short-Circuit Making Capacity	2.1 X Short circuit breaking Capacity
Rated short-time withstand current duration	1s
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 F
Accuracy class & burden	
a) For Protection	5P20, 5 VA PS Class for REF and core balance CT (CBCT)
b) For Metering	Class 0.5, 5 VA (min)
Minimum primary earth fault current to be detected by CBCT	1 A
Instrument Security Factor for metering CT	5
Voltage Transformer (VT)	
Type	Cast Resin
Accuracy Class	0.5
Rated Voltage Factor	1.1 Continuous, 1.5 for 30 seconds
Class of Insulation	E or better
Digital Multifunctional Meter (MFM)	
Accuracy class	0.5 class
Communication with SCADA	RS485 communication with Modbus RTU

7.3 Constructional Details

7.3.1 The panel shall be metal enclosed, free standing, floor mounted, modular type with compartmentalized construction having degree of protection of IP 2X (Indoor) and IP 54 (Outdoor) as per IS/IEC 60529. All doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust.

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

7.3.3 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.

7.3.4 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.

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

7.3.6 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.

7.3.7 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.

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

7.3.9 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.

7.3.10 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.

7.3.11 Suitable lifting hooks shall be provided for each panel.

7.3.12 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.

7.3.13 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.

7.4 Air Circuit Breaker

7.4.1 The circuit breaker shall be three pole, air break, horizontal draw-out type.

7.4.2 The circuit breaker shall have three positions, i.e. SERVICE, TEST and ISOLATED.

7.4.3 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.

7.4.4 The rated control voltage of the spring charging motor shall be 110 VDC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

7.4.5 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.

7.4.6 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.

7.4.7 Mechanical indicators shall be provided to indicate OPEN/CLOSE, SERVICE/TEST positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided.

7.4.8 The circuit breaker shall be provided with microprocessor based front adjustable protection release for overload, short circuit and earth fault.

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

(i) It shall be possible to close the circuit breaker only if it is in SERVICE or TEST position.

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

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

(iv) Racking in the circuit breaker from TEST to SERVICE position shall be possible only if door is closed.

7.4.10 Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit breaker. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn/inserted.

7.4.11 The circuit breaker shall have suitable provision for integration with SCADA.

7.5 Instrument Transformers

7.5.1 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.

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

7.5.3 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.

7.5.4 For auxiliary supply switchgear, 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.

7.6 Bus bar

7.6.1 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.

7.6.2 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.

7.6.3 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.

7.6.4 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.

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

7.7 Earthing

7.7.1 An earth bus made of copper or aluminium 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.

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

7.7.3 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.

7.7.4 Positive earthing of the carriage and breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

7.7.5 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.

7.7.6 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.

7.8 Multi-Function Meter

7.8.1 Digital, flush mounting type Multi-Function Meter (MFM) of 0.5 accuracy class shall be provided. It shall have provision for integration with SCADA.

7.8.2 MFM 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)

7.9 Wiring and Terminal blocks

7.9.1 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.

7.9.2 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.

7.9.3 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.

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

7.9.5 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.

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

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

7.10 Warranty

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

7.11 Testing and Inspection

7.11.1 Type Tests

The switchgear panel shall be of type tested design. Type test reports as per the following 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'.

Equipment	**Standard**
Switchgear Panel	Relevant parts of IEC 61439
Air Circuit Breaker	IEC 60947-2

Moulded Case Circuit Breaker	IEC 60947-2
Current Transformer	Relevant parts of IEC 61869
Voltage Transformer	Relevant parts of IEC 61869

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.

7.11.2 Routine Tests

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

8 HT Switchgear

8.1 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	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages

IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

8.2 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	As per system requirement
Internal Arc Classification	IAC-A, FLR, System fault current for 1s
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3 sec – CO – 3 min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	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

8.3 Switchgear Panel

8.3.1 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.

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

8.3.3 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.

8.3.4 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.

8.3.5 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.

8.3.6 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.

8.3.7 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.

8.3.8 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.

8.3.9 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.

8.3.10 Panel shall be provided with local bus-bar protection.

8.3.11 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.

8.3.12 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.

8.3.13 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.

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

8.3.15 Suitable lifting hooks shall be provided for each panel.

8.4 Circuit Breakers

8.4.1 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.

8.4.2 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.

8.4.3 The rated control voltage of the spring charging motor shall be 110 VDC/220 VDC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

8.4.4 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.

8.4.5 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.

8.4.6 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.

8.5 Relays

8.5.1 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.

8.5.2 The relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.

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

8.5.4 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.

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

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

8.5.7 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

8.5.8 Each feeder shall have two lock out relays powered through two independent DC supplies. Each lock out relay shall send through two separate potential free output contacts signals to each of the two independent trip coils.

8.5.9 Transformer feeder protection relay shall have provision for the following protection functions, as applicable (depending on Type of Transformer).

(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

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

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

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

(ii) Event record – with date and time stamp.

8.5.12 The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.

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

8.5.14 The numerical relays and meters at 33kV and above voltage level shall be IEC 61850 compliant for communicating with the SCADA system.

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

8.5.16 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.

8.6 Instrument Transformers

8.6.1 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.

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

8.6.3 Voltage transformers shall be single phase units. Bus voltage transformers shall be housed in a separate panel on withdrawable truck.

8.6.4 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.

8.7 Earthing

8.7.1 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.

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

8.7.3 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.

8.7.4 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.

8.7.5 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.

8.7.6 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.

8.7.7 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.

8.7.8 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.

8.8 Bus bar

8.8.1 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.

8.8.2 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.

8.8.3 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.

8.8.4 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.

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

8.9 Measuring Instruments

8.9.1 All the measuring instruments shall be digital, flush mounting type with communication facility. Meters at 33 kV and above voltage level shall be IEC 61850 compliant for communicating with the SCADA system.

8.9.2 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.

8.9.3 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)

8.10 Wiring and Terminal blocks

8.10.1 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.

8.10.2 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.

8.10.3 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.

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

8.10.5 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.

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

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

8.11 Warranty

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

8.12 Testing and Inspection

8.12.1 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 requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional requirements	Relevant parts of IEC 60255-100 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.

8.12.2 Routine Tests

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

9 Gas Insulated Switchgear

9.1 Standards and Codes

All equipment provided under Gas Insulated Switchgear (GIS) shall comply with latest edition and amendments of the relevant IEC standards and IS codes. In particular, the GIS 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 60376	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers – Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters – Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems – Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) – General requirements, tests and test conditions – Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) – Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

9.2 Technical Requirements

Parameter	**Specification**
System Parameters	
Nominal system voltage	36 kV
Highest system voltage	33 kV
Number of phases	50 Hz
Frequency	3
Power frequency withstand voltage	70 kV (r.m.s.)
Lightning impulse withstand voltage	170 kV (peak)
Short circuit current rating	As per system requirement
Internal Arc Classification	IAC-A, FLR, System fault current for 1s

Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3 sec – CO – 3 min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C2
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering, 5P20 for protection
Ratio	As per system design
Rated VA burden	As per system requirement
Insulation class	Class E or better

9.3 Construction

9.3.1 Inner Enclosure (Main Tank)

The tank shall be made up of robotically welded stainless-steel sheet of minimum 2 mm thickness. The tank shall be sealed and no handling of gas is required throughout the service life. However, the SF_6 gas pressure inside the tank shall be constantly monitored by a temperature compensating gas pressure indicator offering a simple go, no-go indication. The gas pressure indicator shall be provided with green pressure and red pressure zones. There shall be a non – return valve to fill up the gas. The manufacturer shall give guarantee for maximum leakage rate of SF_6 gas lower than 0.1 % per year. An absorption material such as activated alumina shall be provided to absorb the moisture from the SF_6 gas to regenerate the SF_6 gas following arc interruption. The minimum degree of protection of the inner enclosure shall be IP 67.

9.3.2 Outer Enclosure

The outer enclosure shall be made up of CRCA steel sheet of minimum 2 mm thickness. The outer enclosure shall have degree of protection not less than IP 54. The enclosure shall be painted with two coats of epoxy-based paint of colour shade as decided by the EMPLOYER. The minimum dry film thickness (DFT) shall be 100 micron.

9.3.3 Circuit Breaker

9.3.3.1 Circuit breaker shall be three pole, vacuum type with integrated earth switch. The entire arrangement shall be provided inside welded stainless-steel SF_6 tank. The earth switch shall have short circuit withstand capability as that of the circuit breaker.

9.3.3.2 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.

9.3.3.3 The control voltage of the spring charging motor shall be DC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

9.3.3.4 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.

9.3.3.5 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.

9.3.3.6 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.

9.3.4 Load Break Switch

9.3.4.1 Load Break Switch shall be of tripe pole, simultaneously operated, non-automatic type with quick break contacts and with integral earthing arrangement. It shall be fully insulated by SF_6 gas.

9.3.4.2 Both LBS and earth switch shall have short circuit withstand capability as that of the circuit breaker.

9.3.4.3 The Load Break Switch shall be naturally interlocked to prevent the main and earth

switch being switched ON at the same time. The selection of the main and earth switch is made by a lever on the fascia which is allowed to move only if the main or earth switch is in OFF position.

9.3.5 Current Transformer

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

9.3.6 Relays

Relays shall comply with **Clause 8.5** of Appendix A Chapter 2 (Tenchical Specifications)

9.3.7 Busbar

Busbar shall be made of electrolytic grade tinned copper of sufficient cross section. The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

9.3.8 Earthing

All metal parts of GIS which do not intend to carry current shall be connected to earth bus. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

9.3.9 Interlocks

GIS shall be provided with a comprehensive interlocking system to prevent dangerous or undesirable operations. The specific interlocking requirements shall be finalized during detailed engineering.

9.3.10 Voltage Presence Indicating System

The GIS shall be equipped with Voltage Presence Indicating System (VPIS) to indicate whether or not there is voltage on the cables. The VPIS shall consist of capacitive voltage divider and indicator lamp on the front door according to IEC 62271-206.

9.3.11 Cable Box

All cable boxes shall be air insulated suitable for dry type cable termination and shall have front access. Necessary right-angle boot shall be provided for cable termination.

9.4 Warranty

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

9.5 Testing and Inspection

9.5.1 Type Tests

The Gas Insulated Switchgear shall be of type tested design. Type test reports of GIS, Circuit Breaker, Load Break Switch and Current Transformer as per relevant parts of IEC 62271 and IEC 61869-2 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.

9.5.2 Routine Tests

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

10 AC Cables

10.1 Standards and Codes

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

Standard	Description
IS 7098-I	Crosslinked Polyethylene Insulated Thermoplastic Sheathed Cables, Part 1: For working voltage 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

10.2 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.

10.3 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.

10.4 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

10.5 Cables shall be sized based on the following considerations:

(i) Rated current the equipment

(ii) **In case of Central inverters**, maximum 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**, maximum 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 plant take off point), maximum voltage drop shall be limited to 0.5 % of the rated voltage. The Contactor shall provide voltage drop calculations in excel sheet.

(iii) Short circuit withstand capability as per design for 1s

(iv) De-rating factors according to laying pattern

10.6 Warranty

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

10.7 Testing

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

10.8 Installation

10.8.1 Cable installation on-shore shall be as per IS 1255.

10.8.2 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.

10.8.3 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.

10.8.4 Off-shore

In case of string inverter, AC cables from inverter to AC Combiner Panel shall be laid through UV resistant Double Wall Corrugated HDPE conduits. The size of the

conduits shall be selected on the basis of 40% fill criteria. The conduits shall be routed through closed cable trays fixed on top of the floats on the PV Module floating platform. The conduits shall be routed on top of dedicated floats (on-shore) from PV Module floating platform through appropriate support structure till transformer. Conduits shall be tied to the cable trays at regular intervals using UV resistant cable ties.

11 Auxiliary Supply System

11.1 Scheme for auxiliary supply system shall be submitted by the Contractor during detailed engineering for the approval by EMPLOYER.

11.2 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.

11.3 Auxiliary system shall be provided with two independent sources for reliable auxiliary power supply.

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

(i) 20% future load margin

(ii) 20% design margin

(iii) Total connected load at 0.8 power factor

12 Uninterrupted Power Supply

12.1 Standards and Codes

Uninterrupted Power Supply shall comply with the following standards and codes or equivalent Indian Standards, wherever applicable.

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
IEC 62619 / IS 16805	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications

IEC 62620 / IS 16822	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications
IEC 60896-21	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IEC 60896-22	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements
IS 15549	Stationary valve regulated lead acid batteries - Specification

12.2 General Requirements

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

(i) Data logger / SCADA / EMS
(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

12.2.2 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.

12.3 System Description

12.3.1 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

12.3.2 The UPS shall meet the following minimum specifications.

Parameter	**Specification**
Topology	Online double conversion UPS
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 Hz
Power factor	0.95
Output	
Voltage	230 V ± 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Off-shore: Lithium-ion battery On-shore: Lithium-ion battery OR Sealed, Maintenance-Free (AGM) battery
Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED Indicators	Load on Inverter, Battery operation, Load on Bypass, Overload, LCD Fault, UPS Fault
Electrical contacts	Closing contacts for each of the following conditions: 1. Unit on Battery 2. Low Battery 3. Summary Alarm 4. UPS On 5. Input Fail
Local Display	LCD/ LED
SCADA communications	RS-485 Interface Port
Overall efficiency	>90%
Electrical Protection	Input/ output under voltage, over temperature, overload, Short circuit, battery low trip

12.3.3 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.

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

12.4 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.

12.5 Tests

12.5.1 Routine tests and acceptance tests on final product shall be done as per QAP approved by the EMPLOYER.

12.5.2 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.

13 Battery and Battery Charger

13.1 Standards and Codes

Batteries shall comply with the following standards and codes or equivalent Indian Standards, wherever applicable.

Standard/Code	Description
IEC 62619 / IS 16805	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications
IEC 62620 / IS 16822	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications
IEC 60896-21	Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test
IEC 60896-22	Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements
IS 15549	Stationary Regulated Lead Acid Batteries

13.2 General

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 (for on-shore) complete with racks & accessories

(ii) One No. Float charger.

(iii) One No. Float cum Boost charger.

(iv) DC Distribution Board (DCDB)

13.3 Battery

13.3.1 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 HT circuit breaker

(ii) Spring Charging motors for HT circuits

(iii) Annunciator and Indication circuit for HT Panel

(iv) Auxiliary Supply to protection relays

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

13.3.3 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.

13.3.4 Battery voltage – 220V DC or 110V DC

13.4 Battery Charger

13.4.1 The Float Charger shall be used to supply normal DC loads and float charging current of charged battery. The Float cum Boost charger shall be designed to supply boost charging current requirement of the associated battery as well as to supply normal DC load. After full discharge of battery bank, the Float Cum boost charger shall be capable of charging the battery to its full capacity in 8 hours duration while supplying normal DC load.

13.4.2 The float charger shall have both auto and manual voltage regulation arrangements with provision of selector switch.

13.4.3 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 the DC load level, when they are not connected to a battery.

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

13.4.5 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.

13.4.6 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).

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

13.5 DC distribution board (DCDB)

13.5.1 DCDB shall be a separate panel but shall form an integral part of a battery charger panel board.

13.5.2 Doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust. Also, door shall be provided with lock and key arrangement to prevent unauthorized access to the board.

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

13.6 Warranty

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

13.7 Tests

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

14 Earthing

14.1 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
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEC 62561-2	Requirements for conductors and earth electrodes
IEC 62561-7	Requirements for earthing enhancing compounds

IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
Indian Electricity Rules	

14.2 General Requirements

14.2.1 Earthing system shall be designed based on system fault current and soil/water resistivity value obtained from geo-technical investigation/hydrography report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.

14.2.2 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.

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

14.2.4 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.

14.2.5 Earth electrodes shall not be situated within 1.5 m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be two times the driven depth of the electrode.

14.2.6 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.

14.2.7 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.

14.3 Earthing of Floating Platform

14.3.1 All the conducting parts of floating platform that are not intended to carry current shall be bonded to the earthing system by two distinct connections.

14.3.2 Earth electrodes shall be buried on the reservoir bed or the ground (on-shore). The Contractor may propose alternative arrangement subject to design, safety and statutory requirements.

14.3.3 Earth electrodes of the DC earth grid shall be uniformly distributed so that optimum earth resistance is offered to leakage current flowing from floating platform.

14.3.4 SPD 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.

14.4 PCU Earthing

14.4.1 DC negative bus bar of the PCU shall be earthed to avoid Potential Induced Degradation (PID). DC negative bus bar and PCU equipment earth shall be bonded to the PCU earth bus and connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by the manufacturer. The interconnection of PCU earth electrodes with DC earth grid shall be as per PCU manufacturer recommendation.

14.4.2 In case earthing of DC negative bus bar of PCU is not allowed by the manufacturer, suitable anti-PID device shall be provided with the consent of PV Module and PCU manufacturer. However, PCU equipment earth shall be connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by the manufacturer.

14.5 Transformer Earthing

14.5.1 Inverter transformer neutral shall be floating, not to be earthed. However, recommendation of inverter manufacturer shall also be taken into account.

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

14.5.3 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.

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

14.6 Main Control Room Earthing

14.6.1 Metallic enclosure of all electrical equipment inside the main control room shall be connected to the earth grid by two separate and distinct connections.

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

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

14.7 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.

Switch yard shall be shielded against direct lightning stroke by provision of overhead shield wire or earth wire or spikes (masts) or combination thereof as per CEA 2010(Technical standards)- 42(2)(c).

14.8 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.

15 Lightning Protection System

15.1 Lightning Protection System (LPS) for the entire plant (off-shore and on-shore) against direct and indirect lighting strokes shall be provided as per IS/IEC 62305:2010.

15.2 Lightning Protection Level for the entire plant shall be Level – III.

15.3 Air terminals, down conductors and earth termination system shall be designed as per relevant parts of IS/IEC 62305:2010.

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

15.5 The product shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

15.6 Type test reports as per IS/IEC 62305:2010 shall be submitted during detailed engineering for approval.

16 Communication Cables

16.1 Optical Fibre Cables

16.1.1 Optic Fibre cable shall be 4/8/12 core, galvanized corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor/ indoor application so as to prevent any physical damage.

16.1.2 The cable shall have multiple single-mode or multimode fibres on as required basis

so as to avoid the usage of any repeaters.

16.1.3 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.

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

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

16.1.6 The Contractor shall ensure that minimum 100% cores are kept as spare in all types of optical fibre cables.

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

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

16.2 Communication Cable (Modbus)

16.2.1 Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 Sq.mm. Cable shall be flame retardant according to IEC 60332-1-2.

16.2.2 Cable shall be tested for Peak working voltage of not less than 300 V and shall be suitable for serial interfaces (RS 422 and RS 485).

16.2.3 Communication cable shall be laid through suitable HDPE ducts.

17 Control Cables

17.1.1 Control Cables shall have stranded copper conductor, PVC insulation, PVC inner sheath, FRLS PVC outer sheath according to IS 1554-1. Colour of the outer sheath shall be grey in colour.

17.1.2 The minimum cross section of the conductor shall be 2.5 sq.mm.

17.1.3 At least one (1) core shall be kept as spare in each control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10C or higher size.

18 SCADA

18.1 General Requirements

18.1.1 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.

18.1.2 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.

18.1.3 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/ String Inverter Level) parameters.

(ii) Real time Data Logging with Integrated Analytics & Reporting: Logging of all paramete–s - 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) Support for O&M Activities: The interface shall allow integration with Module Cleaning System and various other O&M support systems to provide a Data Analysis and Decision Support System for smooth and efficient Plant Operations.

(v) AI based Distributed Analytics for Predictive Maintenance, trend analysis and Alerts.

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

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

(viii) Transfer of plant data reliably, to a Cloud server on any kind of remote network including low bandwidth and wireless links such as 4G/5G/VSAT

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

18.1.4 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.

18.2 Architecture

18.2.1 The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database. The SCADA architecture shall be compliant with principles identified in Article 1 a. of CEA (Cyber Security in Power Sector) Guidelines, 2021. (Note: Appointment of CISO shall be the responsibility of Owner).

18.2.2 Data acquisition shall be distributed across MCR and LCRs while plant level data aggregation shall be done in both local and remote server (as specified by Owner).

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

18.2.4 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.

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

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

18.2.7 A virtual/cloud server running SCADA & Monitoring Software shall be configured in parallel with Plant Server to enable easy access to plant data from outside the plant without having to login to plant server. Effectively, the plant data shall be replicated in both places i.e. between systems at the Plant Server and Remote Server to provide data redundancy for complete plant data.

Note: Configuration of Cloud server and procurement of associated subscription services shall be in the scope of the EPC Contractor.

18.2.8 Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant or remote server. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software and Plant Data shall be installed/stored on local and remote servers only with user access control for protecting the software and data assets from accidental deletion or corruption.

18.2.9 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 4G/5G data card from any Internet Service Provider (ISP) may be provided. SCADA system shall be capable of sending all plant data in real time to the Remote Server.

18.2.10 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.

18.3 Industrial IoT Controllers & Data Acquisition

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

18.3.1 The IIoT Controllers shall be distributed in nature.

18.3.2 Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)

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

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

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

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

18.3.7 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.

18.3.8 Controllers shall be capable of sending data over Internet connections USB data cards.

18.4 Functionalities

18.4.1 In case of central inverter, 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.

18.4.2 The SCADA system shall monitor instantaneous and cumulative electrical

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

18.4.3 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. The SCADA shall also monitor water quality and flow parameters.

18.4.4 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.

18.4.5 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.

18.4.6 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.

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

18.4.8 The system shall have Configurable Analysis page for self-configured as well as on demand Analytics charts.

18.4.9 Mobile User Interface: summary of plant performance and issues should be accessible in a mobile Native UI or browser UI.

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

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

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

protocols like Modbus over TCP/IP.

18.4.12 Predictive Maintenance: SCADA system shall have in-built or pluggable frameworks to support AI based Predictive Maintenance for all key equipment including inverters, transformers and switchgear at the plant.

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

18.4.14 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.

18.5 Earthing

18.5.1 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.

18.5.2 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 Inverters, WMS and Switchgear panels.

