SECTION - VII

A.SCOPE OF WORKS (SOW)

1 Introduction

1.1 Project Particulars:

Particulars	Description
Design & Engineering	
AC capacity of the solar power plant	5 MW AC
Technology	(Mono/ Multi crystalline)
O&M Period	10 Years
Estimated life of PV Power plant	25 years
Location/Site Details	
Location	VoCPT Port Trust Premises **Site Co-ordinates:** Latitude: 8º 45' N Latitude: 78º 12' E Altitude: 2m
Type of Land	Government Land
Ownership	VoCPT
District	Thoothukudi (Tuticorin)
State	Tamil Nadu
Electrical Interconnection Details	
Nearest Substation Details	230/110/22kV Auto S/s, Muthaiapuram
Distance to connecting substation	4 km
Access	
Nearest Urban Area	Tuticorin
Nearest Highway	NH – 7A to Madurai
Nearest Railway Station	Tuticorin
Nearest Domestic Airport	Tuticorin
Performance Parameters	
Minimum values of PR and CUF of the plant after netting off the auxiliary consumption.	PR : 78% CUF : 20%
Other Details	
Water and Power for Construction	To be arranged by the Contractor

Scope of Supply and Work

2 Brief Scope of Work

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 5MW (AC) Grid Interactive Solar PV Power Plant and performance demonstration with associated equipment and materials on turnkey basis at V. O. Chidambarnar Port Trust , Tuticorin (TN) and 10 (Ten) years comprehensive operation and maintenance from the date of Operational Acceptance.

All works shall be executed as per provisions of Section – VI 'Technical Specifications'

3 Design and Engineering:

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

3.2 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
- Detailed technical specifications (GTP) of all the equipment
- General arrangement and assembly drawings of all major equipment
- Schematic diagram for entire electrical system
- GTP & GA drawings for all types of structures/ components, protection switchgears & other interfacing panels
- Test reports (for type, routine and acceptance tests)
- Relay setting charts
- Design calculations and sheets (licenced software as well as design templates)
- Shadow analysis
- Concrete mix design report for various grades of concrete to be used for construction
- Geo technical investigation and Topographical survey report including topographical survey data in digital format (Excel file) and Contour plan of the area
- Overall plant layout
- GA, & detail drawings for architectural, civil, structural and RCC works for the entire project which shall include various buildings and facilities like compact sub-station for inverter and switchgear, control room, roads, storm water drainage, sewage, 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
- Quality assurance plans for manufacturing (MQP) 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 manuals for major equipment
- As-built drawings / documents and deviation list from good for construction (GFC)

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

3.4 Design of associated civil, structural, electrical & mechanical auxiliary systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for civil, structural & RCC works 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 etc. Design basis & calculation sheets, and other relevant drawings and documents not covered above but are required for engineering of all facilities within the scope and satisfactory performance of the plant shall be provided.

3.5 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 & Supply

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

4.1.1 Adequate capacity of Solar PV modules of suitable rating including module mounting structures (fixed), fasteners, MMS foundation and module interconnection.

4.1.2 Array Junction boxes, distribution boxes and Fuse boxes: MCBs/ isolators, Surge Arrestors with string monitoring capabilities and with proper lugs, glands, ferrules, terminations and mounting structures.

4.1.3 DC and AC cables of appropriate sizes with adequate safety and insulation

4.1.4 Power Conditioning Units (PCU) with SCADA compatibility, common AC power evacuation panel with bus bars and circuit breakers LT & HT Power Interfacing Panels, Plant Monitoring Desk, AC & DC Distribution boards.

4.1.5 Containerized Sub – Station (CSS) comprising of LT switchgear unit (s), protection and metering units/ compartments, unit batteries and battery chargers, auxiliaries such as HVAC and fire suppression systems, as applicable, step-up transformers to match utility

grid, HT switchgear unit, Control Systems etc. with Power and Energy ratings, details of which are as specified in Part – II of Technical specifications.

4.1.6 Step – up transformers (inverter duty – as part of CSS) in relevance with state grid code and inverter manufacturer requirements.

4.1.7 Auxiliary transformer (s) for internal consumption, as part of CSS.

4.1.8 Metering and protection system along with its battery system, as part of CSS.

4.1.9 LT Power and Control Cables including end terminations and other required accessories for both AC & DC power.

4.1.10 Internal 415V interconnection & Indoor feeder panels to cater auxiliary needs of plant

4.1.11 Indoor switchgear and panels having incoming and outgoing feeders with VCBs, CTs, PTs, Bus bars, cables terminals kits and bus section panel. The control and relay panel should form integral part of the switchgear (i.e., should be physically integrated into one unit). The switchgear will be installed in a separate switchgear room, as part of CSS.

4.1.12 ABT meters (Main and Check) with all necessary metering rated CT's and PT's at the plant take off point as well as at the substation as per CEA Metering Regulation 2006 as amended time to time and state metering code.

4.1.13 Data acquisition system with remote monitoring facilities. Provision for specific data transfer to the State Load Dispatch Centre (SLDC) shall also be provided. Cost towards provision of data over TCP/IP at Jurisdiction LD centre (JLDC) end either by VSAT or any other communication shall be borne by the Contractor.

4.1.14 Lightning arrestors for entire plant area.

4.1.15 PVC pipes, cable conduits, cable trays and accessories/trenches.

4.1.16 Earthing of the entire plant as per relevant standards.

4.1.17 Control room equipment

4.1.18 Testing instruments for maintenance and monitoring of equipment.

4.1.19 Spares & consumables, as required or recommended, for the complete O&M period.

4.1.20 CCTV cameras for plant surveillance. The CCTV connectivity is to be linked with surveillance monitoring system of VOCPT Admin Building.

4.1.21 Fire protection system in buildings and fire extinguishers.

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

- Pyranometers – for horizontal and tilted plane
- Ultrasonic Anemometer (wind speed and direction)
- Temperature Sensor – Ambient and module surface
- Power source to the all sensors
- Data Logger

4.1.23 Construction of suitable structures for termination of transmission line for taking off from

plant end and receipt of lines at Substation end.

4.1.24 Design & construction of Transmission line/ cable from plant take off point to the designated substation including right of way (ROW). Estimated length for the overhead transmission line is 3.2km and 22kV grade UG cable is 0.8km. The UG cable shall also pass under an existing railway siding of SPIC Chemical factory (Refer Annexure: Site Details)

4.1.25 Materials and accessories, which are required for satisfactory and trouble-free operation and maintenance of the above equipment.

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

5 Construction and Erection Works

5.1 The items of civil design and construction work shall include all works required for solar PV project and should be performed specifically with respect to following but not limited to:

5.1.1