18.6 Communication Cable Laying

18.6.1 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.

18.6.2 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.

18.6.3 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.

18.6.4 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.

18.7 Control Cabinets / Panels / Desks at Main Control Room

18.7.1 The cabinets shall be IP 22 protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.

18.7.2 The cabinets shall be totally enclosed, free standing type and shall be constructed

with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per suppl'er's standard practice for similar applications.

18.8 Software Licences

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

18.9 Hardware at Main Control Room

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

18.9.2 The Local Monitoring & Control Server and the Operating Work station, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories:

Plant Server	
Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 X 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 Windiws 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	
Hardware	i7 CPU running at 3.0 GHz or faster with 16GB 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. Screen Display Unit: Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer. 3. UPS of required capacity with 2 hour battery backup.

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

18.10 Factory Acceptance Test (FAT)

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

19 Energy Management System

19.1 Energy Management System (EMS) system shall be a computerized system for real time monitoring, operation, control, reliable & efficient operation of the Plant facilities. EMS shall be able to acquire real time data of various equipment of Plant facilities, have in built logic/programming to monitor, control, and optimize the performance of Plant facilities as per specification. The Contractor shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire Plant facilities and its auxiliary systems. The Contractor shall include in his proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in this specification.

19.2 Standards and Codes

19.2.1 The EMS shall comply with IEC 61970 for interoperability.

19.2.2 The EMS shall have the functionality to ensure compliance to the CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 with 2013 and 2019 amendment.

19.2.3 The EMS 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.

19.3 EMS functionality for the Plant Control

19.3.1 The EMS monitors grid and Plant facility variables and should be programmable for

selecting the optimum-operating mode of the whole plant w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behaviour to the new settings.

19.3.2 The EMS shall perform following functionality to control the Plant facilities.

- Communication with grid or SCADA
- Communication with PV Inverters and other power units
- Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)
- Control capability of PV Inverters and other power units
- The EMS shall allow following operation modes for the Plant facilities:
- Reactive Control (Q Control, setting point of reactive power Q at EMS)
- Power Factor Control (PF Control, setting point of cos(L) at EMS)
- Voltage Control (V closed loop control, setting point of V at EMS)
- Voltage Droop (Reactive power vs Voltage programmable curve or droop)
- Apparent Power Control (S Lim, setting point of S Lim at EMS)
- Active Power Limitation (P Lim, setting point of P Lim at EMS)

19.3.3 The EMS shall have the functionality to receive the target values specified by operators using a standard protocol (i.e. Modbus TCP/IP).

19.4 Control and Power Supply Scheme

The Contractor shall provide the UPS/ DC Power supply of suitable rating to cater all the load requirements of EMS system and its auxiliaries.

20 Power Transformer

Two nos. of 50 MVA, 33/132 kV 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).

21 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.

21.1 Standards and Codes

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

Standard	Description
IS 10028-2	Code of practice for selection, installation and maintenance of transformers; Part 2: Installation
IS 7285-2	Refillable Seamless Steel Gas 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	

21.2 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

21.3 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.

21.3.1 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) Butterfly 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

21.3.2 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.

21.3.3 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.

21.3.4 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.

21.3.5 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.

21.3.6 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.

21.3.7 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.

21.3.8 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.

21.4 Protection Philosophy

21.4.1 The NIFPS shall have the operating modes and operate on receipt of corresponding activation signals.

21.4.1.1 Auto Mode

A. Fire Prevention

The system shall operate on receipt of all the following three signals.

(i) Differential relay trip

(ii) Operation of Buchholz relay (OR) Pressure Relief Device (OR) Rapid Pressure Rise Relay

(iii) Master trip (OR) Tripping of LV / HV circuit breaker in series

B. Fire Extinction

The system shall operate on receipt of all the following three signals.

(i) Operation of fire detector

(ii) Operation of Buchholz relay (OR) Pressure Relief Device (OR) Rapid Pressure Rise Relay (OR) Oil Surge Relay

(iii) Master trip (OR) Tripping of LV / HV circuit breaker in series

21.4.1.2 Remote Manual Mode

The system shall operate on receipt of both the following signals:

(i) Master trip (OR) Tripping of LV / HV circuit breaker in series.

(ii) Operation of emergency operating switch on the control box.

21.4.1.3 Local Manual Mode

In case the system fails in Auto Mode / Local Remote Mode (OR) Power Failure, the system can be operated manually from the Fire Extinguisher Cubicle.

21.4.2 On receipt of all required activating signals, the system shall drain pre-determined volume of oil from top of the tank through outlet valve to reduce tank pressure and simultaneously inject nitrogen gas at high pressure through inlet valves for stirring the oil and thus bringing the temperature of oil below flash point to extinguish the fire. Transformer conservator isolation valve shall block the flow of oil from conservator tank.

22 Control and Relay Panel

22.1 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 controlle–s - 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 arreste–s - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Syste–s - Part 3: Metal Oxide Lightning Arresters Without Gaps

IEC 62052-11	Electricity metering equipment (A.C–) - General requirements, tests and test conditio–s - 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

22.2 Construction

22.2.1 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.

22.2.2 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.

22.2.3 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.

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

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

22.3 Relays

22.3.1 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.

22.3.2 Relays shall operate on suitable Auxiliary voltage and the relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.

22.3.3 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.

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

22.3.5 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.

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

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

22.3.8 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 –with date and time stamp.

22.3.9 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.

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

22.3.11 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.

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

22.3.13 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.

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

22.3.15 Each feeder shall have two lock out relays powered through two independent DC supplies. Each lock out relay shall send through two separate potential free output contacts signals to each of the two independent trip coils.

22.4 Protection Scheme

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
(v) Buchholz Alarm and Trip
(vi) OTI Alarm and Trip
(vii) WTI Alarm and Trip
(viii) PRV Trip
(ix) MOG Alarm
(x) 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.

22.5 Measuring Instruments

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

22.5.2 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.

22.5.3 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.

22.6 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.

22.7 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.

22.8 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.

22.9 Earthing

22.9.1 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.

22.9.2 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.

22.9.3 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.

22.9.4 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.

22.10 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.

22.11 Wiring and Terminal Blocks

22.11.1 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.

22.11.2 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.

22.11.3 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.

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

22.11.5 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.

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

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

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

22.12 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

22.13 Warranty

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

22.14 Testing and Inspection

22.14.1 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.

22.14.2 Routine Tests

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

23 132 kV Switchyard Equipment

23.1 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 ge–r - 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 ge–r - Part 102: AC Disconnectors and Earthing Switches
IEC 61869	Instrument Transformers
IS 2099	Bushings for alternating voltages above 1000 Volts
IS 2544	Porcelain post insulators for systems with nominal voltage greater than 1000 Volts
IS 335, IEC 60296	Insulating oil
IS/IEC 60034	Rotating electrical machines
IS 996	Single-phase AC industrial motors for general purpose
IS 3070, IEC 60099-4	Surge arreste–s - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
Indian Electricity Act, CBIP manual, CEA rules and guidelines	

23.2 General Technical Parameters

System Parameters	Specification
Highest system voltage	145 kV
Rated system voltage	132 kV
Rated frequency	50 Hz
Number of phases	3
One minute power frequency withstand voltage	275 kV (rms)
Full wave impulse withstand voltage (1.2 / 50 μs)	650 kV (peak)
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	500 μV at 92 kV rms
Rated short-time withstand current	31.5 kA for 1 s
Rated peak withstand current	80 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	 1300 mm 1300 mm 4000 mm 4800 mm

23.3 Supplier Qualification Criteria

Only PGCIL approved components shall be used for construction of 132 kV switchyard.

23.4 Circuit breaker

23.4.1 Technical Parameters

Parameters	**Specification**
Type	Outdoor SF6, single pressure
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	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

23.4.2 Duty Requirements

23.4.2.1 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.

23.4.2.2 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.

23.4.2.3 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.

23.4.3 Construction

23.4.3.1 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.

23.4.3.2 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.

23.4.3.3 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.

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

23.4.3.5 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.

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

23.4.3.7 Circuit breakers shall be provided with two (2) independent trip coils operated through two independent DC supplies, 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.

23.4.4 Operating Mechanism and Control

23.4.4.1 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.

23.4.4.2 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.

23.4.4.3 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.

23.4.4.4 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.

23.5 Disconnector

23.5.1 Technical Parameters

System Parameters	Specification
Service	Outdoor
Type	Gang operated, Double break type
Rated short-time withstand current for isolator & earth switch	31.5 kA for 1 s
Rated peak withstand current for isolator & earth switch	80 kAp
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

23.5.2 Duty Requirements

23.5.2.1 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.

23.5.2.2 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.

23.5.2.3 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.

23.5.2.4 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.

23.5.3 Construction

23.5.3.1 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.

23.5.3.2 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.

23.5.3.3 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.

23.5.3.4 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 600 kg.

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

23.5.3.5 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.

23.5.4 Operating Mechanism and Control

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

23.5.4.2 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.

23.5.4.3 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.

23.5.4.4 Control cabinet / operating mechanism box shall conform to requirements stipulated elsewhere in the document and IS/IEC 61439 as applicable.

23.5.5 Operation

23.5.5.1 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.

23.5.5.2 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.

23.5.5.3 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.

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

23.6 Surge Arrester

23.6.1 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	120 kV
Continuous operating voltage at 50°C	102 kV
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	 280 kVp 310 kVp 330 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

23.6.2 Duty Requirements

23.6.2.1 The Surge Arresters shall be capable of discharging over-voltages occurring due to switching of unloaded transformers, reactors and long lines.

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

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

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

23.6.3 Construction

23.6.3.1 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.

23.6.3.2 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.

23.6.3.3 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.

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

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

23.6.3.6 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.

23.6.4 Fittings and Accessories

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

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

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

23.6.4.4 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.

23.7 Instrument Transformer

23.7.1 Technical Parameters

Parameter	**Specification**
Current Transformer	
Accuracy class	Metering – 0.2S Protection – PS / 5P20
Rated VA burden	As per requirement
Insulation class	Class E

One minute power frequency withstand voltage between secondary terminals & earth	5 kV
Rated short time thermal withstand current	31.5 kA for 1 s
Rated dynamic current	80 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
Insulation class	Class E
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

23.7.2 General Requirements

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

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

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

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

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

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

23.7.3 Current Transformer

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

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

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

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

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

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

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

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

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

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

23.7.3.7 Current transformers shall be suitable for high speed auto reclosing.

23.7.4 Capacitor Voltage Transformer

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

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

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

23.7.4.4 All the secondary windings of the CVT shall be protected by HRC cartridge type fuses or MCBs. In addition, fuses/MCBs shall also be provided for protection and metering windings for connection to fuse monitoring scheme.

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

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

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

furnished by Contractor for EMPLOYER's review.

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

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

23.8 Warranty

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

23.9 Testing and Inspection

23.9.1 Type Tests

All switchyard 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.

23.9.2 Routine Tests

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

24 Illumination

24.1 Standards and Codes

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

Standard/Code	Description
LM 79-08	Electrical and Photometric Measurements of Solid-State Lighting Products
LM 80-15	Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

24.2 General Specification

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

24.2.2 The Contractor shall furnish Guaranteed Technical Particulars of the LED luminaires, from renowned brands available in the market for approval of EMPLOYER.

24.2.3 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. Indoor and outdoor emergency lights shall be provided at each inverter room, main control room, security room and main gate.

24.3 Lighting Levels

24.3.1 The average LUX level of 10 lumen is to be maintained in switchyard. However, a lux level of 20 lumen (comprising of minimum 2 sources of 10 lumen each) is to be maintained in switchyard on transformer.

24.3.2 The lighting system for outdoor and indoor areas of solar power plant shall be designed in such a way that uniform illumination is achieved. Average LUX level to be maintained in different areas shall be as under:

Area	**LUX**
Control Room and equipment rooms	300
Office	300
Battery & other rooms	150
Internal / Periphery Roads	4
Transformer Floating Platform / Switchyard	20
H – pole and metering point	10

24.3.3 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 minimum 0.3.

24.4 LED Luminaire for Outdoor Applications

24.4.1 LED luminaires shall meet the following parameters.

Parameter	**Specification**
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)

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

24.4.3 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.

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

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

24.4.6 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.

24.4.7 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.

24.4.8 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.

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

24.4.10 Lighting cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.

24.4.11 Suitable illumination system shall be provided along the floating fence.

24.5 LED Luminaire/Lamps for Indoor Applications

24.5.1 LED luminaire/lamps shall be of reputed make.

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

24.6 Warranty

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

25 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.

25.1 Pyranometer

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

25.1.2 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 +/- 1 W/m^2
Output	Analog output: 4 – 20 mA Serial output: RS485

25.1.3 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 Contractor shall provide instrument manual in hard and soft form.

25.2 Temperature Sensor

25.2.1 The Contractor shall provide minimum 3 (three) temperature sensors (1(one) for ambient temperature measurement with shielding case and 2 (two) 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.

25.2.2 The Contractor shall provide built-in wireless modem placed on the Floating Platform for wireless transmission of Module temperature data to the SCADA.

25.3 Anemometer

The Contractor shall provide minimum two nos. of ultrasonic wind sensor (no moving parts) for wind speed and direction monitoring (one at MCR and one at floating system).

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

25.4 Data logger and Data Acquisition System

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

25.4.1 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:

- RS 485 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

26 Water Quality Monitoring System

26.1 The Contractor shall provide 2 (two) nos. of water quality monitoring buoys with all necessary hardware and software required for real-time monitoring of the following parameters via SCADA.

(i) Temperature (0 – 50°C)

(ii) Pressure (Range – according to water depth)

(iii) pH (0 – 14)

(iv) Electrical Conductivity (0 – 2000 µS/cm)

(v) Dissolved Oxygen (0 – 20 ppm)

26.2 The water quality monitoring buoy shall have multi-parameter sonde to house the sensors. The multi-parameter sonde shall have wiper to prevent bio-fouling.

26.3 The water quality monitoring buoy shall have vertical profiler to monitor the above-mentioned parameters at various water depths from water surface till reservoir bed.

26.4 The water quality monitoring buoy shall have suitable wireless communication infrastructure for logging and transmitting water quality parameters to SCADA in real-time.

26.5 One set of water quality monitoring buoy shall be installed on open water while the other shall be installed such that water quality parameters under the floating platform can be measured.

26.6 All sensors shall possess valid calibration certificate issued from ILAC accredited laboratories.

26.7 Maintenance, calibration, up keeping, repair & replacement of instruments shall be in the scope of the Contractor during O&M.

27 Water Flow Monitoring System

27.1 The Contractor shall provide one no. of buoy for measurement of surface water current velocity and wave parameters with all necessary hardware and software for real-time monitoring via SCADA.

27.2 The water flow monitoring buoy shall be provided with suitable anti-fouling coating.

27.3 The water flow monitoring buoy shall have suitable wireless communication infrastructure for logging and transmitting water quality parameters to SCADA in real-time.

27.4 All sensors shall possess valid calibration certificate issued from ILAC accredited laboratories.

27.5 Maintenance, calibration, up keeping, repair & replacement of instruments shall be in the scope of the Contractor during O&M.

28 CCTV Camera

28.1 CCTV Cameras along with monitoring station and all other accessories required for its proper operation must be installed to have complete coverage of following areas for 24 hours.

(i) Main Control Room: Covering Entry/Exit and Equipment Rooms
(ii) Switchyard
(iii) PV Module Floating Platform & Transformer Floating Platform
(iv) Main entry: covering all entry/exits
(v) Along the Plant Perimeter: Covering complete perimeter of Plant Area to capture all possible intrusion
(vi) Security Cabin

28.2 Monitoring station of the CCTV Network shall be installed in Main Control Room.

28.3 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.

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

28.5 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.

28.6 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.

29 Fire Alarm System

29.1 Standards and Codes

Standard/Code	Description
IS 2189	Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System Code of Practice
IS 2171	Portable Fire Extinguishers, Dry Powder (Cartridge Type)
IS 8149	Functional requirements for twin CO_2 fire extinguishers (trolley mounted)
IS 2546	Galvanized mild steel fire bucket
National Building code 2016	

29.2 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.

29.3 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.

29.4 Minimum two numbers of fire extinguishers (CO_2 and Foam type each, of capacity 9 kg having BIS certification marking as per IS 2171) shall be provided at every building/ enclosure, transformer yard and switchyard. However, the Contractor must comply with existing building code for fire protection and relevant IS codes.

29.5 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.

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

29.7 The Contractor shall submit the plan for fire and smoke detection system for the EMPLOYER's approval.

30 Testing Instruments

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

30.1 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	

30.2 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	

30.3 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.	

30.4 Digital Multimeter

Parameter	**Specification**
Voltage Range	1500 V DC / 1000 V AC (True RMS)
Display	4 ½ digits, Backlit LCD or LED
Measuring Category	1000V CAT III as per IEC 61010-1
Additional Functions	Resistance, Temperature, Continuity, Diode, Capacitance, Frequency, Duty cycle measurement
Accessories	
Temperature Probe – 1 No.	
Test Leads with Alligator Clips – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories.	

30.5 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.	

30.6 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

30.7 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.	

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

30.9 Instruments of superior rating is allowed after seeking consent of the EMPLOYER.

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

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

31 Power Evacuation System

31.1 Design, Construction, Testing and Commissioning of the power evacuation system and its integration to 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 shall be as per the requirement of the STU/EMPLOYER.

31.2 The Contractor shall get the route approval from the EMPLOYER and STU prior to start of the construction. Any changes in the route or scheme at any point of the time prior to commissioning shall be complied without any additional cost to the EMPLOYER. The Contractor shall implement the ESMP for Transmission Line route as per Annexure M.

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

31.4 Only STU approved components shall be used for construction of transmission line and underground cables.

31.5 Overhead Transmission Line

In case the power evacuation is planned with overhead transmission line for plant

external evacuation, the design of tower and its accessories shall be as per STU's requirement and the design shall be submitted to EMPLOYER for approval/ accord.

31.6 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 STU's requirement and the same shall be submitted to EMPLOYER for approval/ accord.

C Civil Works

1 General

1.1 This section of Technical Specifications describes detailed technical and functional requirements of all civil and structural works included in the scope.

1.2 This excludes design, supply and installation of Galvanised 220 kV and 132 kV Transmission Line towers, Tower extensions & accessories and 11 kV, 22 kV, 22kV & 33 kV transmission poles & accessories which shall be designed following latest guidelines of respective SEB (State electricity board) and got approved before execution. In absence of SEB/ STU guidelines REC (Rural electrification corporation) standards may be followed. Poles at corner with angle > 10^0 shall be provided with 4-pole structure or lattice tower. Use of PCC spun poles is not acceptable. Approved copies of these designs & drawings shall be submitted to the EMPLOYER for reference and record.

1.3 Standards & Codes

1.3.1 All design and construction of civil works shall conform to relevant Indian standards such as BIS, IRC, MORTH, NBC etc. Specific guidelines have been provided for the design of floats, anchoring and mooring system under Cl 28 & 29.

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

1.3.3 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 Floating Solar PV plants.

1.3.4 The design calculations for Floats, Anchoring & Mooring, RCC structures, Steel structures, Foundation systems including piling, Road works, Drainage works, etc. shall be submitted for prior approval of Engineer before commencement of construction.

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

1.4 The design calculations shall be supplemented with neat sketches 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.

1.5 The methodology for assembly of floats, installation of anchoring & mooring arrangements and construction of road & drainage works shall also be submitted for prior approval of Engineer before start of these works.

2 Survey Works

2.1 The contractor shall carry out detailed Topographical (on-shore) and Hydrographic survey of the proposed water body for floating solar project site. The work shall be carried out through an agency with relevant experience and qualified survey team. The Contractor shall submit the credentials of the proposed agency along with relevant certificates in support thereof and the names of the key personnel with details of their qualification, designation and relevant work experience for verification/ approval of the Agency by the EMPLOYER.

2.2 All survey equipment shall be tested for their accuracy before use. Only calibrated instruments with valid certification shall be used for conducting the survey.

3 Topographical Survey

3.1 The Contractor shall be responsible for detailed Topographical Survey of the proposed project site (on-shore).

3.2 The Topographical survey shall be conducted at 20m x 20m grid, or as directed by the Engineer, with the help of digital surveying instruments like Total Station.

3.3 The Contractor shall carry the Bench Mark from nearest Greatest Trigonometric Survey (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 2 Permanent Bench Marks (PBM) at site with an accuracy of 0.005m. 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 PBMs and RPs shall be shown on the survey drawings.

3.4 The survey work shall be carried out based on WGS 84 reference ellipsoid and UTM grid system. The contractor shall also establish the latitudes and longitudes 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.

3.5 Positions 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, water bodies etc. shall also be noted and plotted on contour maps.

3.6 The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Engineer's review before submission of final contour map. The contour interval shall be as required for proper representation of the topography however it shall not be more than 0.5m. The Contractor shall submit survey maps of the site in 1:10,000 scale indicating grid lines and contour lines, demarcating all permanent features like roads,

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

4 Hydrographic Survey

4.1 The Contractor shall be responsible for detailed hydrographic survey of the proposed project site. The Contractor shall mobilize all required number of survey equipment and survey vessel with all necessary equipment including equipment for collecting water samples etc.

4.2 The contractor shall visit the site to collect all required information like depth of water in the reservoir, access to survey vessel etc. to decide the requirement of manpower and equipment to be mobilised for hydrographic survey work

4.3 The Contractor shall be responsible for establishing horizontal control (accuracy ± 1m) and vertical control (accuracy ± 0.1m) & establishing peg marks at survey grid interval along the shore.

4.4 The detailed hydrographic survey shall be conducted using Automated Hydrographic Survey System (AHSS), using multi-beam echo sounder for depth measurement, GPS/DGPS for position fixing and Hypack (or) equivalent hydrographic survey software for data logging. For the hydrographic survey work using multi-beam echosounder, suitable line spacing shall be followed with at least 25% overlap.

4.5 Analysis of data obtained, contour plots, cross sections, L Section, vertical sediment distribution, curve table and estimation of sedimentation in different zones of study area etc. shall be in line with the objectives laid down for the study.

4.6 The soundings shall be reduced to Chart Datum (CD) / Sounding Datum (SD) to assess the bed profile. All co-ordinates to be shown in the report shall be based on WGS, 1984 reference ellipsoid and UTM, relevant zone with WGS 84 co-ordinates and MSL.

4.7 The Contractor shall be responsible for collecting and testing water sample at surface (at min. 9 strategic locations to be decided during the survey as per project needs) at 0.5 d & at 0.2 d from reservoir bed (d = Depth of Water).

4.8 The Contractor shall install water level gauges at critical locations (to be established during the survey) for recording daily & seasonal water level variations, low water level (LWL), high water level (HWL). The Contractor shall also collect data for daily water

levels for preceding 10-15 years, LWL, HWL, High and Low tide etc. from Central water commission (CWC), state and local authorities. The contractor shall evaluate mean yearly values of MWL & LWL for 25 years return period using proven statistical data analysis software.

4.9 The Contractor shall measure water flow/ current velocity at designated depths from the water surface for 30 days at the time of survey work. The Contractor shall also collect data for max daily flow/ max current velocity over preceding 10-15 years(as applicable) from reservoir authorities.

4.10 Water Current velocity and wave height shall be measured at upstream and downstream of proposed site for at least 30 days using suitable Acoustic Doppler Current Profiler (ADCP) /Current Meter. The velocity measurements should be undertaken at surface, at half of the water depth, and at 0.5 mtr above the reservoir bed. In the estimation, impact of reservoir gate operation, flash flood discharge etc. should also be considered. The Contractor shall also collect data for daily flow/ current velocity over preceding 10-15 years from CWC, State and local authorities.

4.11 Suitable care shall be taken during the survey work to safeguard any biodiversity at the project location.

4.12 Submission of Hydrographic survey Report

4.12.1 The survey charts shall be prepared on scale of 1:10000 (for width more than 500m) and 1:5000 (for width less than 500m) with contours at interval not more than 0.5m shall be indicated on the charts. The charts/ drawings shall also include cross sectional and longitudinal profiles of the bed surface surveyed showing LWL (Chart Datum) and HWL with respect to MSL

4.12.2 Records (values) of measurement of Current Velocity, Wave height and their positions shall be plotted on the chart and details shall be mentioned in the report. The report shall also include reports of water sample tests and the positions of sampling points shall be shown on the charts.

4.12.3 Information regarding any prominent under water obstructions, large coral formations etc. which may affect the design of maroon/ anchor supports shall be recorded and included in the report.

4.12.4 The existing conditions of the banks, whether protected or unprotected are to be collected and indicated in the report including recommendations (as required to ensure stable slopes) for proposed protection works etc. shall be included in the report.

4.12.5 The survey data shall also be submitted in digital format for record and future

reference

5 Geotechnical & Geophysical Investigations

5.1 The Contractor shall be responsible for detailed Geotechnical investigation at the proposed project site (on-shore & off-shore) and Geo-physical investigation (off-shore) for the purpose of foundation design for various structures, anchor design for floating platforms/PV array 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.

5.2 The scope of work for geotechnical investigation includes execution of complete soil exploration including boring and drilling, standard penetration test (SPT), collecting disturbed (DS) and undisturbed samples (UDS), collecting ground water samples, electrical resistivity tests (ERT), conducting laboratory tests on collected samples of soil/ rock & 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. SPT and UDS collection shall be alternately done at every 1.5 m interval or at change of strata. The starting depth of SPT/UDS Collection shall be 0.5 m from ground level. For soil strata where UDS collection is not possible, the same shall be replaced with SPT.

5.3 The field investigations shall mainly include drilling of min. 7m deep borehole (for on-shore) & 10m deep borehole (for off-shore), conducting SPT and collecting Disturbed (DS) and Undisturbed samples (UDS) and Electrical Resistivity Test. Number and location of bore holes and Trial pits shall be decided as per the project layout, site topography and soil conditions in consultation with the EMPLOYER. For the on-shore investigation, there shall be minimum 3 nos. of Boreholes, 1 no. of Trial pit, 2 nos. of ERT and 1 no. of Ground water sample for laboratory investigations. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient nos. For the off-shore investigation, there shall be min. 1 no. of BH for every 10 acres of selected site.

5.4 For the off-shore Geotechnical investigation work including boring and testing, the contractor shall use jacked up barge with stable platform or vessel/boat with necessary equipment arrangement and adequate stability.

5.5 The proposed Geotechnical investigation plan indicating proposed locations of Trial

pits, Boreholes & ERT shall be submitted to the EMPLOYER for review and approval before start of work.

5.6 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 (UU), Undrained shear test, Consolidation tests, Unconfined compression tests, Free swell index, chemical analysis of soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, Organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc.

5.7 The scope of work for Geophysical investigation shall include carrying out shallow seismic survey using sub-bottom profiler to chart the stratigraphy of the reservoir bed scanning the bed surface of the entire area of the selected site. The results of Geophysical Survey in association with findings of Geotechnical Investigations and Side Scan Sonar Survey shall be used for designing of anchoring and mooring system of the FSPV plant.

5.8 After completion of field and laboratory work, the contractor shall submit a Geotechnical & Geophysical Investigation Report for EMPLOYER'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, min. depth and safe bearing capacity (SBC) for various Plant buildings (MCR etc.) and Open installations, Switchyard structures & Sub-Station, Transformer foundation, HT lines etc. corresponding to settlement of 25mm & 40mm. Calculations and recommendations for anchor, pile or any other foundation type suitable for floating platforms/SPV array shall also be included in the report.

5.9 The report shall include the findings of Geophysical Investigation. The contractor shall review and analyze the requirement for removal of debris/sunken objects, if any, which may damage the FSPV plant during the life of the project. The same shall be provided as part of the report. The removal of debris/sunken objects, etc, if necessary based on the findings of the investigation, shall be in the scope of the Contractor.

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

5.11 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 per Cl 13.

5.12 All buildings/ Open installations, Switchyard and Sub-station area shall have levelled ground. No foundation for Buildings, Switch yard equipment & structures, Sub-stations, HT Line Towers, Transformer etc. shall rest on filled up ground. However, minor structures like cable trench, cable rack, pipe pedestal etc. may rest in filled up soil with max. safe bearing capacity for design consideration not more than 3 T/m^2.

6 Other Investigations

6.1 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 (max. 24hour rainfall for 25 years return period), Maximum & Minimum ambient temperature, Humidity, HFL etc.

6.2 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 different grades of concrete to be used before start of work. The concrete mix shall be designed for each source of cement and aggregates as per provisions of relevant BIS Standard. 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, he shall submit the Concrete mix design report from the RMC supplier for review and approval by the Engineer. (In case of RMC, reports for periodic cube tests from the supply batch shall also be submitted for review and record).

7 Roads & Access Pathways:

7.1 Suitable approach road (as applicable) from nearest public road up to Main gate(s) and Landing Area adjacent to the reservoir, Access road from Main gate to Control Room Buildings(office building and Equipment Building), Internal roads connecting Control Room Buildings and other facilities, Sub-station & Switch yard (as applicable) etc., Peripheral road all around Sub-station Area shall be provided for safe and easy

transportation of men, material and equipment during construction and subsequent operation & maintenance (O&M).

7.2 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 roads and internal roads shall have 3.5 m wide carriage way with 0.5m wide shoulders on either side. The top elevation of road (TOR) shall be minimum 200 mm above FGL to avoid flooding during rains. The roads shall be provided with alongside drains as per design requirements of drainage system to avoid flow of storm water over the road.

7.3 The roads shall be designed as per IRC SP-72 corresponding to traffic category T3 and critical field CBR(soaked) value of the subgrade. However, following minimum road section details shall be followed:

(i) Topping: 2 course surface bituminous dressing conforming to Cl. 505 of MORD specs or 20 mm thick open graded pre-mix carpet + Type – B or Type –C seal coat conforming to Cl. 506 of MORD specs. shall be provided.

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

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

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

(v) Compacted subgrade: 300mm thick below sub-base (non-expansive soil with max. dry density > 1.65 kN/m3) conforming to Cl 303 of MORD specs, compacted up to 98% of standard proctor density in layers of 150mm thickness. In case of expansive soils like black cotton soil suitable treatment as per Cl. 403 of MORD specs shall be provided before laying sub-base course.

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

7.4 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.

7.5 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.

7.6 The construction of road shall conform to MORD specifications for rural roads published by IRC.

7.7 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. Water supply pipe for drinking water or any other usage shall be taken through Medium class GI steel pipe conforming to IS: 1161.

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

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

8 Area Grading and Land Development

8.1 The Finished Grade Level for every patch of land 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 minimum plinth level of all buildings/ open installations shall be 500 mm above FGL.

8.2 A detailed drawing for site levelling and grading (if necessary) shall be submitted by the Contractor before commencement of grading and area development works. The estimated volume of cutting and filling shall also be marked on the grading drawings for reference. The final grade levels to be adopted for different land patches shall be clearly marked on the on-shore Plant Layout

8.3 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 EMPLOYER), 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.

8.4 It shall be ensured that the land is graded or levelled properly for free flow of surface run-off. All existing drains passing through the patch of project land shall be re-routed along the periphery outside boundary fence for smooth flow of diverted surface run-off to natural drainage channel. It is advisable to follow the natural flow of water at the ground as far as possible for drainage design.

8.5 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 EMPLOYER), 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 EMPLOYER.

9 Peripheral boundary Fence / Wall & Main gate

9.1 Boundary Wall

9.2 The Substation/MCR plot shall be provided with precast boundary wall to demarcate the plant boundary and to keep away unauthorized access to the plant.

9.3 The boundary wall shall be with 2.5m height above grade level including 400mm dia GI concertina wire along with 3 nos. of barbed wires on either arm to be fixed on Y shape angle brackets.

9.4 The boundary wall shall comprise of pre-stressed precast RCC wall panels (min. 75mm thick) and columns (min. 200 mm x 200 mm) of M30 grade.

9.5 The founding depth (below NGL) for the precast column shall be min. 800 mm and the column shall be embedded in PCC (1:2:4) block of 600 mm x 600 mm.

9.6 Columns shall be provided at a center to center spacing of 2.5 m (max.).

9.7 Main Gate

Main Gate shall be provided as per the indicative drawing titled 'Entrance Gate Drawing' provided in Annexure-K: Tender Drawings.

9.8 Floating fence

9.8.1 Floating fence with floating buoys (with durable UV resistant material suitable to withstand the aqueous environment, be eco-friendly to bio diversity, and withstand pressure of debris/trees/flotsam through river during monsoon period) shall be formed around every floating platform.

9.8.2 Concept design and drawings shall be submitted for approval prior to execution.

10 Plant Layout:

10.1 The contractor shall submit drawing showing proposed layout of On-shore and off-shore plant facilities and floating SPV modules. The layout drawing shall show 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, Layout of main approach road to main gate, Internal roads, Security cabin (s), MCR and Open installations with coordinates, Lightening arrester, UG/Over ground water Tank(s), Storm water drains, Corridor for buried cables etc. All the facilities and buildings shall be presented with suitable Legend. The drawing shall be in suitable scale to have proper representation of the information.

10.2 The On-shore and off-shore plant facilities shall be submitted by the contractor for review/ approval by the EMPLOYER.

11 Design Loads

11.1 For design loads of Floating System, the following guidance/recommended practices shall be referred to by the Contractor.

- ISO 2394: General principles on reliability for structures
- DNV GL RP 0584: Recommended practice for design, development and operation of floating solar photovoltaic systems
- IS 875: Code of practice for design loads (other than earthquake) for buildings and structures
- IS 1893: Criteria for Earthquake resistant design of structures
- ASCE 7: Minimum design loads and associated criteria for buildings and other structures
- DNV GL-RP-C204: Recommended practice for design against accidental loads

- DNV GL-RP-C205: Recommended Practice for Environmental conditions and Environmental loads

11.2 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.

11.3 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	Minimum Imposed (Live) Load
1	Roof	1.50 kN/ Sqm
2	Building floors (GF) & Grade Slab	10.00 kN/ Sqm
3	RCC Floors (General)	5.00 kN/ Sqm
4	Outdoor platforms, Stairs, Landing and Balconies, Walkway, 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 – 'A' loading (Wheeled & Tracked both) 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 10kN /Sqm 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 outs side
7	Pre-cast and chequred plate cover over cable trench	4.00 kN/ Sqm

11.4 Primary Loads

(i) Dead Load (DL)

(ii) Live Load (LL)

(iii) Snow Load (SnL), if applicable

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

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

(vi) Loads due to design wave height and design current velocity (applicable for

floating system design)

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

11.6 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 1.0, 1.05 and 1.0 respectively)

11.7 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.

11.8 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. (The factor 'k_d' shall be taken as 1.0 in case of plant site within 60km of sea coast).

11.9 The Seismic Load shall be considered corresponding to Earth quake zone at site as per IS: 1893 (Part- 4) with Importance factor 1.5.

11.10 Design Load combinations

11.10.1 Appropriate Load factors in LSM design for concrete structures and WSM design (WSD) for steel structures shall be considered as per relevant BIS standard.

11.10.2 Following load combinations(with applicable load factors) shall be considered in design:

(i) DL + LL
(ii) DL + LL ± WLx
(iii) DL + LL ± WLz
(iv) DL + LL ± ELx
(v) DL + LL ± ELz

11.10.3 In addition to the combinations specified above, load combinations inculcating the loads due to design wave height and design current velocity shall also be considered for design of floating system including anchoring and mooring arrangement.

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

12 Foundations (General)

12.1 Contractor shall design all foundations for buildings, equipment, HT line Towers, Switch yard structures, Transformer and all other structures as per relevant BIS standards and recommendations of Geotechnical investigation report. The depth of foundation (below

NGL) shall not be less than 1m except in case of chain link fencing post (for boundary & transformer yard fencing) where it shall not be less than 800mm (below NGL).

12.2 Min. thickness of PCC below brick wall shall be 150mm.

12.3 All foundations of one 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.

12.4 All design & drawings shall be submitted to the Engineer for approval before execution.

13 Concrete Works

13.1 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.

13.2 For onshore installations, 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).

13.3 For all offshore installations, min. grade of concrete shall be M30 for all concrete works.

13.4 Cement higher than 43 Grade shall not be used in construction.

13.5 Unless otherwise specified elsewhere, PCC shall be of min. grade M10 (nominal mix 1:3:6) except for mud mat, back filling of ground pockets or leveling course which shall be of grade M7.5 (nominal mix 1:4:8).

13.6 Reinforcement steel shall be of high strength TMT bars of grade Fe500 D conforming to IS: 1786 with anti-corrosive coating to withstand aqueous environment. Ductile detailing in accordance with IS: 13920 shall be adopted for all RCC buildings.

13.7 Unless specified otherwise for grouting works anti shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound shall be used. The grout shall be high strength grout having min. characteristic strength of 35 N/mm^2 at 28 days.

14 Miscellaneous Steel Works

14.1 Unless otherwise specified elsewhere, all structural steel work shall be designed as per provisions of IS: 800 with working stress method of design (WSD).

14.2 Structural steel hot rolled sections, flats and plates shall conform IS: 2062, structural Pipes shall be medium (M)/ high (H) grade conforming to IS: 1161, chequered plate shall conform to IS: 3502 and Hollow steel sections for structural purposes shall

conform to IS 4923.

14.3 Structural steel shall be Hot dip galvanized with minimum GSM 610 kg/ sqm and/or minimum coating thickness of 80 microns for protection against corrosion. Galvanization shall conform to IS-2629, 4759 & 4736 as applicable.

14.4 Foundation/Anchor bolts shall be Hot dip galvanized conforming to IS 800 & IS 5624.

15 Plinth protection and drain

15.1 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.

15.2 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. The drain shall be provided with 12mm thick plaster in CM 1:5 on inside face and 25mm thick PCC (1:3:6) coping at top

16 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 bounder 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)

17 Fire Extinguishers

17.1 All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. Liquefied CO_2/ foam/ ABC type fire extinguisher shall be upright type of capacity 10kg conforming to IS: 2171, IS: 10658.

17.2 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.

18 Sand buckets

18.1 Sand buckets shall be wall mounted made from at least 24 SWG sheet with bracket fixing on wall conforming to IS 2546.

18.2 All buildings shall be provided with required number of sand buckets as per relevant BIS standard and NBC. 4 (four) number of bucket stands with four buckets on each stand shall be provided in the transformer yard.

19 Sign Boards and Danger Boards

19.1 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.

19.2 The Signboard shall be made of steel plate of not less than 3 mm. Letters on the board shall be with appropriate illumination arrangements.

19.3 Safety signs, building evacuation plan and direction signs, assembly points shall also be placed at strategic locations.

19.4 The Contractor shall provide to the Engineer, detailed specifications of the sign boards.

20 Masonry Work

20.1 The masonry work shall be of bricks, laterite blocks (as per site conditions) or concrete blocks.

20.2 All external walls of buildings shall be 230mm and internal walls shall be 230mm or 115mm as per requirements.

20.3 All concrete block masonry walls shall be min. 200mm thick.

20.4 Brick work shall be in cement mortar (CM) 1:6 & 1:4 for 230 mm and 115 mm thick brick wall respectively unless specified.

20.5 Unless otherwise specified elsewhere, Bricks shall be of class designation 5 conforming to IS: 1077, IS: 2212 & IS: 3495.

20.6 All concrete blocks shall be of min. compressive strength of 7.5 N/mm2 and shall be of Grade-A conforming to IS: 2185.

20.7 The laterite blocks shall conform to IS: 3620.

20.8 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.

20.9 The construction of brick masonry shall conform to IS: 2212. Construction of Concrete block masonry shall conform to IS: 2572.

21 Plastering, Pointing & Coping Works

21.1 All brick masonry work shall be provided with plaster.

21.2 Wall and ceiling plaster shall be in cement mortar (CM) 1:6 and 1:3 respectively.

21.3 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.

21.4 All joints in stone masonry shall be raked and pointed in cement mortar (CM) 1:3 except specified otherwise.

21.5 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.

21.6 All door and window chajja shall be provided with 10mm wide drip course.

22 Building Water Supply & Plumbing Works

22.1 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.

22.2 Rain water pipe shall be of PVC conforming to relevant BIS standard.

22.3 All sewerage, waste water and ventilation pipes shall be of HDPE conforming to relevant BIS standard.

22.4 MCR building and Security room shall be connected to Sewage treatment facility including all associated works like Manholes etc.

23 Sewage Treatment facility

23.1 The Contractor shall design & provide soak pit and RCC Septic tank for treatment of sewage and waste water from MCR. The septic shall be designed as liquid retaining structure conforming to IS:3370 for design loads as specified under Clause No.11. However, in case of ground water within 1.5 m 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.

23.2 The design and drawings shall be submitted for approval prior to execution.

24 Pipe & Cable Trenches

24.1 All trenches inside the building shall be of RCC. The min. wall and base slab thickness shall be 100mm for depth ≤ 850mm and 150mm for depths > 850mm.

24.2 The trench shall be designed for lateral load due to external soil fill, ground water table

at FGL and 10.0 KN/ Sqm surcharge. External trenches shall be kept min. 100mm 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.

24.3 Internal trenches (inside buildings) shall be provided with chequred plate (min. 8mm thick with angle stiffeners as required) covers while external trench shall have precast concrete covers.

24.4 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 lugs.

24.5 The trench cover (chequered or pre – cast both) shall be provided with suitable lifting hooks.

24.6 As required suitable MS insert plates shall be provided on trench wall to support the cable rack/ pipe.

24.7 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.

24.8 The external buried cables shall be laid in excavated trench as specified under specifications for Electrical works. The sand for filling shall be of Grade – IV conforming to IS: 383.

25 Transformer Yard Civil Works

25.1 On-shore 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.

25.2 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.

25.3 In case of transformer oil tank capacity more ≥ 5000 litres, the soak pit shall be connected to a separate burnt oil pit through discharge pipe (300 mm dia) and shall be suitably sized to accommodate full oil volume (excluding free board above inlet pipe) of the transformer connected to it, without backflow. In this case the capacity of the

soak pit may be reduced to min. 1/3rd of the total transformer oil volume. The burnt oil pit shall be further connected to oily water drainage system. The water shall be discharged into the nearest drain by gravity flow or pumping after suitable treatment as per statutory and code provisions.

25.4 Both, the transformer soak including side walls and the burnt oil pit shall be of RCC and shall be provided with sump (min. 500 mm x 500 mm x 400mm deep) and slope of 1:50 in concrete screed of 1:1 – ½:3 to the floor slab towards the sump pit. The oil collection pit shall be provided with 20mm dia. MS rung ladder with 2 coats of epoxy paint over 2 coats of primer, a manhole & removable RCC cover. The inside of oil collection pit shall be plastered with 6 mm thick CM 1:6 and painted with 2 coats of epoxy paint over 2 coats of primer.

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

25.6 The transformer yard and switchyard area shall be provided with galvanized chain link fence of height min 1.8m with 3.5m wide gate as detailed below:

25.6.1 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) with 100mm thick M15 PCC foundation (min. width 450mm and min. depth 450 mm below GL).

25.6.2 Intermediate, corner and stay posts shall be supported with min. 300 mm dia. and 850 mm deep (below GL) piles in cement concrete (nominal mix 1:1:2). The column posts shall be extended in to the pile up to 800mm with 50mm cover at the bottom. The pile shall project 150mm above GL. The intermediate, corner and stay posts shall be supported by angle struts that shall have the same foundation as that of the main posts.

25.6.3 Spacing of intermediate posts shall not be more than 2.5m. Every 10^{th} intermediate post shall be provided with a stay post while every corner post shall be provided with two stay posts on either side.

25.6.4 Joints in RR masonry shall be properly raked and pointed with CM (1:3).

25.6.5 The GI chain link mesh fabric (40x40 mm with min. wire gauge 3.15mm, both ends twisted) and fencing shall conform to IS: 2721.

25.6.6 Each fence panel, in lieu of tie wire, shall be provided with 35x35x3mm GI edge angle at top and bottom with mesh fabric firmly secured to them and to intermediate support angles.

25.6.7 All MS sections shall be painted with 2 coats of epoxy paint of approved make and

shade over 2 coats of suitable primer.

25.6.8 The Gate of size 3.5m shall be of MS pipe (medium class conforming to IS: 1161) frame with hard drawn steel wire fabric mesh (50x50mmx3mm thick conforming to IS: 1566) including all accessories and fittings. MS angle posts shall conform to IS 2062.

25.6.9 In addition to main gate, a wicket gate of MS pipe (medium class conforming to IS: 1161) frame with 1.0 m width with hard drawn steel wire fabric (50x50x3mm thick conforming to IS: 1566) shall be provided for man entry for maintenance purpose.

25.6.10 The transformer yard and switchyard fencing work shall conform to CEIG requirements.

25.6.11 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.

26 Water Supply and Cleaning of Modules

26.1 The Contractor shall design and install the effective module cleaning system. The module cleaning arrangement may be manual or based on robotic system.

26.2 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.

26.3 The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at regular frequency in order to operate the plant at its guaranteed plant performance. However, minimum consumption of 2 litre / sq.m of surface area of SPV module shall be considered in estimation of required quantity of water storage.

26.4 As the ground water at site may not be suitable for construction and module cleaning purposes. Suitable water for construction and module cleaning purposes (during plant operation) by providing RO plant of requisite capacity including storage facilities shall be arranged by the bidder.

26.5 Water used for drinking & PV module cleaning purpose shall 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.

26.6 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.

26.7 The Contractor shall propose a suitable module cleaning system which shall include installation of ground mounted/offshore polyethylene 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.

26.8 The Polyethylene 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.

26.9 The water supply mains shall be of HDPE material with suitable UV resistant additives.. Module cleaning frequency, procedure and pressure requirement at discharge point (for manual cleaning) shall be as per the recommendation of PV module manufacturer.

26.10 The Contractor may also propose Wet type - Robotic Cleaning system with micro-fibre based brushes to avoid scratches on the PV Module.

26.11 The necessary design considerations in lieu of mounting the robotic system shall be incorporated in the design of module mounting arrangement, floating system, anchoring and mooring system as well as PV array layout.

26.12 The system shall be designed for operation under the climatic conditions at site.

26.13 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.

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

27 Miscellaneous Structures

27.1 Support Structure for Weather Monitoring Station

27.1.1 Weather monitoring station shall be located on-shore and shall be mounted on tubular steel pole of required height. The pole shall conform to IS: 2713.

27.1.2 The pole shall be secured to an independent RCC foundation structure through Base plate and Anchor bolt assembly.

27.1.3 200 long 20 dia. rods shall be welded to the pole at 300 mm C/c for access to the device for maintenance purpose.

27.1.4 The support structure shall be hot dip galvanized.

28 Floating System

28.1 Floating system comprises of the Floating unit, Module support structure (if applicable) and anchoring & mooring system.

28.1.1 Vendor Qualification Criteria

The Floating Unit (Floats) Supplier should have supplied minimum 20 MW capacity globally or 5 MW in India in the past 5 years as on last date of bid submission.

28.2 Standards and Codes

28.2.1 Float materials shall comply with the latest edition of the following standards and codes including amendments.

Code	Description	Property Value
ASTM D 792 / ASTM D 1505	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement/ Standard Test Method for Density of Plastics by the Density-Gradient Technique	Re. Density > 0.9
ASTM D1693	Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics	Environmental Stress-Cracking Resistance: Zero Cracking for 48 Hours
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials	Secant Flexural Modulus at 2% Strain > 750 MPa
ASTM D 638	Standard Test Method for Tensile Properties of Plastics	Tensile Strength at Yield > 22 MPa
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics	Compressive Stress at Yield > 6 MPa
ASTM D 2565	Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications	More than 50% of its original break elongation after 3,000 hours exposure (Cycle 4 of

		ASTM D 2565)
UL 94 or Equivalent IEC/ISO standard	Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing	Classification HB or better

28.2.2 For design of anchoring and mooring system, the following standards may referred (for guidance) – API RP 2SK, API Spec 2F, API RP 2I, API RP 2MIM, BS 6349-6, DNV-RP-0584 & DNV-RP-C205. API RP 2A may be referred for floater strength verification, spreader bar design & pad eye design.

28.2.3 The complete system (floating, anchoring & mooring system) shall be designed to withstand design wind speed of the location as per IS 875 – Part 3, worst-case waves, and water currents prevailing at the proposed reservoir.

28.3 The Floating system shall be able to support the weight of PV module, Module support structure (if applicable), load of O&M Personnel (at least 2 personnel 80 kg each), cables & support railing and equipment like String inverter, String Combiner Box, Lightning Arrester etc.

28.4 The floating system shall consist of multiple modular floating units/platforms and connected to the ground using anchoring and mooring system. However, the float unit shall have average material thickness of 3 mm (minimum material thickness of 2.5 mm), with moisture retention of less than 5%. Floating system/platform shall be fenced with vacant floats to demarcate boundary.

28.5 The Contractor shall consider following factors while designing the floating systems:

i. Buoyancy of the floats shall maintain the minimum clearance and stability of the floating system in the reservoir under loading conditions stipulated in Cl 28.3.

ii. Weight of algae/vegetation growth: Sufficient factor of safety shall be considered to account for algae/vegetation growth on the structures, including floating unit.

28.6 Floats shall be designed to prevent/mitigate stagnation of water. Any opening in the float body shall be provided with water ingress resistant capping(like neoprene, etc.)

28.7 The floating unit shall be manufactured from thermoplastic material with UV stabilizer and corrosion-resistant additives so that the floating unit shall sustain for 25 years in

the aqueous environment.

28.8 All the materials used in the floating system shall comply with national and international environment laws and regulations.

28.9 The materials used for manufacturing the floating unit shall be tested at CIPET/NABL accredited testing laboratory for ensuring the suitability of the material for use in aqueous applications.

28.10 All the modules shall be accessible for maintenance once multiple floating units are connected together.

28.11 All fasteners used in the floating system shall be made of SS 316.

28.12 Aluminium alloy, if used in the floating system, should be of 5052 grade or higher, suitable for aqueous applications. Coating class for Aluminium alloy shall be AC25 conforming to IS 1868.

28.13 The floating units shall be re-processable and recyclable at the end of its useful life.

28.14 The design of complete system comprising of Floating unit and anchoring & mooring system, shall be vetted by IITs / NIOT, Chennai/ Indian Register of Shipping (IRClass) and submit it for EMPLOYER's approval during detailed engineering.

28.15 Tethering hawser for mooring/anchoring system shall be stranded steel (with protective Zinc coating)/polyester/ rubber type to withstand abrasion, UV radiation and chemical weathering for the plant design life. The hawser ends shall incorporate provision for shock-absorption (via elongation) under impulse loading conditions.

28.16 The mooring system shall be designed to keep the floating platform in position during fluctuation in water level between FRL and MDDL.

28.17 The contractor may propose any of the following arrangement for anchoring of floating platform:

i. Dead Weight Anchor
ii. Anchor Pile
iii. Helicoidal/Plate Anchor

In case the contractor proposes to use Anchor pile or Helicoidal/Plate Anchor, initial load tests shall be performed to ascertain the adequacy of the system as per applicable BIS/International Standards.

28.18 Design of anchoring and mooring system shall consider mooring lines and anchoring system well distributed all around the floating platform. The arrangement shall necessarily have provisions of mooring and anchoring system at the corner of the float system to prevent overturning.

28.19 The Contractor shall prepare the Manufacturing Quality Plan for production of all components of floating system and submit it for EMPLOYER's approval during detailed engineering.

28.20 The Contractor shall propose an Erection and Construction methodology with a minimum of following details:

i. Float Assembly Plan
ii. Equipment required for Assembly
iii. Mooring and Anchoring methodology
iv. Safety Plan for Installation

28.21 **Warranty:** The Floating System including floats, mooring and anchoring mechanism shall be warranted for 10 years.

28.22 Floating System for Transformer & Other equipment

28.22.1 The floating platform shall be made of HDPE/FRP or precast or cast in-situ fixed platform and shall be of adequate size for installation of equipment, associated facilities, movement and working of O&M personnel, etc.

28.22.2 The material shall be chosen for the working life of 25 years and have a high Resistance to Impact, De-gradation, Chemicals, UV rays, corrosion etc.

28.22.3 The floating platform shall have a minimum free board of 0.5 m under most critical combination of loading.

28.22.4 Equipment installed on the floating platform shall be provided with requisite clearance for installation of cables.

28.22.5 The Handrails of Stainless steel (SS316) of minimum 1 m height should be provided all around the floating platform. Step ladder for access from boat or land with handrail to the platform shall also be provided.

28.22.6 The design of complete system comprising of Floating unit and anchoring & mooring system, shall be vetted by IITs or NIOT, Chennai, Indian Register of Shipping (IRClass) and submit it for EMPLOYER's approval during detailed engineering.

28.22.7 Other requirements for this floating system shall be as applicable in case of floating system for modules.

29 Buildings

29.1 General Requirement

The minimum plinth height (FFL) for all buildings and open installations shall be 500 mm above FGL.

29.2 MCR Building

29.2.1 Main Control Room shall be provided as per the indicative drawing titled 'MCR Building: Plan, Elevation, Sections and Finishing Details' provided in Annexure-F: MCR Drawing & Detailed Specifications.

29.2.2 Structural design of MCR building shall conform to IS 456. Ductile detailing as per IS 13920 shall be followed.

29.2.3 MCR shall be provided with adequate number of split type air conditioning units and fans.

29.3 Security Room/Cabin

29.3.1 Contractor shall provide required number of pre-fabricated security cabins at strategic locations & at corners of the plot and 1 nos. of security room at Main entry gate.

29.3.2 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.

29.3.3 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- 0.5mm, 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.

29.3.4 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.

29.3.5 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.

29.3.6 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.

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

29.3.8 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.

29.3.9 The Security Room shall be supported on RCC framed structure with foundations, columns and plinth beams with 450 high plinth above FGL.

D 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-B.

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.

CHAPTER – 3

SPECIAL TECHNICAL CONDITIONS

Note: All works shall be executed as per Technical Specifications given in Chapter – 2 of Appendix – A to Section – VII. Chapter – 3 of Appendix – A to Section – VII lays down Special Technical Conditions with reference to site specific design requirements. However, in case of any conflict in requirements between Chapter – 2 and Chapter – 3, Chapter – 3: Special Technical Conditions shall have precedence.

1. **Design Considerations:**

S. No.	Description	Value
1	Basic Wind Speed 'Vb' (m/s) (As per IS: 875 – Part III)	39 m/s
2	Seismic Zone (as per IS: 1893)	II
3	Average annual rainfall (mm)	1424 mm
4	Hourly rainfall intensity for storm water drainage (mm/hr)	65 mm/hr
5	Probability of Exceedance (Energy Yield Simulation)	P75 (with minimum 5% Variability)

2. Relevant drawings/site details have been appended with this document.
3. **Specific Requirements:**

S. No.	Clause referred	Requirement
1	Cl 9.2 (Scope of Works)	Angle of tilt for the PV array shall not exceed 5°.
2	General	Maximum block size for the FSPV plant shall not be higher than 4 MW (AC). Blocks shall be symmetrical in shape.
3	Cl 6.9 (Scope of Works)	Security Room/Cabin: (i) One no. of Security room - At the main gate of plot where the substation shall be located. (ii) One no. of Security cabin - Near the platform for access to the floating system.

4	Cl 6.15 (Scope of Works)	Construction of floating fence around off-shore portion of the plant.
5	Cl 3 (Section: B of Technical Specifications)	There shall be no requirement of String Combiner Box as only string inverters shall be employed as per the scope.
	Cl 4 (Section: B of Technical Specifications)	String inverter shall be installed on the floating platforms along the walkway and cable trays. The inverters shall not be placed on the edge of the platforms.
6	Cl 24 (Section: B of Technical Specifications)	The Weather Monitoring Station, except the Module Temperature sensors and one ultrasonic wind sensor, shall be mounted on-shore as per specifications provided in Chapter – 2 of Appendix – A to Section VII.
8	Cl 7 & 8 (Section: C of Technical Specifications)	Requirement of area grading & land development, roads & access pathways shall be applicable for on-shore facilities.
13	Cl 4 (Section: C of Technical Specifications)	Bathymetric Survey and Geotechnical Investigation for the reservoir area have been conducted by the employer and corresponding drawings/reports have been attached as Annexure to these Specifications. The Bidder shall be responsible for any inference drawn from the attached details and is advised to inspect the site and study the nature of soil before submission of the Bid. The Employer shall not be responsible for any variations in reservoir profile and soil characteristics, if observed during contract execution and there shall be no compensation what so ever in the contract price on this account.
15	New Clause	The following is the excerpt from the Site Survey Report pertinent to measurement of water current velocity. "For measurement of the velocity of water, cup type current meter as well as 'float' were utilized during the period of conducting hydrographic survey from 15th November 2019 to 7th January 2020. Extreme efforts were spent to measure the

		velocity with the current meter by placing it at various locations across the width of reservoir at 0.2d and at 0.6d (where 'd' is depth of water at that place), even at a distance of 250m upstream of the reservoir. The float was used near the middle of the reservoir along with northern and southern sides to measure the velocity. Even with all above endeavours, the velocity of water observed was not so significant enough to be measured. This happened primarily on account of the fact that it was not a monsoon season and the barrage gates were almost closed. Although there was some outflow of water through the intake to power channel, its effect to the overall water velocity was negligible and not measurable either by the float or by current meter." The information given above 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 accurate picture of the site. The Contractor shall be responsible for any inference it may draw from such information. The Employer shall not be responsible for any variation in water current velocity, if observed, during water current velocity measurement 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.

Annexure – A

Pre-dispatch Inspection Protocol for Crystalline PV Modules by Employer or Employer Deputed Agency

Contents

Pre-dispatch inspection procedure

1. Objective:

The objective of this document is to establish General inspection protocol with objectivity for verification of Quality Parameters of Solar Modules by the customer (or its authorised inspection agency) prior to dispatch. The decision rules and procedure specified herein seek to uphold quality standards based on industry best practices and technical specifications laid out in tender documents as well as to control risks associated with item procurement.

2. Standards and Codes:

1. Sampling for determining Acceptance Quality Level (AQL) shall follow ISO 2859-1: 1999.
2. IEC 60904-9 (Photovoltaic Devices – Part 9: Solar Simulator Performance Requirements)

3. Definitions:

1. Lot: All products/items manufactured in one batch.
   Notwithstanding the aforementioned definition, the customer or authorized inspection agency can lay down alternate/additional criteria for determining a lot.
2. Major Defect: A defect that reduces the usability or causes the product to fail to fulfil its nominal characteristic function.
3. Minor Defect: A defect that does not reduce the usability of the product, but does not meet the quality standard.

4. Inspection Schedule:

Customer representative shall propose the schedule for Pre-despatch Inspection of Finished Goods to the Customer well in advance, and in no case less than 3 working days prior to commencement of Inspection at a location within India and 14 days in case of a foreign country.

5. Scope of Inspection:

Supplier representative will accompany the Inspector while doing the inspection which shall typically consist of 2 steps for clearance of each Lot:

BOM verification: To be conducted prior to the commencement of production.

The details of materials used will be verified from the ERP/Manufacturing data and corroborated with the Construction Data Form (CDF). This shall include verification of following:

Item	Method of Verification
Shelf life of the following BOM items: • Encapsulant • PV Module Back sheet (not applicable in case of glass-glass Modules) • Sealant and potting material (Silicone)	Verify the expiry date/shelf life and storage conditions *The PV Module manufacturer shall submit all required information to prove that materials being used are within their shelf life.*

Note: Supplier shall provide the necessary documents for approval of BOM as per IEC standards and tender Technical Specifications.

Witness Tests:

Manufacturer shall assist the Inspecting agency to witness following checks, the details of which are provided elsewhere in this document:

I. Flash test- As per sampling Plan

II. Visual Inspection- As per sampling Plan

III. EL Inspection-As per Sampling Plan

IV. Electrical Characteristics (Other than Flash Test)- As per Sampling Plan

Note: The Supplier shall furnish soft and hard copy of the Production Quality Plan prior to commencement of the Inspection.

6. Sampling Process:

a. Supplier shall provide the list of modules in a lot ready for despatch, along with flash test data (Measured Electrical Data, P_{max}) prior to commencement of Inspection tests.
Note: Smallest lot size for Inspection: 20% of the capacity as per the PO.

b. Supplier will arrange to move the PV Modules from FG to Inspection area.

c. Same samples shall be used for all Witness Tests stated at 5.2 above.

d. Inspector shall commence Inspection process by randomly selecting samples from the list of serial nos. (pallet-wise) provided by Supplier as per ISO 2859: Single Sampling Plan for Normal Inspection, General Inspection plan level-I. However, the

Inspector shall reserve the right to switch to tightened or reduced level of Inspection as per the lot quality.

7. Decision Rules for Acceptance/Rejection

Following is a summary of Decision Rules for Acceptance/Rejection of a given Sample in a lot offered for Inspection:

Table 1: AQL Levels

Defect Type	AQL (%)
Major (Ma)	2.5
Minor (Mi)	4

Table 2: Inspection Levels

Inspection steps	Inspection item	Inspection level
1	Flash Test	General inspection level I
2	Visual	General inspection level I
3	EL	General inspection level I
4	EC (Other than Flash Test)	10 Nos. per lot

8. Inspection Process

a. Electrical Inspection – Flash Tests

For Electrical inspection following preparation will be done:

- Module Temp Stabilisation: Modules will be kept in controlled environmental condition till it reaches 25 ±2ºC
- Calibration of Sun-simulator: Sun-simulator will be Class AAA type as per IEC 60904-9 (Photovoltaic Devices – Part 9: Solar Simulator Performance Requirements) with a valid calibration certificate on the date of testing.
- Reference PV Module for testing shall be traceable to accredited calibration laboratory lab (TUV / Fraunhofer etc.).

Note:

(i) All modules selected for sampling inspection will be re-tested in the sun-simulator. A P_{max} retest (repeatability test) variation of ± 2 % on actual flash P_{max} value will be acceptable.

(ii) The Supplier shall provide a valid calibration certificate of the apparatus used.

b. Visual Inspection:

- Customer representative will verify the module visual characteristics as per the Visual Acceptance norms.
- The Visual Inspection shall be carried out in a well-lit room. It shall be the responsibility of the Supplier to ensure adequate brightness in the room.

c. Electroluminescence (EL) Inspection:

- The EL image shall have sufficient resolution for analysis of defects.
- Hi-pot test shall be done as per IEC procedure. The Supplier shall provide a valid calibration certificate of the apparatus used.

9. Re-inspection and review

In case of minor non-conformities like cleaning issues, label mismatch, etc. which can be easily reworked, Supplier shall rework/replace the modules and offer them for re-inspection to Inspector.

10. Inspection Summary:

Once the inspection is completed Customer Representative will compile his Inspection Summary Report and share with Supplier and give necessary recommendation on despatch depending upon the audit findings based on the observations made. This report shall be provided within same day of inspection (Format Attached).

11. Disclaimer:

Inspection by SECI/ Employer does not absolve the responsibility of the Supplier/vendor to ensure quality during production of the material and its transport to site. Any damages during transport/ handling shall be replaced before erection at site as directed by Engineer-in-charge without any extra cost to the purchaser.

Sampling Plan

(Sampling Plan as Per ISO 2859) -1

Table 1 - Sample size code letters (see 10.1 and 10.2)

Lot size		Special inspection levels				General inspection levels		
		S-1	S-2	S-3	S-4	I	II	III
2 to	8	A	A	A	A	A	A	B
9 to	15	A	A	A	A	A	B	C
16 to	25	A	A	B	B	B	C	D
26 to	50	A	B	B	C	C	D	E
51 to	90	B	B	C	C	C	E	F
91 to	150	B	B	C	D	D	F	G
151 to	280	B	C	D	E	E	G	H
281 to	500	B	C	D	E	F	H	J
501 to	1 200	C	C	E	F	G	J	K
1 201 to	3 200	C	D	E	G	H	K	L
3 201 to	10 000	C	D	F	G	J	L	M
10 001 to	35 000	C	D	F	H	K	M	N
35 001 to	150 000	D	E	G	J	L	N	P
150 001 to	500 000	D	E	G	J	M	P	Q
500 001 and over		D	E	H	K	N	Q	R

(Sampling Plan as Per ISO 2859) – 2 – Normal, Tightened and Reduced)

Table 2-A — Single sampling plans for normal inspection (Master table)

Sample size code letter	Sample size	Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (normal inspection)																													
		0,010		0,015		0,025		0,040		0,065		0,10		0,15		0,25		0,40		0,65		1,0		1,5		2,5		4,0		6,5		10	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A	2	⇩																										0	1	⇩	
B	3			⇩																								⇩		1	2
C	5					⇩																						0	1	⇩	
D	8							⇩																				1	2	2	3
E	13									⇩																		0	1	3	4
F	20											⇩																1	2	5	6
G	32													⇩														0	1	7	8
H	50															⇩												1	2	10	11
J	80																	⇩										2	3	14	15
K	125																			⇩								3	4	21	22
L	200																					⇩						5	6	⇩	
M	315																							⇩				7	8		
N	500																									⇩		10	11		
P	800																											14	15		
Q	1 250																											21	22		
R	2 000																														

Sample size code letter	Sample size	Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (normal inspection)																													
		15		25		40		65		100		150		250		400		650		1 000											
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re										
A	2	⇩																													
B	3			⇩																											
C	5					⇩																									
D	8	1	2					⇩																							
E	13	2	3	1	2					⇩																					
F	20	3	4	2	3	1	2					⇩																			
G	32	5	6	3	4	2	3	1	2					⇩																	
H	50	7	8	5	6	3	4	2	3	1	2					⇩															
J	80	10	11	7	8	5	6	3	4	2	3	1	2					⇩													
K	125	14	15	10	11	7	8	5	6	3	4	2	3	1	2					⇩											
L	200	21	22	14	15	10	11	7	8	5	6	3	4	2	3	1	2					⇩									
M	315	⇩		21	22	14	15	10	11	7	8	5	6	3	4	2	3	1	2					⇩							
N	500			⇩		21	22	14	15	10	11	7	8	5	6	3	4	2	3	1	2					⇩					
P	800					⇩		21	22	14	15	10	11	7	8	5	6	3	4	2	3	1	2					⇩			
Q	1 250							⇩		21	22	14	15	10	11	7	8	5	6	3	4	2	3	1	2					⇩	
R	2 000									⇩		21	22	14	15	10	11	7	8	5	6	3	4	2	3	1	2				⇩

⇩ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 % inspection.

⇧ = Use the first sampling plan above the arrow.

Ac = Acceptance number

Re = Rejection number

Table 2-B — Single sampling plans for tightened inspection (Master table)

Sample size code letter	Sample size	0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1 000
		Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (tightened inspection)																									
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1 250	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2 000	0 1	↑	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
S	3 150			1 2																							

↓ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 % inspection.

↑ = Use the first sampling plan above the arrow.

Ac = Acceptance number

Re = Rejection number

Table 2-C — Single sampling plans for reduced inspection (Master table)

Sample size code letter	Sample size	Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (reduced inspection)																									
		0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1 000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
C	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	14 15	21 22	↑
D	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	14 15	21 22	↑	↑
E	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	14 15	21 22	↑	↑	↑
F	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑
G	13	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑
H	20	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑
J	32	↓	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	50	↓	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	80	↓	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	125	↓	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	200	↓	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	315	↓	0 1	↑	↓	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	500	0 1	↑	↑	↓	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	800	↑	↑	↑	1 2	2 3	3 4	5 6	6 7	8 9	10 11	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

↓ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 % inspection.

↑ = Use the first sampling plan above the arrow.

Ac = Acceptance number

Re = Rejection number

Customer inspection Report

CUSTOMER INSPECTION REPORT			
Ref. No. & Date:			
Client:	**PMC**: SECI	**EPC Contractor**: PO Ref. No.:	
Place of Inspection:	**Date of inspection:**	**Lot Size**	**Sample Quantity**
Problem Quantity: **Detail:** **Inspection Result (OK/Not OK):**			
Visual Inspection **Problem Quantity:** **Detail:**			
Flash Test **Problem Quantity:** **Detail:**			
EL Inspection: **Problem Quantity:** **Detail:**			
EC Inspection (Hipot,DC Continuity,IR): **Problem Quantity:** **Detail:**			
Any Other Criteria/Remarks:			
Is the shipment qualified to be released? ☐ ☐ **Yes** **No**			
From Client	From EPC Contractor	Solar Energy Corporation of India Limited	

Enclosed: Test Details, Flash Test Report, EL test (images- soft copy), EC Test Report

Disclaimer: *This Inspection by SECI/ Employer does not absolve the responsibility of the vendor to ensure quality during production of the material and its transport to site. Any damages during transport/ handling shall be replaced before erection at site as directed by Engineer-in-charge without any extra cost to the purchaser.*

Details:

Lot :				**Date**
S.No.	**Defect**	**Module Id**	**Type (Ma/Mi)**	**Details**
1				
2				
….				

ANNEXURE – B

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*** (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**	
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								
70	iv	Check Pile Location	Total Station										
71	v	GL, Pile depth, diameter and alignment	As required		Measurement								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
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		IS 2911, Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
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*** (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**	
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								

	A	B	C	D	E	F	G	H	I	J	K	L	M
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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**	
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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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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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, Reviewof 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 Downcommer**											
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 Items (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**											

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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 Items (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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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	Tech. Specification, Approved Drawing & Method Statement.		√	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				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**					Design Specification, Drawings, Manufacturer Manual Method Statement	SR					
497		**Pre Installation**											
498	i	Check for site physical layout as per drawing.		Major	Visual	100%			√	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 (SW-SEPC-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													

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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 – C

PG Test Procedure

TABLE OF CONTENTS

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

Functional Guarantee for Solar PV Plant shall comprise of following Guarantees:

(1) Performance Ratio Guarantee test for operational acceptance.

2.1 PERFORMANCE RATIO GUARANTEE TEST

A Performance Ratio Guarantee test shall be commenced within 60 days of 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 Ratio (PR) 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. The procedure of PR test is described further in Clause 2.1.4. The report shall contain all the measured energy and Met data values, calculations, results and conclusions.

2.1.1 Performance Ratio

The Performance Ratio (PR) of the PV Plant is calculated as follows (according to IEC 61724 Ed.2).

$$PR = \frac{E_{out}}{\sum_k \left(\frac{(C_k \times P_o) \times (G_{i,k} \times \tau_k)}{G_{i,ref}} \right)}$$

where

PR Temperature Corrected Performance Ratio

E_{out} Cumulative AC energy measured at the Plant End (ABT meter) over the duration of reporting period (kWh)

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

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 ($°C^{-1}$)

$T_{avg\_mod,k}$ Average PV Module temperature measured at the commencement of time interval 'τ_k' (°C)

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

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

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

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

2.1.2 **General Requirement**

- The Functional Guarantee shall comprise of a set of visual/mechanical/Electrical checks followed by a Performance Ratio (PR) test of the Plant Facilities.
- The PR 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.
- 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 will 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.
- PR is calculated as per the formula given in Clause no. 2.1 and recorded as per the format provided at ***Annexure 1***.
- The filled-in format shall be signed by both the parties (EPC Contractor and SECI) and each party will keep one copy for record. **The same will be recorded for 30 days.**
- 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).
- During this PR test, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of a breakdown, the test may be resumed once the complete system is rectified and working properly.

  ***** 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 (Refer Clause 2.1.5) is not attributable. In such case, the test shall be extended for affected no. of days (up to 5 days)

2.1.3 **Pre-PR Test**

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

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

Note:

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

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

(c) Ensure proper functioning (e.g. Multimeters 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.

2.1.4 **PR Test Procedure**

The date of commencement of the PR 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 PR test shall be mutually discussed and agreed between SECI and EPC Contractor. It shall comprise of the following procedures.

2.1.4.1 Pre-test Procedure

(1) Before the commencement of Performance Ratio (PR) test, the plant shall have completed Pre-PR tests as per Clause 2.1.3 above and SCADA system and WMS shall be fully commissioned and functional.

(2) Trial Run: The PG Test for Plant Facilities shall commence with a trial run for 7 consecutive days. The EPC Contractor shall provide the data in requisite formats (specified elsewhere in the document) to SECI. SECI shall vet the data for any discrepancies and systemic errors and revert within 3 working days. Post the trial run period, the 30 days PR test will commence after communication from SECI in this regard.

(3) 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**.

(4) The average POA radiation of all the Pyranometers ($G_{i,k}$) shall be considered for the calculation of PR. The average of module temperatures recorded by all the temperature

sensors shall be used for calculation of PR. The Pyranometers and Temperature sensors used for the purpose of the PR Test shall have valid calibration certificates.

2.1.4.2 Following the completion of the pre-test procedures, Performance Ratio Test of plant shall commence in accordance with the procedures, conditions and requirements provided in the next section.

2.1.4.3 General Procedure for the PR Test

The PR Test Procedure shall include the following components:

(1) Data Collection: 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 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 EPC Contractor shall document data which is to be eliminated along with reasons. The following criteria shall be excluded from the dataset used for this test:

- **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 at site level). The same shall be corroborated/verified by SECI. Suitable statistical methods may be applied to filter such erroneous data.
- Time blocks with insufficient (less than equal to 10) 1-minute records.
- **Grid Interruptions** – Time periods (in 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.
- As per the hindrance record maintained at site.

Note: Minimum 24 Nos of 15-minute time blocks shall be considered to account the day for PR measurement. Otherwise the PR test shall be extended to another day.

2.1.5 **Determination of PR Test**

Daily PR shall be calculated as the average of the PR calculated for valid 15-minute time blocks (Refer Clause 2.1.4.3) for the 30-day duration. If the ABT Meter data is not available on daily basis, PR shall be calculated based on the MFM data and shared for record. However, at the end of the PR test period, the daily PR shall be re-calculated with the ABT Meter data for sign-off.

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.

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.

2.1.6 **Raw Data Formats and Reports**

The EPC Contractor shall submit to SECI the raw data from the Plant SCADA on daily basis in the following format.

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.

PR Test Report shall be generated from the Raw Data (Sample Report provided in the Annexure) after data filtering as per criteria laid out in (2). The Report shall contain the signature of both representatives (SECI/Employer & EPC Contractor).

Note: In case of multiple pyranomters/temperature sensors, the radiation and temperature data for the purpose of calculation of PR shall be derived from the average values from tilted pyranometer /temperature sensors.

Reports

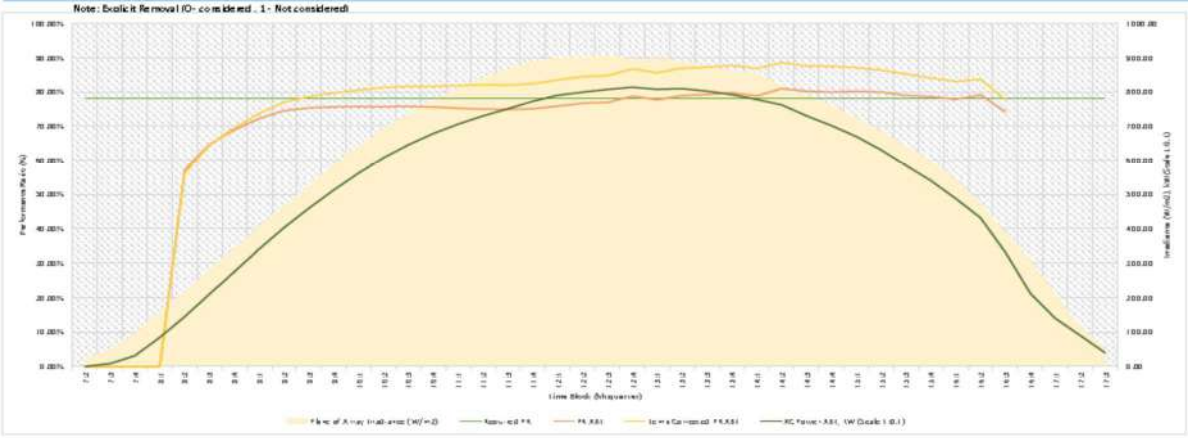
Sample Report for PR Test

PR Guarantee Test Report

Day	20-Nov-2016	Criteria	>200	Average POA Irradiance in a time block in W/m2	
No. of Timeblocks considered	36 /42	Tot Gen	53694	kWh	Source: ABT Meter at GSS
Plant PR for the day ABT	80.66%	Average PR (temp corrected) of 15 min time blocks where POA irradiance is greater than 200W/m2 and not explicitly removed			
	(Guaranteed PR: 78%)				

Time Block (hh:Qtr)	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	POA Radiation (kWh/m2)	Plane of Array Irradiance (W/m2)	GHI (W/m²)	Humidity (%)	Wind Direction (°)	Generation ABT GSS (kWh)	AC Power ABT, kW (Scale 1:0.1)	PR ABT	Temp Corrected PR ABT	Explicit Removal
7:2	1.62	13.91	15.10	2.17	25.25	27.00	45.92	88.10	0.00	0.00	0.00%	0.00%	0
7:3	1.41	14.47	15.25	12.34	47.92	50.47	45.53	38.35	21.00	8.40	14.73%	14.10%	0
7:4	0.57	15.84	15.73	25.08	98.48	92.93	44.41	0.00	79.00	31.60	27.27%	26.24%	0
8:1	0.26	17.73	16.01	39.51	156.11	143.67	44.55	0.00	212.00	84.80	46.45%	45.07%	0
8:2	0.66	20.64	17.01	54.73	216.78	193.67	42.19	0.00	361.00	144.40	57.10%	56.08%	0
8:3	0.43	24.09	17.94	70.40	279.62	245.80	40.17	0.00	526.00	210.40	64.69%	64.45%	0
8:4	0.71	27.22	18.85	86.46	343.62	291.80	38.39	0.00	688.00	275.20	68.90%	69.52%	0
9:1	0.71	29.93	19.74	102.34	407.36	348.47	36.74	0.00	854.00	341.60	72.25%	73.71%	0
9:2	0.71	32.98	20.73	117.25	466.99	398.00	35.17	0.00	1009.00	403.60	74.51%	76.95%	0
9:3	0.80	35.60	21.52	132.29	527.14	445.27	33.94	0.00	1151.00	460.40	75.33%	78.61%	0
9:4	0.74	38.17	22.31	146.86	585.56	486.27	32.98	0.00	1283.00	513.20	75.64%	79.72%	0
10:1	0.87	40.55	23.23	160.77	641.34	516.87	31.86	0.00	1406.00	562.40	75.72%	80.54%	0
10:2	0.93	42.99	24.08	173.62	692.91	540.33	31.13	0.00	1518.00	607.20	75.70%	81.28%	0
10:3	0.99	43.78	24.78	184.38	736.02	559.67	30.67	0.00	1613.00	645.20	75.74%	81.57%	0
10:4	1.18	44.44	25.53	194.12	775.43	576.53	29.87	12.76	1695.00	678.00	75.60%	81.63%	0
11:1	1.05	46.52	26.17	203.12	811.43	593.60	28.97	0.00	1765.00	706.00	75.23%	81.87%	0
11:2	0.89	48.11	26.74	210.57	841.02	609.07	28.28	0.00	1824.00	729.60	75.00%	82.10%	0
11:3	1.51	47.95	27.61	217.05	867.66	624.60	26.97	0.00	1877.00	750.80	74.87%	81.92%	0
11:4	2.03	48.74	28.04	222.77	890.54	642.47	25.69	76.95	1932.00	772.80	75.09%	82.40%	0
12:1	1.61	49.61	28.91	225.54	902.04	656.13	24.24	0.00	1975.00	790.00	75.82%	83.47%	0
12:2	2.03	49.58	29.45	225.55	902.30	664.40	22.97	129.40	1998.00	799.20	76.69%	84.42%	0
12:3	2.34	48.79	29.73	227.09	907.75	672.60	21.62	131.02	2018.00	807.20	76.94%	84.75%	0
12:4	2.48	49.66	29.92	223.65	895.29	671.87	20.71	96.20	2034.00	813.60	78.74%	86.70%	0
13:1	2.10	49.70	30.20	224.96	899.51	670.93	18.75	0.00	2019.00	807.60	77.71%	85.57%	0
13:2	2.32	49.80	30.31	222.11	889.25	665.80	18.11	22.42	2024.00	809.60	78.90%	86.92%	0
13:3	2.59	48.39	30.42	219.07	877.23	649.13	17.75	219.19	2005.00	802.00	79.24%	87.17%	0
13:4	2.22	48.55	30.70	215.00	859.72	630.67	17.39	0.00	1980.00	792.00	79.73%	87.76%	0
14:1	1.87	49.88	30.98	213.62	855.38	620.80	16.27	0.00	1944.00	777.60	78.79%	86.83%	0
14:2	2.27	47.80	31.28	203.86	816.52	584.27	16.13	19.15	1906.00	762.40	80.95%	88.51%	0
14:3	2.30	47.34	30.99	196.95	788.89	548.20	16.46	38.30	1825.00	730.00	80.23%	87.58%	0
14:4	2.05	47.88	31.01	189.95	760.16	520.20	16.53	7.33	1754.00	701.60	79.95%	87.45%	0
15:1	1.75	45.99	31.44	180.73	724.65	484.80	15.75	0.00	1674.00	669.60	80.19%	87.10%	0
15:2	2.30	44.51	31.33	170.69	684.26	442.27	15.51	95.39	1576.00	630.40	79.94%	86.34%	0
15:3	2.10	44.35	31.19	160.33	642.47	402.40	15.57	28.93	1462.00	584.80	78.95%	85.21%	0
15:4	2.33	41.86	31.19	148.67	596.65	358.47	15.41	45.73	1350.00	540.00	78.62%	84.06%	0
16:1	1.91	41.25	31.19	135.70	544.70	311.80	15.33	90.91	1220.00	488.00	77.84%	83.02%	0
16:2	2.37	38.99	31.12	118.23	475.45	255.73	14.96	5.47	1080.00	432.00	79.09%	83.62%	0
16:3	2.57	36.66	30.95	96.68	389.67	195.27	15.01	86.82	829.00	331.60	74.24%	77.79%	0
16:4	1.60	34.83	30.62	70.86	306.83	143.86	15.44	76.91	531.00	212.40	64.88%	67.50%	0
17:1	1.56	32.61	30.19	52.45	212.88	92.47	15.59	63.97	350.00	140.00	57.78%	59.58%	0
17:2	1.75	29.57	29.68	26.61	117.56	48.14	15.94	103.66	226.00	90.40	73.53%	74.91%	0
17:3	0.84	27.22	28.80	4.19	52.66	21.40	16.82	0.00	100.00	40.00	206.71%	208.59%	0

Note: Explicit Removal (0- considered , 1- Not considered)



Remarks: [to be recorded, if any]

Liquidated Damages for Shortfall in PR

For every 0.01 shortfall in PR below the committed PR value, a penalty of 1% of the total Contract Value (i.e., total sum of all the Supply and Service) shall be levied. In case the Contract Performance Security has already been encashed on account of any default/delays, the penalty amount will be recovered from any due payments to the contractor. In case the Plant PR Shortfall is more than 0.05 than the specified PR value, then the total plant will be accepted on as-is basis & the total Contract Performance Security submitted by the contractor will be forfeited & payments linked to operational acceptance will not be made.

Annexure – D

Procedure for Plant Testing, Commissioning and Documentation

TABLE OF CONTENTS

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 Chapter – 2 of Appendix – A to Section VII: Technical Specifications for testing instruments):
  - Earth resistance tester
  - IV curve tracer
  - Insulation tester
  - Digital multimeter
  - 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 checking 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, 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: Vdc,max, Vmpp,min, Vmpp,max, Idc,max, Pac,r, Vac,r, f r , Iac,max;
    - 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 ductor 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 labeling
- 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”.

ANNEXURE – E

MANDATORY SPARES

S. No.	Equipment/Material	Quantity (For each type and rating)
1	PV Modules	0.5% of total supply
2	Floats	1 % of total supply
3	MC4 connectors (including Y-connector if used)	1% of total supply
4	Power Conditioning Unit	1% of total supply
5	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
6	Power Transformer	
	(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) Complete set of gaskets	1 set
7	Gas Insulated Switchgear	As per OEM Recommendation
8	HT Switchgear	
	(i) Vacuum pole	2 nos.
	(ii) Closing coil	2 nos.
	(iii) Tripping coil	2 nos.
	(iv) Spring charging motor	2 nos.
	(v) Relay	2 nos.

S. No.	Equipment/Material	Quantity (For each type and rating)
	(vi) Meter	2 nos.
	(vii) Current Transformer	2 nos.
	(viii) MCCB	2 nos.
	(ix) MCB	2 nos.
	(x) Fuse	10% of total supply
	(xi) Indicating lamp	10% of total supply
	(xii) Rotary switch	10% of total supply
9	LT Switchgear	
	(i) MCCB	2 nos.
	(ii) MCB	2 nos.
	(iii) Fuse	10% of total supply
	(iv) Relay	2 nos.
	(v) Meter	2 nos.
	(vi) Current Transformer	2 nos.
	(vii) Voltage Transformer	2 nos.
	(viii) Indicating lamp	10% of total supply
	(ix) Rotary switch	10% of total supply
10	DC Cable	1% of total supply
11	AC Cable	1% of total supply
12	Communication Cable	1% of total supply
13	Control Cable	1% of total supply
14	Fuse	10% of total supply
15	132 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	2 set
	(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

S. No.	Equipment/Material	Quantity (For each type and rating)
	(iii) Conductor, Earth Wire and OPGW	1 km each
16	132 kV Switchyard 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
	(ii) Isolator	
	(a) One complete pole of Isolator 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
	(c) Open/Close Contactor Assembly, Timer, Key	1 set

S. No.	Equipment/Material	Quantity (For each type and rating)
	(d) Interlock push button switch & auxiliary switches	
	(e) Limit switch	2 nos.
	(f) Terminal pads & Connectors	3 nos.
	(g) Corona shielding ring	3 nos.
	(iii) Surge Arrestor	1 no.
	(a) Complete surge arrestor 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.

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.

Detailed Finishing Schedule for MCR Building

S. No.	Description	Quantity
A	**Flooring**	
1	Toilet	
	Providing and laying Ceramic glazed floor tiles of size 300x300 mm (thickness to be specified by the manufacturer), of 1st quality conforming to IS : 15622, of approved make, in all colours, shades, except White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick bed of cement mortar 1:4 (1 Cement : 4 Coarse sand), jointing with grey cement slurry @ 3.3 kg/ sq.m including pointing the joints with white cement and matching pigments etc., complete with matching skirting. Colour & Shade to be finalized by Engineer-in-charge.	sqm
2	Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Pantry, Guest Room, Servant Room & Passage	
	Providing and laying vitrified floor tiles in different sizes (thickness to be specified by the manufacturer) with water absorption less than 0.08% and conforming to IS: 15622, of approved make, in all colours and shades, laid on 20mm thick cement mortar 1:4 (1 cement : 4 coarse sand), jointing with grey cement slurry @ 3.3 kg/ sqm including grouting the joints with white cement and matching pigments etc., with matching skirting complete. Size 600 X 600 mm Shade & Colour to be finalized by Engineer-in-charge.	sqm
3	Porch	
	Providing and laying flamed finish Granite stone flooring in required design and patterns, in linear as well as curvilinear portions of the building all complete as per the architectural drawings with 18 mm thick stone slab over 20 mm (average) thick base of cement mortar 1:4 (1 cement : 4 coarse sand) laid and jointed with cement slurry and pointing with white cement slurry admixed with pigment of matching shade including rubbing, curin and polishing etc. all complete as specified and as directed by the Engineer-in-Charge. Flamed finish granite stone slab Jet Black, Cherry Red, Elite Brown, Cat Eye or equivalent.	sqm
B	**Walls**	
1	Interior walls of Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Guest Room, Servant Room, Pantry & Toilet etc.	
	12 mm cement plaster of mix 1:6 (1 cement: 6 coarse sand)	sqm
	Providing and applying plaster of paris putty of 2 mm thickness over plastered surface to prepare the surface even and smooth complete.	sqm

	Wall painting with acrylic emulsion paint of approve brand and manufacture to give an even shade : Tw or more coats on new wor	sqm
2	Exterior walls of Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Guest Room, Servant Room, Pantry, Toilet & Parapet etc	
	15 mm cement plaster on rough side of single or half brick wall of mix: 1:6 (1 cement: 6 coarse sand)	sqm
	Providing and applying plaster of paris putty of 2 mm thickness over plastered surface to prepare the surface even and smooth complete.	sqm
	Finishing walls with textured exterior paint of required shade : New work (Two or more coats applied @ 3.28 ltr/10 sqm) over and including priming coat of exterior primer applied @ 2.20kg/10 sqm	sqm
3	Glass Partition	
	Providing & fixing 12mm thick toughened glass frameless partitions, having machine polished edges. It shall have SS top, bottom and locking arrangement hardwares of approved brand and design. Include door opening where necessary including SS handle of approved design and shape. The toughened glass shall have design/pattern on it Gap between two glass edge shall be filled with colorless silicon sealant. the job shall be completed including all hardwares and cleaning of glasses etc., and as per directions of Engineer In Charge	sqm
	Providing and fixing 12 mm thick frameless toughened glass door shutter of approved brand and manufacture, including providing and fixing top & bottom pivot & double action hydraulic floor spring type fixing arrangement and making necessary holes etc. for fixing required door fittings, all complete as per direction of Engineer-incharge.	sqm
4	Wall tiles in toilet and kitchen	
	Providing and fixing Ist quality ceramic glazed wa tiles conforming to IS: 15622 (thickness to be specified by the manufacturer), of approved make, in all colours, shades except burgundy, bottle green, black of any size as approved by Engineer-i Charge, in skirting, risers of steps and dados, over 12 mm thick bed of cement mortar 1:3 (1 cement : 3 coarse sand) and jointing with grey cement slurry @ 3.3kg per sqm, including pointing in white cement mixed with pigment of matching shade complete. Colour & Shade to be finalized by Engineer-in-charge	sqm
C	**Ceiling**	
1	6 mm cement plaster of mix : 1:3 (1 cement : 3 fine sand)	sqm
2	Providing and applying plaster of paris putty of 2 mm thickness over plastered surface to prepare the surface even and smooth complete.	sqm

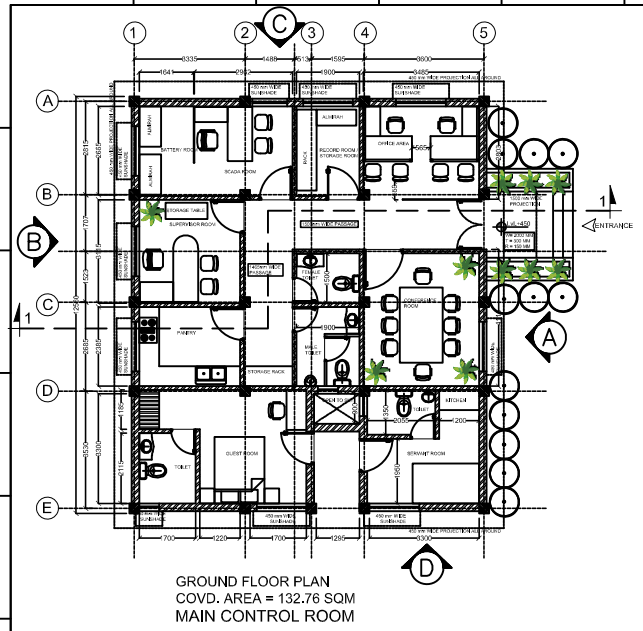
3	Wall painting with acrylic emulsion paint of approve brand and manufacture to give an even shade : Tw or more coats on new wor	sqm
D	**Doors & Window**	
1	Providing and fixing ISI marked flush door shutters conforming to IS : 2202 (Part I) non-decorative type core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters: 30 mm thicl including ISI marked Stainless Steel butt hinges with necessary screws	sqm
2	Providing and fixing stainless steel sliding door bolts, ISI marked, transparent or dyed to required colour or shade, with nuts and screws etc. complete : 300x16 mm	each
3	Providing and fixing stainless steel tower bolts, ISI marked, transparent or dyed to required colour or shade, with necessary screws etc. complete : 250x10 mm	each
4	Providing and fixing stainless steel handles, ISI marked, transparent or dyed to required colour or shade, with necessary screws etc. complete : 125 mm	each
5	Providing and fixing stainless steel hanging floor door stopper, ISI marked, transparent or dyed to required colour and shade, with necessary screws etc. complete with twin rubber stoppe	each
6	Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required dia & length. Second class teak wood	cum
7	Providing and fixing factory made laminated veneer lumber glazed shutter conforming to IS: 14616 and TADS 15:2001 (Part B), using 4 mm thick float glass panes for doors, windows and clerestory windows fixing with butt hinges of required size with necessary screws, all as per directions of Engineer-in-charge. 30 mm thick shutters	sqm
8	Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete. Fixed to openings /woode frames with rawl plugs screws etc. Providing and fixing fly proof galvanized M.S. wire gauge as wire meshing to windows and clerestory windows using wire gauge	kg
9	Applying priming coat: With ready mixed pink or Grey primer of approved brand and manufacture on wood work (hard and soft wood)	sqm
10	Painting with synthetic enamel paint of approved brand and manufacture to give an even shade : Tw or more coats on new wor	sqm

E	**Stainless Steel**	
1	Roof	
	SS 304 Ladder to be provided for accessing roof for maintenance purpose	kg
F	**Kitchen & Other Slabs**	
1	Providing and fixing 18 mm thick gang saw cut, mirror polished, premoulded and prepolished, machine cut for kitchen platforms, vanity counters, window sills, facias and similar locations of required size, approved shade, colour and texture laid over 20 mm thick base cement mortar 1:4 (1 cement : 4 coarse sand), joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edges to give high gloss finish etc. complete at all levels. Granite of any colour and shade.	sqm
G	**Sanitary & Plumbing Fixtures**	
1	Providing and fixing floor mounted, white vitreous china single piece, double traps syphonic water closet of approved brand/make, shape, size and pattern including integrated white vitreous china cistern of capacity 10 litres with dual flushing system, including all fittings and fixtures with seat cover, cistern fittings, nuts, bolts and gasket etc including making connection with the existing P/S trap, complete in all respect as per directions of Engineer-in-Charge.	Nos.
2	Providing and fixing wash basin with C.I. brackets, 15 mm C.P. brass pillar taps, 32 mm C.P. brass waste of standard pattern, including painting of fittings and brackets, cutting and making good the walls wherever require: White Vitreous China Flat back wash basin size 550x 400 mm with single 15 mm C.P. brass pillar tap	Nos.
3	Providing and fixing Stainless Steel A ISI 304 (18/8 kitchen sink as per IS:13983 with C.I. brackets and stainless steel plug 40 mm, including painting of fittings and brackets, cutting and making good the walls wherever required : Kitchen sink without drain board 610x510 mm bowl depth 200 mm	No.
4	Providing and fixing PTMT Bottle Trap for Wash basin and sink. Bottle trap 31mm single piece moulded with height of 270 mm, effective length of tail pipe 260 mm from the centre of the waste coupling, 77 mm breadth with 25 mm minimum water seal, weighing not less than 260 gms	Nos.
5	Providing and fixing mirror of superior glass (of approved quality) and of required shape and size with plastic moulded frame of approved make and shade with 6 mm thick hard board backing : Rectangular shape 453x357 mm	Nos.

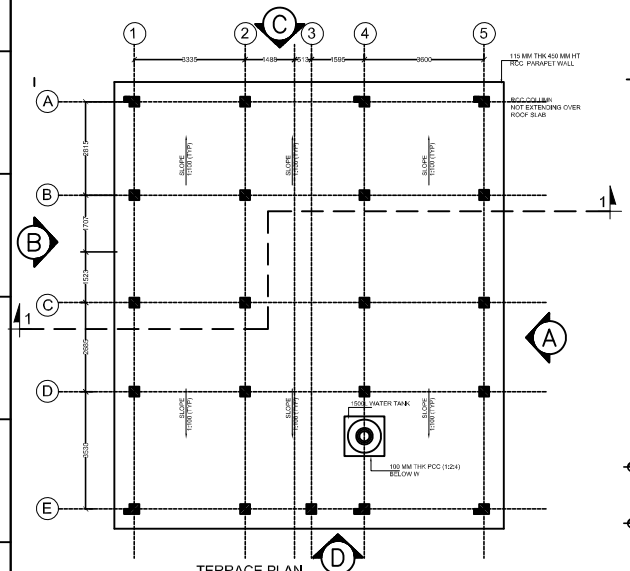
6	Providing and fixing 600x120x5 mm glass shelf with edges round off, supported on anodised aluminium angle frame with C.P. brass brackets and guard rail complete fixed with 40 mm long screws, rawl plugs etc., complete	Nos.
7	Providing and fixing toilet paper holder : C.P. brass	Nos.
8	Providing & Fixing of SS body 0.5 litre liquid soap dispenser with simple push lever fitted with liquid soap (one time) including cutting and making good the walls, wherever requirec	Nos.
9	Providing & Fixing ABS/Plastic body paper towel dispenser complete with brackets fixed to wall with PVC rawl plug with CP brass screws complete in all respects, including cutting and making good the wa wherever required	Nos.
10	Providing and fixing C.P. brass shower rose with 15 or 20 mm inlet : 150 mm diamete	Nos.
11	Lightweight, Durable, Rustproof overhead Water tank of capacity 1000 L to be provided at roof.	Nos.
H	**Water Proofing**	
1	Providing and laying water proofing treatment t vertical and horizontal surfaces of depressed portions of W.C., kitchen and the like consisting of: (i) Ist course of applying cement slurry @ 4.4 kg/sqm mixed with water proofing compound conforming to IS 2645 in recommended proportions including rounding off junction of vertical and horizontal surface. (ii) IInd course of 20 mm cement plaster 1:3 (1 cement : 3 coarse sand) mixed with water proofing compound in recommended proportion including rounding off junction of vertical and horizontal surface. (iii) IIIrd course of applying blown or residual bitumen applied hot at 1.7 kg. per sqm of area. (iv) IVth course of 400 micron thick PVC sheet. (Overlaps at joints of PVC sheet should be 100 mm wide and pasted to each other with bitumen @ 1.7 kg/sqm).	sqm
2	Providing and laying integral cement based water proofing treatment including preparation of surface as required for treatment of roofs, balconies, terraces etc. consisting of following operations: (a) Applying a slurry coat of neat cement using 2.75 kg/sqm of cement admixed with water proofing compound conforming to IS. 2645 and approved by Engineer-in-charge over the RCC slab including adjoining walls upto 300 mm height including cleaning the surface before treatment. (b) Laying brick bats with mortar using broken bricks/brick bats 25 mm to 115 mm size with 50% c cement mortar 1:5 (1 cement : 5 coarse sand) admixed with water proofing compound conforming to IS : 2645 and approved by Engineer-in-charge over 20 mm thick layer of cement mortar of mix 1:5 (1 cement :5 coarse sand) admixed with water proofing compound conforming to IS : 2645 and approved by Engineer-in-charge to required slope and treating similarly the adjoining walls upto 300 mm height including rounding of junctions of walls and slabs.	sqm

	(c) After two days of proper curing applying a second coat of cement slurry using 2.75 kg/ sqm of cement admixed with water proofing compound conforming to IS : 2645 and approved b Engineerin- charge. (d) Finishing the surface with 20 mm thick jointless cement mortar of mix 1:4 (1 cement :4 coarse sand) admixed with water proofing compound conforming to IS : 2645 and approved b Engineerin- charge including laying glass fibre cloth of approved quality in top layer of plaster and finally finishing the surface with trowel with neat cement slurry and making pattern of 300x300 mm square 3 mm deep. (e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test."All above operations to be done in order and as directed and specified by the Engineer-in-Charge: With average thickness of 120 mm and minimum thickness at khurra as 65 mm.	
I	**Fire Extinguisher**	
	Supply, installation, testing and commissioning ISI marked (IS:15683) portable fire extinguisher, dry powder & clean agent both complete in all respects including initial fill and wall suspension brackets as required as per specifications.	No.
J	**Light and Fan**	
1	Supply & installation of Surface Mounted 18W LED Batten tube light having housing made from CRCA steel sheet with driver etc complete as required.	Nos.
2	Supply & installation of 150mm dia sweep metal body, 1400 RPM Exhaust fan with guard and mounting arrangement.	Nos.
3	Supply & installation of 1200mm dia sweep ceiling fan copper wound with blades white in color, ISI marked and 5 star rated complete with capcitor, down rod, split pin , reel but without regulator complete as required.	Nos.
4	Supply of 12W Sleek surface mounted round LED downlighter luminaire in Portico, Store, Toilet etc.	Nos.
5	Supply of 18W Sleek surface mounted round LED downlighter luminaire in Office Area, Record Room Scada cum Battery Room, Supervisor Room, Conference Room, Pantry & Passage etc.	Nos.
6	Scada Room, Office Area, Conference Room and Supervisor Room shall be equipped with appropriat split type air conditioning unit	Nos.

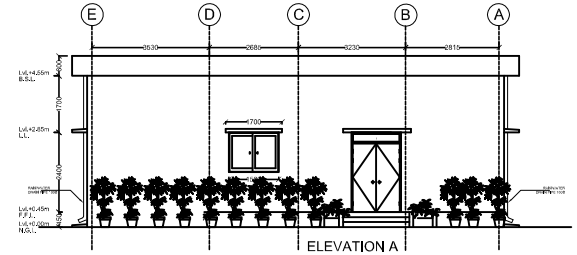
Note: All quantities to be worked out from the architectural drawing provided.



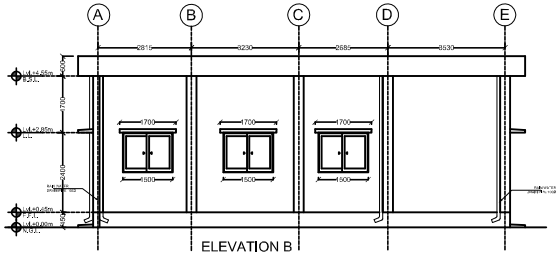
GROUND FLOOR PLAN
COVD. AREA = 132.76 SQM
MAIN CONTROL ROOM



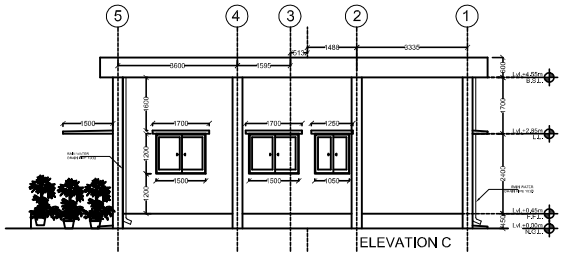
TERRACE PLAN
MAIN CONTROL ROOM



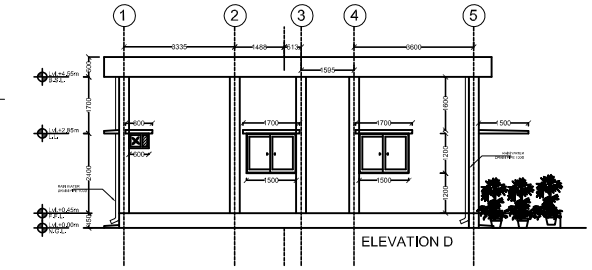
ELEVATION A



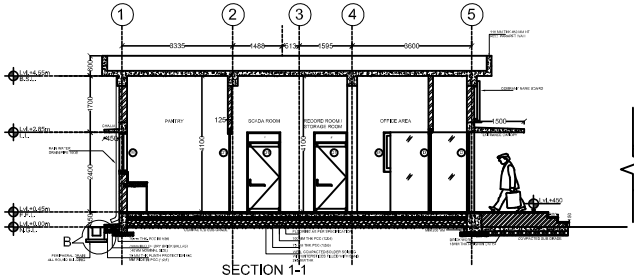
ELEVATION B



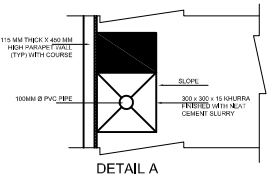
ELEVATION C



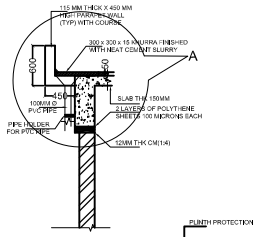
ELEVATION D



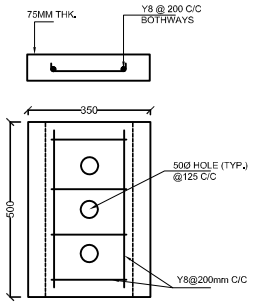
SECTION 1-1



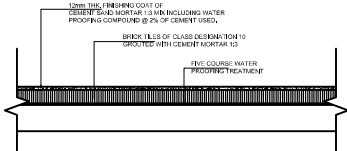
DETAIL A



DETAIL B



DETAILS OF PRECAST SLAB



TYP. SECTION FOR WATER
PROOFING OF TERRACE

NOTES:

1. ALL DIMENSIONS ARE IN MM OTHERWISE SPECIFIED.
2. ANTI TERMITE TREATMENT SHALL BE PROVIDED BELOW FOUNDATION AND AT FLOOR LEVEL.
3. THIS DRAWING IS NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
4. EL(+) 0.00M CORRESPONDS TO NATURAL GROUND LEVEL (N.G.L.).
5. 6MM CEMENT PLASTER, 2 MM POP PUTTY & ACRYLIC EMULSION PAINT ON CEILING.
6. ALL QUANTITIES TO BE WORKED OUT FROM THE ARCHITECTURAL DRAWING PROVIDED.
7. IN RCC WORKS CONCRETE SHALL BE OF GRADE M30 AND REINFORCING STEEL SHALL BE OF GRADE FE500 CONFORMING TO IS: 1786.
8. BRICK WORK SHALL BE OF CLASS DESIGNATION 7.5 CORRESPONDING TO IS: 1077, IS: 2212 AND IS: 3620.
9. ALL DOORS AND WINDOW, CHAJJA SHALL BE PROVIDED WITH 10MM WIDE DRIP COURSE.
10. ALL PLUMBING AND WIRING WORKS SHALL BE OF CONCEALED TYPE ONLY.
11. BRIEF FINISHING SPECIFICATIONS HAS BEEN OUTLINED AS UNDER. FOR DETAILS PLEASE REFER TO "DETAILED FINISHING SCHEDULE FOR MCR BULDING."
12. NO CHANGES IN THE DRAWING OR SPECIFICATIONS SHALL BE MADE WITHOUT PRIOR APPROVAL OF THE EMPLOYER.

Brief Finishing Specifications for General MCR Building

S. No.	Description	Quantity
A	**Flooring**	
1	Toilet: Ceramic glazed floor tiles of size 300x300 mm.	sqm
2	Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Guest Room, Servant Room, Pantry & Passage: Vitrified floor tiles of size 600 X 600 mm.	sqm
3	Porch: 18 mm thick flamed finish Granite stone.	sqm
B	**Walls**	
1	Interior walls of Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Guest Room, Servant Room, Pantry & Toilet etc., 12 mm cement plaster of mix 1:6 (1 cement: 6 coarse sand). Plaster of paris putty of 2 mm thick, Wall painting with acrylic emulsion paint.	sqm
2	Exterior walls of Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Guest Room, Servant Room, Pantry, Toilet & Parapet etc. 15 mm cement plaster of mix: 1:6 (1 cement: 6 coarse sand), Plaster of paris putty of 2 mm thick, Textured exterior paint.	sqm
3	Glass Partition. 12mm thick toughened glass frameless partitions.	sqm
4	Wall tiles in toilet and kitchen: Ceramic glazed wall tiles.	sqm
C	**Ceiling**	
1	6 mm cement plaster of mix 1:3 (1 cement: 3 fine sand). Plaster of paris putty of 2 mm thick, Wall painting with acrylic emulsion paint.	sqm
D	**Doors & Window**	
1	Flush door shutters	sqm
2	All accessories such as Stainless Steel sliding door bolts, S.S. tower bolts, S.S. handles, S.S. hanging floor door stopper	each
3	Wood work in frames of doors, windows	cum
4	M.S. grills of required pattern in frames of windows	kg
5	Applying priming coat (With ready mixed pink or Grey primer of approved brand and manufacture on wood work	sqm
E	**Stainless Steel**	
1	SS 304 Ladder for accessing roof for maintenance purpose.	kg
F	**Kitchen & Other Slabs**	
1	18 mm thick mirror polished Granite stone.	sqm
G	**Sanitary & Plumbing Fixtures**	
1	Floor mounted, white vitreous china single piece water closet with cistern having dual flushing system including all fittings and fixtures	Nos.
2	White Vitreous China Flat back wash basin size of 550x 400 mm.	Nos.
3	Stainless Steel A ISI 304 (18/8) Kitchen sink without drain board 610x510 mm.	Nos.
4	PTMT Bottle Trap for Wash basin and sink.	Nos.
5	Mirror of superior glass 6 mm thick hard board backing : Rectangular shape 453x357 mm.	Nos.
6	600x120x5 mm glass shelf with edges round off.	Nos.
7	Toilet paper holder : C.P. brass.	Nos.
8	SS body 0.5 litre liquid soap dispenser with simple push lever fitted with liquid soap.	Nos.
9	ABS/Plastic body paper towel dispenser.	Nos.
10	C.P. brass shower rose of 150 mm diameter.	Nos.
11	Lightweight, Durable, Rustproof overhead Water tank of capacity 1000 L	Nos.
H	**Water Proofing**	
1	As specified.	sqm
I	**Fire Extinguisher**	
1	Portable fire extinguisher, dry powder and clean agent both complete in all respects.	No.
J	**Light and Fan**	
1	Surface Mounted 18W LED Batten tube light	Nos.
2	150mm dia sweep metal body, 1400 RPM. Exhaust fan with guard.	Nos.
3	1200mm dia sweep ceiling fan copper wound with blades white in color.	Nos.
4	12W Sleek surface mounted round LED downlighter luminaire in Portico, Store, Toilet etc.	Nos.
5	18W Sleek surface mounted round LED downlighter luminaire in Office Area, Record Room, Scada cum Battery Room, Supervisor Room, Conference Room, Pantry & Passage etc.	Nos.
6	Scada Room, Office Area, Conference Room and Supervisor Room shall be equipped with appropriate split type air conditioning unit.	Nos.

DRAWING TITLE	MCR BUILDING : PLAN, ELEVATION, SECTIONS AND FINISHING DETAILS

ISSUED
☐ FOR REVISION ☐ FOR FABRICATION ☐ GOOD FOR CONSTRUCTION

	DRAWN BY	CHKD. BY	APPR. BY
	-------	-------	-------
DATE	-------	-------	-------

SHEET	SHEET SIZE	REV	SCALE
1 OF 1	A2	-------	

“Annexure G”

“10 Years Plant Operation & Maintenance Agreement of 100 MW (AC) Floating Solar PV Project at Getalsud Dam, Ranchi”

1 Term of the Contract

This Contract shall become effective upon final signature by the Parties for a term of ten (10) years. The O&M of the plant will commence from the date of Operational Acceptance of the plants.

2 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, POSOCO, SLDC, Local DISCOM & TRANSCO 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 labour 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 Contractor shall make arrangements to provide monthly reports from the SCADA system to the Employer. The Contractor shall arrange to connect the Plant to the SCADA system operating at the Site enabling the remote monitoring of the Plant by the Contractor and to provide access to information pertaining to the Plant to the Owner's Representative at Site and SLDC. The Employer may collect the data generated by the SCADA system in respect of the Plant from the Contractor.

1.15 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.

1.16 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 Annexure G.

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 Owner 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 Owner 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 Owner in accordance with Performance Standards and Technical Specifications. If either the Contractor or the Owner 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 Owner (at the Owner's 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. Grid Connection and balance of electricity commitments

The Contractor acknowledges that to allow the Owner 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 Owner 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 Owner from time to time (or of which the Contractor otherwise becomes aware), and/or with the reasonable requests of the Owner 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;

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 **Owner**'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 Owner, 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 Owner'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 Owner, indemnify the Owner 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 Owner 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 Owner immediate notice of the same and provide a written report to Owner within five (5) Business Days; and the Owner 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 Owner 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 Owner for any additional damage or loss caused by the delay to notify the Owner.

5. ADDITIONAL SERVICES

5.1. Owner 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 Owner 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 Owner 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 Owner, 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 Owner.

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 Owner 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 Owner 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 Owner'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 Owner in accordance with the contract. Unless otherwise specified in the contract, the Contractor shall provide the Owner 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 Consumables and Tools

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 Equipment and Spare Parts

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 Owner. 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 Owner 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 Inspection of Replaced Parts

Contractor shall give to the Owner seven (7) days' notice of the time when the Replaced Part is being transported to the Site. Contractor shall permit Owner to inspect, at Owner'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:

(i) 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 Owner 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:

(i) 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 Owner upon:

(i) 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, Owner 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 Owner 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 Owner 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 Owner 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 Owner is work which the Contractor was liable to do at its own expense under the contract, the costs incurred by the Owner 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 Owner 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 Owner (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 Owner 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 Owner, 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 Owner 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 Owner 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 Owner 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 Owner, 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 Owner pursuant to *Owner 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 Owner, 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 Owner, 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 Owner or Other Subcontractors of Owner may be present at the Site and agrees, at no cost or expense to the Owner, to reasonably cooperate with such Other Subcontractors to allow the performance of its and their respective obligations to occur concurrently. Owner 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 Owner'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 Owner 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 Owner; 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 Owner 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 Owner and such changes and improvements are carried out at no cost to the Owner and in accordance with Reserved Rights.

14. CERTAIN NOTIFICATIONS BY CONTRACTOR

14.1 Contractor shall, upon obtaining actual knowledge thereof, promptly give the Owner 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 Owner'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 Owner 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, Owner 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 Contractor, the Contractor shall, subject to Limitations of Remedies and Liability, indemnify the Owner for any loss the Owner may suffer as a consequence, including, without limitation, compensation pursuant to Owner'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 Owner. 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 Owner'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 Owner 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 Owner pursuant to Applicable Law, the Owner 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 Owner and any Owner 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 Owner, independent engineer, Grid Operator, Grid Administrator, and any other Contractor or Contractors employed by the Owner 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 Owner (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 Owner 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 Owner 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 Owner 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 Owner 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 Owner's and/or any of the Project Parties' inspector and provide the Owner 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 Owner'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 Inspection during the Term and at the End of the Term:

During the Term, the Plant may be submitted to a general inspection performed by a Contractor selected by Owner:

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 Owner under this Clause will be for the Owner'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 Owner.

Subject to the Owner's reasonable advance notice as to the date of such inspection, Contractor is required to attend and assist the Owner 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 Owner and if any defect or damage found, same shall be rectified/replaced.

16.10.4. Without relieving Contractor from its obligations and without limiting Owner's ability to reasonably pursue the reliefs available to it, if applicable:

(i) Contractor shall, promptly following receipt of the report, submit to the Owner (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 Owner shall be entitled, at Contractor's cost and risk, to employ a Replacement Contractor to perform the works.

16.11 Owner Site Visit

16.11.1. If Owner decides to visit the Plant, Contractor shall provide personnel on the Site for mutual inspection with no additional cost to Owner. If the Contractor is reasonably unable to attend such visit for unexpected reasons and/or safety reasons, Contractor shall immediately inform the Owner. 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 Owner shall adhere to the HSE practices of the Contractor.

16.11.2. If, upon request of the Owner made in accordance with Owner 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, Owner may request that Contractor provide personnel on the Site for additional inspections as an Additional Service.

16.11.3. If, upon request of the Owner 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 Owner 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 Owner 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 Owner. 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 Owner 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. **Owner'S OBLIGATIONS**

During the Term, Owner shall perform the following obligations:

18.1 Access

18.1.1. On and from the Commencement Date, Owner 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 Owner in writing, on the Time to time Basis.

18.1.2. The Owner 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 Owner 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 Owner 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 Owner's Permits

Contractor, on behalf of the Owner, shall obtain and maintain all Permits and any Permits required by Applicable Law to be obtained in the name of the Owner in order to (i) perform Owner'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

Owner 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 Owner

20.1 Owner 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 Owner 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 Owner 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 Owner shall not affect the Contractor's obligations to perform its obligations. Contractor.

21. Owner '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 Owner 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 Owner 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 Owner 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 Owner and the Contractor shall provide all reasonable assistance requested by the Owner in order to obtain such rights and benefits.

22. PRICE AND PAYMENT

22.1 Total Annual O&M Cost

Commencing on the Commencement Date and for the remainder of the Term, Owner 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 the Term of the Contract 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.

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 Owner 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 Owner 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 Owner no later thirty (30) days from the date of submission of the invoice along with all other requisite documents (If so required). The Owner 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 Owner 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 Owner within thirty (30) days from the date of submission of the invoice along with all other requisite documents (If so required).

23.4 In the event that the Owner fails to make any payment on its respective due date, the Owner shall pay to the Contractor interest on amount of such delayed payment at the rate as applicable for 46 days term deposit scheme as established by State Bank of India for Local currency payment and London Inter Bank Offered Rate (LIBOR) for Foreign currency payment, shall become payable as from the end of the 15 days period on certified amount due, but not paid, at the end of such period.

23.5 To the extent permitted by Applicable Laws, if the amount of an invoice is disputed by the Owner, the Owner 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 Owner shall pay at the applicable time the undisputed amount of such invoice including any undisputed portion of the invoice item in dispute. Further, the Owner 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 Owner to make any payment when due hereunder to Contractor or any other Person providing labour or services to the Project under Contract to the Owner, 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 Owner, 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 Owner against any loss, damage, cost or expense (including legal fees) of the Owner 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 EMS software, as required for the ongoing adequate operation of the Plant Facility. Such updates shall also be provided to the Owner 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 Owner 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 Owner 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 Owner 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:

a) Notify without delay to the Owner
b) 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.
c) Collaborate with Owner and the insurer and provide them with all information and documents they may request.
d) Arrange immediate reinstatement of the damage to the Owner's satisfaction, without waiting for the settlement for the corresponding insurance claim.

e) 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 Owner 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 Owner under the Contract. In the event if Contractor does not pay the premium, then the Owner 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 Owner. The Premium if paid by the Owner shall be recovered from the Annual O&M Fees payable by the Owner 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 Owner 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) **Owners 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 Owner'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 DISCOM/SLDC 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 Owner or any Owner'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 Owner or Owner'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 Owner. However, Owner shall have access to all such records at any time. Generation and O&M reports should be made available to Owner 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 Owner in the desired format as per the Contract with the Owner or Owner'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 Owner 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 Owner 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 Owner (or parties designated by the Owner) 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 Owner to all data for the Plant Facility from the EMS including the SCADA system.

xxvi) Contractor shall at all times allow and provide Owner 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 Owner's personnel in relation to the operation of the complete plant facility. Training shall be provided to the Owner 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 Owner including but not limited to the officials of the insurance company of the Owner, 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 Owner. All representatives of the Owner 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 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 Owner due to any deviation of actual generation from scheduling beyond the allowed limit. If any penalty is imposed on the Owner 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 Owner'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 Owner the CUF Guarantee on the terms and conditions set forth in the contract.

B. The Contractor guarantees the annual CUF committed herein over the O&M Period ("**Annual CUF Guarantee**") from the date of Operational Acceptance. In the event the CUF is less than the Guaranteed CUF, the Contractor shall immediately, upon demand, indemnify the Owner, as liquidated damages and not as penalty, amounts equivalent to remuneration of the equivalent Energy, subject to a maximum of hundred (100%) percent of the Total Annual O&M Price.

C. Capacity Utilization Factor (CUF) for Solar Plant shall be calculated as per the following formula.

$$\mathrm{CUF} = \frac{\mathrm{E_{ac}} + \mathrm{E_{outage}}}{8760 \times \mathrm{P_{ac}} \times [1 - \mathrm{DF} \times (\mathrm{N} - 1)] \times \mathrm{RCF}}$$

where,

E_{ac} = (Energy export recorded in the ABT meter) - (Energy import recorded in the ABT meter), kWh

E_{outage} is the energy adjusted for grid outage hours, kWh

$E_{outage} = 2 \times (E_b + E_a) \times Q_{outage}$

E_b is the energy export recorded in the ABT meter during complete 15-min period preceding the start of grid outage, kWh

E_a is the energy export recorded in the ABT meter during complete 15-min period succeeding the end of grid outage, kWh

Q_{outage} is the number of grid outage hours

(The Contractor shall submit grid outage certification from competent authority of STU/DISCOM).

8760 refers to the number of hours in non-leap year. It shall be replaced by 8784 hours during leap year

P_{ac} is the plant AC capacity, kW

DF is module degradation factor, 0.5% per year

N is the number of years of operation after operational acceptance of the plant

RCF is the Radiation Correction Factor:

$$RCF = \frac{Measured\ Irradiation}{Reference\ Irradiation'}$$

Reference Irradiation for the site = 1840 kWh/m^2/year

The Measured Irraditation (GHI_{mes}) shall be recorded from the Pyranometer installed in horizontal plane at the site location (average in case of multiple pyranometers). The radiation data of the Pyranometer shall be compared with the Reference Irradiation mentioned above. The radiation data from the Plant Pyranometer shall be used for computation of CUF, except in case of any discrepancy (i.e. more than ± 10% variation from the Reference Radiation, GHI_{ref}), in which case the radiation data from SolarGIS database for the said period will be used for computation of CUF. Missing data (GHI_{mes}) from the Plant Pyranometer shall be substituted by average of GHI measured for the same period in the past three (3) days. The plant Pyranometer has to be under CCTV coverage.

Note:

1. CUF shall be calculated on annual basis from the date of operational acceptance of the plant till the end of O&M period.
2. Module degradation factor will not be considered for first year CUF calculation. It is the Contactor's responsibility to envisage and install extra DC capacity to accommodate any degradation during first year.

D. Liquidated Damages for Shortfall in Annual CUF for Solar PV Plant

If the Contractor fails to achieve guaranteed annual CUF at the end of First Year, the Contractor shall pay compensation to the Owner (amount to be deducted from the Final Payment at the end of 1 year), an amount equal to the NPV of the estimated shortfall in cash flow resulting over the period of 25 years due to reduced Plant CUF, calculated at a tariff of Rs.3.5 per unit (kWh) and discount rate of 6.5%.

The Contractor may take corrective action during the ensuing year to demonstrate the guaranteed CUF at the end of the 2nd year. In such case, the part of the Final Payment withheld by the Owner on account of Liquidated Damages shall be released and the CUF shall remain unchanged from the tender specifications.

If the Contractor fails to demonstrate the guaranteed CUF at the end of 2nd Year as well, the CUF achieved at the end of First Year shall be fixed as the new Guaranteed CUF for the remaining period of this Contract.

Illustration:

Guaranteed Annual Energy (MWhs) after 1 Year (assuming RCF =1):

$$P_{ac} * 8760 * CUF_e * (1 - DF \times (N - 1))$$

= 100*8760*0.226*(1-0.007*(1-1)) = 1,97,976 MWh

If Actual Generation during First Year = 1,95,000 MWh i.e. CUF = 22.26%

Estimated Shortfall in Cash Flows over 25 years:

Year	Expected Energy as per Guaranteed CUF (MUs), A	Estimated Energy Based on First Year Performance (MUs), B	Estimated Shortfall in Revenue in Rs. Crores (A-B)*3.5/10, C
1	197.98	195.00	1.0424
2	196.59	193.63	1.0351
3	195.20	192.27	1.0278
4	193.82	190.90	1.0205
5	192.43	189.54	1.0133
6	191.05	188.17	1.0060
7	189.66	186.81	0.9987
8	188.28	185.44	0.9914
9	186.89	184.08	0.9841
10	185.50	182.71	0.9768
11	184.12	181.35	0.9695
12	182.73	179.98	0.9622

13	181.35	178.62	0.9549
14	179.96	177.25	0.9476
15	178.57	175.89	0.9403
16	177.19	174.52	0.9330
17	175.80	173.16	0.9257
18	174.42	171.79	0.9184
19	173.03	170.43	0.9111
20	171.65	169.06	0.9038
21	170.26	167.70	0.8965
22	168.87	166.33	0.8892
23	167.49	164.97	0.8819
24	166.10	163.60	0.8746
25	164.72	162.24	0.8673

LD applicable = NPV of Column C calculated at Discount Rate of 6.5%

= ₹ 11,92,75,343.67 (to be deducted from the final payment)

(i) In case the EPC Contractor takes corrective action and demonstrates guaranteed CUF at the end of 2nd Year i.e. :

LD Applicable = Shortfall in Generation in the First Year*Rs.3.5

= (197.98-195)*3.5/10 = Rs. 1.0424Cr.

The Balance Final Payment Amount shall be released to the EPC Contractor.

(ii) In case the EPC Contractor fails to demonstrate the guaranteed CUF at the end of 2nd Year, Annual CUF guarantee for the remaining period of the Contract shall be fixed as the CUF demonstrated at the end of First Year, as revised CUF. Liquidated Damages applicable in subsequent years, on account of shortfall in generation, shall be determined with reference to this revised CUF.

E. Incentives for excess Generation

(i) Any excess generation over and above the minimum Expected energy in an year, calculated as per the formula below, shall be entitled to an incentive of 50% of PPA tariff per unit of energy:

Minimum Expected Energy (MWhs) in Nth Year:

$$P_{ac} * 8760 * CUF_e * (1 - DF \times (N - 1))$$

Pac, Plant AC capacity (MW)	100
DF, Module degradation factor (%/year)	As per OEM Datasheet

N, Number of years of operation after operational acceptance of the plant	N= 1,2,3,…..15
CUFe, Guaranteed Annual CUF at the end of First Year (%)	22.6

(ii) The incentive under this Clause is subject to the upper limit of 110% of the Minimum Expected Energy in the Nth year (Refer (i) above).

Illustration:

The Minimum Expected Energy in 5th Year as per (i) = 100*8760*0.226*(1-0.007*(4))
= 1,92,432.672 MWh

PPA Tariff = Rs. 3.5/kWh

50% of PPA Tariff = 50% of Rs. 3.5/kWh = Rs. 1.75/kWh

Case I: Actual Energy generated in 5th Year = 2,10,000 MWh

110% of the Minimum Expected Energy in the 5th year = 110%* 1,92,432.672 = 2,11,675.9392 MWh

Since 2,10,000 < 2,11,675.9392

Generation Incentive = Rs. (2,10,000 - 1,92,432.672)*1000*1.75 = Rs. 3,07,42,824/-

Case II: Actual Energy generated in 5th Year = 2,15,000 MWh

Since 2,15,000 > 2,11,675.9392,

Generation Incentive = Rs. (2,11,675.9392- 1,92,432.672)*1000*1.75 = 3,36,75,717.6/-

Case III: Actual Energy generated in 5th Year = 1,90,000 MWh

Since 1,90,000 < 1,92,432.672

LD applicable as per Clause D = (1,92,432.672 - 1,90,000)*1000* 3.5 =

Rs. 85,14,352/-

F. 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.

G. 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 a Scope of Work for the Project (Section-VII: Scope of Works & Technical Specifications) 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 yearly O&M cost. Cumulative value of such penalty shall be limited to 50% of yearly O&M cost.

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**
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
Floats	Check for and replacement of leakages in floats, Repair and Maintenance of Bolts/joints	Once in every 6 months under the O&M Contract period
Anchoring & Mooring System	Check for the integrity of the anchors at the reservoir bed, the health of tethering hawsers, Repair and Maintenance of the same as required. Note : The employment of trained divers, safety equipment, necessary tools and tackles for survey, boats for access shall be	Once every year prior to Monsoon season, in Consultation with the Owner

	the responsibility of the Contractor	
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, RO system etc.	Once Every Year in Consultation with the Owner.
Measurement of Water BOD and COD	Water Biological and Chemical Demand Measurement	Once Every Year
Periphery Lighting	Repair and maintenance of Peripheral Lighting including replacement of non-functional lighting fixtures, Junction Boxes, Conduits etc.	Once every Six Months
Floating Platform for Transformer and Other Equipment	Repair and Maintenance	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	Tightening/fastening of bolts	Once every Year

structures	that are exposed to winds/vibrations like MMS members/foundation bolts	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.
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.*

H. Void

I. The Penalty specified on account of delays, as specified in Liquidated Damages and Penalty specified on account of deviations in Functional Guarantees as above shall be assessed independent of each other. Above mentioned Penalties specified under this clause of SCC are independent of each other.

Recovery of Compensation

The above compensations shall be deducted from Contract Performance Security (CPS) submitted by the developer.

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 Owner due to any deviation of actual generation from scheduling beyond the allowed limit. If any penalty is imposed on the Owner due to such deviations beyond allowed limit the same shall be recovered from the CPS given by the contractor.

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.

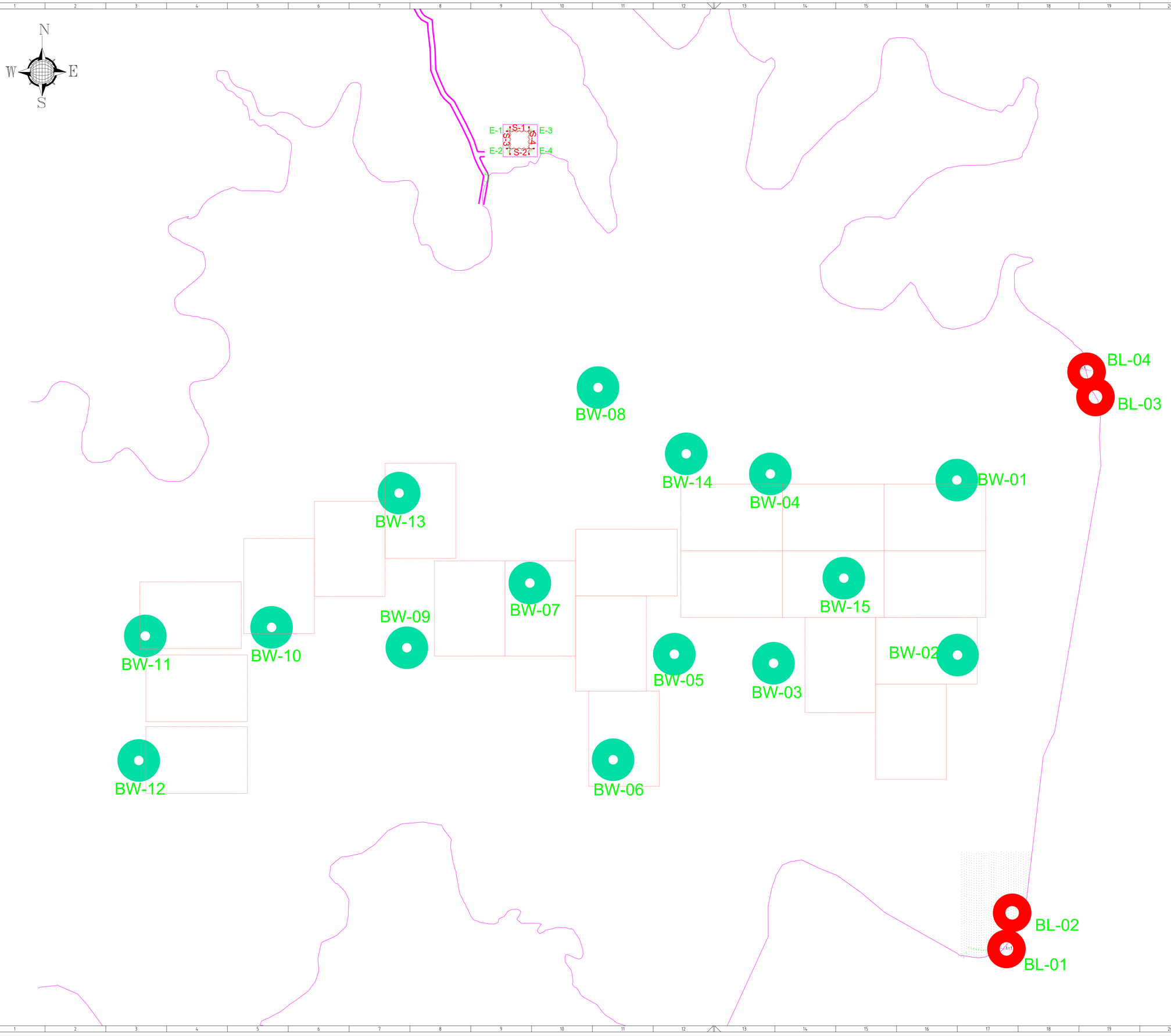
2.1 In case of any deviation due to forecasting and scheduling error, Contractor shall bear the cost/Penalty.

2.2 In case of localized thunderstorm/sand storm, SECI 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. SECI 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**



LEGEND:

	RESERVOIR AREA
S-1	SEISMIC REFRACTION TOMOGRAPHY
E-1 E-2	ERT TEST LOCATION
BW-01 BW-02	BORE HOLE TES LOCATION (WATER)
BL-01 BL-02	BORE HOLE TES LOCATION (LAND)
	PROPOSED SOLAR PANEL
	PROPOSED SUBSTATION AREA

BORE HOLE (WATER) COORDINATES

S.N	X	Y	Z	Test
1	351966	2595411	569.90	BW-01
2	351967	2594704	569.51	BW-02
3	351223	2594670	578.61	BW-03
4	351210	2595437	573.92	BW-04
5	350822	2594707	578.00	BW-05
6	350574	2594277	573.03	BW-06
7	350236	2594997	572.71	BW-07
8	350512	2595785	578.99	BW-08
9	349742	2594733	574.50	BW-09
10	349193	2594813	574.00	BW-10
11	348683	2594781	574.13	BW-11
12	348656	2594277	571.98	BW-12
13	349709	2595359	574.84	BW-13
14	350871	2595518	576.50	BW-14
15	351508	2595015	568.21	BW-15

BORE HOLE (LAND) COORDINATES

S.N	X	Y	Z	Test
1	352166	2593515	588.23	BL-1
2	352189	2593661	587.17	BL-2
3	352526	2595748	587.78	BL-3
4	352490	2595850	588.43	BL-4

Seismic Refraction Tomography Location

S.N.	Start		End		Test
	X	Y	X	Y	
1	350142	2596823	350257	2596823	S-1
2	350142	2596753	350257	2596753	S-2
3	350157	2596842	350157	2596727	S-3
4	350234	2596842	350234	2596727	S-4

ERT LOCATION

S.N	X	Y	Test
1	350157	2596823	E-1
2	350156	2596753	E-2
3	350234	2596822	E-3
4	350234	2596753	E-4

ANNEXURE-A

REV. NO.	DATE	MECH.	CIVIL	ELEC.	RE	DESCRIPTION
		CHECKED				

CLIENT: AGENCE FRANÇAISE DE DÉVELOPPEMENT (AFD) — SOLAR ENERGY CORPORATION OF INDIA LIMITED (A Government of India Enterprise)

CONSULTANT : TRACTEBEL ENGINEERING S.A.

CONTRACT NO :	PROJECT :	PREPARATORY STUDY FOR FLOATING SOLAR PV PLANT AT GETALSUD RESERVOIR IN JHARKHAND, INDIA
PREPARED / DRAWN BY / DESIGNED BY / CHECKED BY / APPROVED BY	NAME / DATE	
SHEET SIZE: A0	DRAWING TITLE :	BORE HOLE LOCATION PLANT AT GETALSUD RESERVOIR
SCALE: 1:5000	DRAWING NO :	ANNEXURE-A — REV. 00 — SHEET 01

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE	ELEVATION	DEPTH	DATE	WATER DEPTH	LOCATION	BORE HOLE	ANNEXURE C
			2595411 N 351966 E	569.90	7.0 m	29.01.2020	16.10m	Reservior	BW-01	

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	13	-		2	19	68	11	32	22	10	19	1.99	1.58	25.8	2.67	8		UU	0.55	8	0.69	0.104	0.04
SPT DS	3.0 4.0			16	-		3	18	69	10	31	22	9	20												
SPT UDS	5.0			27	-		3	16	62	19	33	23	10	19	2.01	1.63	23.6	2.65	6		UU	0.95	6	0.63	0.087	
CORE	6.0		Whitish gray highly weathered Micaceous Phyllite Rock	CR=4%																						
DS	7.0						8	85	7	0	*Non- Plastic*															
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2594704N 351972E	ELEVATION 569.51	DEPTH 7.0 m	DATE 12.01.2020	WATER DEPTH 16.50m	LOCATION Reservior	BORE HOLE BW-02	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	15	-		0	21	67	12	32	22	10	19	2.00	1.60	24.9	2.66	8		CD	0.35	21	0.66	0.102	0.03
SPT DS	3.0			18	-		2	19	69	10	31	22	9	20												
SPT UDS	4.0			24	-		2	17	69	12	32	22	10	19	2.01	1.62	24.1	2.66	6		UU	1.05	8	0.64	0.097	
CORE	5.0		Whitish gray highly weathered Micaceous Phyllite Rock	CR=4%																						
DS	6.0						6	85	9	0	*Non- Plastic*															
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
CD Triaxial test Consolidated drained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE	ELEVATION	DEPTH	DATE	WATER DEPTH	LOCATION	BORE HOLE	ANNEXURE C
TRACTEBEL ENGIE		2594670N 351233E	578.61 (1)	7.0 m	18.01.2020	7.40m	Reservior	BW-03	

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
CORE	2.0		Whitish gray highly weathered Micaceous Phyllite Rock	CR=8%			9	84	7	0	*Non- Plastic*															
DS							RQD=0%																			
CORE	3.0			CR=48%			Mohs hardness index Hg = 4								2.17	2.07	4.7	2.83			Porosity =		0.27			
	4.0						RQD=38%				UCS = 185 kg/cm^3				Slake durability = 42%						Point Load strength = 23kg/cm^2					
CORE	5.0		Whitish gray fine grained Micaceous Phyllite Rock	CR=74%			RQD=56%																			
	6.0						Mohs hardness index Hg = 5								2.18	2.09	4.5	2.78			Porosity =		0.25			
CORE				CR=82%			RQD=68%				UCS = 235 kg/cm^3				Slake durability = 78%						Point Load strength = 29kg/cm^2					
CORE	7.0			CR=89%			RQD=74%																			
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE

SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE	ELEVATION	DEPTH	DATE	WATER DEPTH	LOCATION	BORE HOLE	ANNEXURE C
		2595437N 351210E	573.92	7.0 m	27.01.2020	12.10m	Reservior	BW-04	

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	9	-		3	18	71	8	30	22	8	19	2.03	1.65	23.2	2.67	4		UU	0.75	5	0.62	0.098	0.04
SPT DS	3.0 4.0			14	-		4	18	68	10	29	22	7	20												
SPT UDS	5.0			18	-		3	19	65	13	33	23	10	18	2.04	1.67	22.4	2.67	6		CU	1.25	7	0.60	0.087	
SPT	6.0			21	-																					
SPT	7.0			36	-		4	16	69	11	31	22	9	21												
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE

SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE	ELEVATION	DEPTH	DATE	WATER DEPTH	LOCATION	BORE HOLE	ANNEXURE C
		2592007N 350822E	577.81 (1)	7.0 m	21.01.2020	8.10m	Reservior	BW-05	

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'K' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_0	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Silty clay of low plasticty (CL)				2	13	72	13	29	22	7	21												
SPT	2.0		Whitish gray highly weathered Micaceous Phyllite Rock	>100			3	92	5	0		*Non- Plastic*			1.92	1.61	19.5	2.65			DST*	0.00	32	0.65		
CORE DS	3.0 4.0			CR=6%			9	87	4	0		*Non- Plastic*			1.92	1.60	19.7	2.64			DST*	0.00	34	0.65		
CORE	5.0			CR=11%			RQD=0%																			
							Mohs hardness index Hg = 5								2.13	2.04	4.6	2.73			Porosity =		0.25			
CORE	6.0		Whitish gray fine grained Micaceous Phyllite Rock	CR=62%			RQD=43%																			
CORE	7.0			CR=69%			RQD=55%																			
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

UCS = 165 kg/cm^3

Slake durability = 43%

Point Load strength = 22kg/cm^2

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2594277N 350574E	ELEVATION 573.03	DEPTH 7.0 m	DATE 22.01.2020	WATER DEPTH 12.90m	LOCATION Reservior	BORE HOLE BW-06	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	14	-		0	17	69	14	35	23	12	18	1.99	1.59	25.4	2.67	4		UU	0.45	7	0.68	0.098	0.03
SPT DS	3.0			17	-		2	15	71	12	33	23	10	19												
SPT UDS	4.0			28	-		6	19	64	11	31	22	9	18	2.00	1.61	24.5	2.66	6		UU	0.95	5	0.65	0.084	
CORE	5.0		Whitish gray highly weathered Micaceous Phyllite Rock	CR=9%																						
DS	6.0						8	88	4	0	*Non- Plastic*															
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2594997N 350236E	ELEVATION 572.71	DEPTH 7.0 m	DATE 23.01.2020	WATER DEPTH 13.30m	LOCATION Reservior	BORE HOLE BW-7	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_0	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	17	-		0	19	73	8	32	22	10	21	1.99	1.59	25.4	2.67	4		UU	0.60	7	0.68	0.097	0.03
SPT DS	3.0			19	-		4	16	71	9	33	23	10	19												
SPT CORE	4.0			>100																						
DS CORE	5.0			CR=7%			8	88	4	0	*Non- Plastic*															
DS	6.0		Whitish gray highly weathered Micaceous Phyllite Rock	RQD=0% CR=11%			8	87	5	0	*Non- Plastic*				1.91	1.59	20.1	2.65			DST*	0.00	33	0.67		
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2595785N 350512E	ELEVATION 578.99	DEPTH 7.0 m	DATE 27.01.2020	WATER DEPTH 7.10m	LOCATION Reservior	BORE HOLE BW-08	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Silty clay of low plasticty (CL)				4	16	71	9	31	22	9	19												
SPT	2.0		Whitish gray highly weathered Micaceous Phyllite Rock	>100			8	87	5	0		*Non- Plastic*			1.82	1.58	15.3	2.65			DST*	0.00	32	0.68		
CORE	3.0			CR=8%																						
DS	4.0						7	87	6	0		*Non- Plastic*			1.81	1.57	15.6	2.65			DST*	0.00	34	0.69		
CORE	5.0			CR=13%			RQD=0%																			
CORE	6.0		Whitish gray fine grained Micaceous Phyllite Rock	CR=23%			RQD=12% Mohs hardness index Hg = 4								2.11	2.01	4.8	2.73		Porosity =		0.26				
CORE	7.0			CR=59%			RQD=43%				UCS = 145 kg/cm^3				Slake durability = 33%					Point Load strength = 19kg/cm^2						
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 3594733N 349742E	ELEVATION 574.50	DEPTH 7.0 m	DATE 25.01.2020	WATER DEPTH 11.50m	LOCATION Reservior	BORE HOLE BW-09	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Silty clay of low plasticty (CL)				3	14	76	7	31	22	9	19												
SPT	2.0		Whitish gray highly weathered Micaceous Phyllite Rock	56	35		6	87	7	0	*Non- Plastic*				1.83	1.59	15.2	2.66			DST*	0.00	31	0.67		
CORE	3.0			CR=8%																						
DS	4.0						8	89	3	0	*Non- Plastic*				1.84	1.61	14.5	2.64			DST*	0.00	33	0.64		
CORE	5.0			CR=13%			RQD=0%																			
CORE	6.0		Whitish gray fine grained Micaceous Phyllite Rock	CR=28%			RQD=11% Mohs hardness index Hg = 3								2.13	2.03	4.7	2.73			Porosity =		0.26			
	7.0			CR=61%			RQD=38%				UCS = 160 kg/cm^3				Slake durability = 28%						Point Load strength = 219kg/cm^2					
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE	ELEVATION	DEPTH	DATE	WATER DEPTH	LOCATION	BORE HOLE	ANNEXURE C
			2594813N 349193E	574.00	7.0 m	24.01.2020	12.0m	Reservior	BW-10	

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	14	-		3	15	71	11	34	23	11	18	2.01	1.61	24.7	2.67	4		UU	0.65	6	0.66	0.093	0.02
SPT DS	3.0			21	-		0	17	73	10	32	22	10	19												
SPT CORE	4.0			>100																						
CORE	5.0			CR=7%			11	82	7	0		Non- Plastic														
DS	6.0		Whitish gray highly weathered Micaceous Phyllite Rock	RQD=0% CR=11%			16	82	2	0		Non- Plastic			1.96	1.61	21.8	2.64		DST*	0.00	34	0.64			
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2594781N 348683E	ELEVATION 574.13	DEPTH 7.0 m	DATE 25.01.2020	WATER DEPTH 11.80m	LOCATION Reservior	BORE HOLE BW-11	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ——— Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	14	-		0	21	69	10	31	22	9	18	1.99	1.59	25.4	2.67	4		UU	0.65	8	0.68	0.102	0.02
SPT DS	3.0			14	-		0	19	68	13	33	23	10	19												
SPT UDS	4.0			34	-		4	18	68	10	32	22	10	18	2.01	1.62	24.0	2.65	6		UU	0.95	6	0.64	0.085	
CORE	5.0		Whitish gray highly weathered Micaceous Phyllite Rock				RQD=0%																			
DS	6.0				CR=9%		8	85	7	0		*Non- Plastic*														
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2594277N 348656E	ELEVATION 571.98	DEPTH 7.0 m	DATE 26.01.2020	WATER DEPTH 14.20m	LOCATION Reservior	BORE HOLE BW-12	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	16	-		0	18	72	10	32	22	10	19	2.00	1.60	25.0	2.67	4		UU	0.75	6	0.67	0.081	0.03
SPT DS	3.0			33	-		3	17	69	11	33	23	10	18												
SPT CORE	4.0			>100																						
CORE	5.0		Whitish gray highly weathered Micaceous Phyllite Rock	CR=7%			9	88	3	0	*Non- Plastic*															
DS	6.0			RQD=0% CR=12%			11	85	4	0	*Non- Plastic*				1.95	1.59	22.6	2.65			DST*	0.00	32	0.67		
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2595359N 349709E	ELEVATION 574.84	DEPTH 7.0 m	DATE 26.01.2020	WATER DEPTH 11.10m	LOCATION Reservior	BORE HOLE BW-13	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	18	-		0	18	69	13	33	23	10	19	2.02	1.63	23.9	2.67	6		UU	0.75	6	0.64	0.094	0.04
SPT DS	3.0			21	-		5	21	62	12	30	22	8	17												
SPT CORE	4.0			>100																						
CORE	5.0			CR=9%			8	87	5	0	*Non- Plastic*															
DS	6.0		Whitish gray highly weathered Micaceous Phyllite Rock	RQD=0%																						
	7.0			CR=8%			7	89	4	0	*Non- Plastic*				1.97	1.62	21.5	2.64		DST*	0.00	32	0.63			
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2595518N 350871E	ELEVATION 576.50	DEPTH 7.0 m	DATE 30.01.2020	WATER DEPTH 9.50m	LOCATION Reservior	BORE HOLE BW-14	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	15	-		0	21	69	10	32	22	10	19	2.01	1.61	24.7	2.67	6		UU	0.55	8	0.66	0.103	0.03
SPT DS	3.0			18	-		3	21	67	9	31	22	9	18												
SPT UDS	4.0			26	-		4	15	71	10	33	23	10	18	2.01	1.63	23.6	2.65	6		UU	0.95	6	0.63	0.093	
CORE	5.0		Whitish gray highly weathered Micaceous Phyllite Rock				RQD=0%																			
DS	6.0			CR=6%			6	88	6	0	*Non- Plastic*															
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2595015N 351508E	ELEVATION 568.21	DEPTH 7.0 m	DATE 31.01.2020	WATER DEPTH 17.80m	LOCATION Reservior	BORE HOLE BW-15	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Accumulated river sediments																							
SPT UDS	2.0		Dark redish clayey silt of low plasticity with small gravels (CL)	17	-		2	19	67	12	32	22	10	18	2.01	1.62	24.3	2.67	6		UU	0.65	8	0.65	0.940	0.02
SPT DS	3.0			19	-		4	17	68	11	31	22	9	19												
SPT UDS	4.0			26	-		4	15	73	8	29	22	7	19	2.03	1.64	23.5	2.67	4		UU	0.85	6	0.63	0.087	
SPT	5.0			29	-																					
SPT	6.0			32	-		6	88	6	0	*Non- Plastic*															
	7.0																									
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2593515N 352166E	ELEVATION 588.23	DEPTH 7.0 m	DATE 01.02.2020	WATER TABLE 3.20m	LOCATION Right Bank	BORE HOLE BL-01	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Dark redish clayey silt of low plasticity with small gravels (CL)				0	15	73	12	33	23	10	18												
SPT UDS	2.0			14	-		0	21	66	13	31	22	9	18	1.82	1.58	15.5	2.67	6		UU	0.45	9	0.69	0.970	0.02
SPT DS	3.0 4.0			21	-		4	18	67	11	33	23	10	20												
SPT UDS	5.0			28	-		0	15	73	12	33	23	10	19	1.93	1.61	19.7	2.67	4		UU	0.85	6	0.66	0.091	
SPT	6.0			27	-																					
SPT	7.0			35	-		4	13	72	11	31	22	9	20												
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2593661N 352189E	ELEVATION 587.17	DEPTH 7.0 m	DATE 01.02.2020	WATER TABLE 2.20m	LOCATION Right Bank	BORE HOLE BL-02	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded _____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Dark redish clayey silt of low plasticity with small gravels (CL)				0	17	72	11	32	22	10	20												
SPT				15	-																					
UDS	2.0						0	19	69	12	31	22	9	19	1.82	1.57	15.7	2.67	4		UU	0.55	9	0.70	0.102	0.03
	3.0																									
SPT				21	-		2	21	67	10	32	22	10	18												
DS	4.0																									
SPT	5.0			23	-																					
UDS							0	16	73	11	33	23	10	19	1.93	1.62	19.4	2.67	6		UU	0.95	6	0.65	0.092	
SPT	6.0			27	-																					
	7.0																									
SPT				33	-		3	16	69	12	31	22	9	18												
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2595748N 352526E	ELEVATION 587.78	DEPTH 7.0 m	DATE 02.02.2020	WATER TABLE 2.80m	LOCATION Left Bank	BORE HOLE BL-03	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---------- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Silty clay of low plasticty (CL)				3	21	68	8	29	22	7	18												
SPT	2.0		Whitish gray highly weathered Micaceous Phyllite Rock	>100			12	86	2	0		*Non- Plastic*			1.79	1.59	12.5	2.64			DST*	0.00	32	0.66		
CORE	3.0			CR=07%			RQD=0%																			
DS	4.0						16	79	5	0		*Non- Plastic*			1.85	1.61	14.6	2.65			DST*	0.00	33	0.65		
CORE	5.0			CR=23%			RQD=13%																			
CORE	6.0		Whitish gray fine grained Micaceous Phyllite Rock	CR=34%			RQD=22% Mohs hardness index Hg = 3								2.13	2.03	4.7	2.73			Porosity =		0.26			
CORE	7.0			CR=71%			RQD=32%				UCS = 135 kg/cm^3				Slake durability = 29%						Point Load strength = 17kg/cm^2					
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples

TRACTEBEL ENGIE	SOIL PROFILE	Soil Investigation for proposed FSPV Project at Gelalsud reservoir in Jharkhand, India	COORDINATE 2595850N 352490E	ELEVATION 588.43 (1)	DEPTH 7.0 m	DATE 02.02.2020	WATER TABLE 3.40m	LOCATION Left Bank	BORE HOLE BL-04	ANNEXURE C

TYPE OF SAMPLES	DEPTH BELOW NGL (m)	SUB SOIL PROFILE	SOIL DESCRIPTION AND ITS CLASSIFICATION	SPT 'N' VALUE		PLOT OF SPT 'N' VALUES	GRAIN SIZE DISTRIBUTION				ATTERBERGS' LIMIT				DENSITY (gm/cm^3)		NATURAL MOISTURE CONTENTS (%)	SPECIFIC GRAVITY	FREE SWELLING	PERMEABILITY TEST 'k' x 10^{-5} (cm/sec)	SHEAR PARAMETER			CONSOLIDATION PARAMETER		
				RECORDED	CORRECTED	Recorded ____ Corrected ---- 20 40 60 80	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SHRINKAGE LIMIT	BULK DENSITY	DRY DENSITY					TYPE OF TEST	COHESION C (Kg/cm^2)	FRICTION ANGLE ϕ	VOID RATIO e_o	COMPRESSION INDEX C_c	SWELLING PRESSURE (Kg/cm^2)
DS	1.0		Whitish gray highly weathered Micaceous Phyllite Rock																							
SPT	2.0			>100			8	87	5	0		*Non- Plastic*			1.81	1.62	12.0	2.65			DST*	0.00	33	0.64		
CORE	3.0			CR=09%			RQD=0%																			
DS	4.0						Mohs hardness index Hg = 3								2.13	2.04	4.6	2.73			Porosity =		0.25			
CORE	5.0			CR=42%			RQD=18%				UCS = 145 kg/cm^3				Slake durability = 26%						Point Load strength = 18kg/cm^2					
							RQD=24%																			
CORE	6.0		Whitish gray fine grained Micaceous Phyllite Rock	CR=48%			Mohs hardness index Hg = 4								2.15	2.06	4.5	2.73			Porosity =		0.25			
CORE	7.0			CR=66%			RQD=32%				UCS = 185 kg/cm^3				Slake durability = 35%						Point Load strength = 24kg/cm^2					
	8.0																									
	9.0																									
	10.0																									
	11.0																									
	12.0																									
	13.0																									
	14.0																									
	15.0																									

SPT Standerd Penetration test
CORE Rock core samples
UDS Undistrebd sample
DS Disturmbed sample
DST Direct shear Test
UU Triaxial test Undrained
CR Core recovery
RQD Rock Quality Digignation
* Test on remoulded samples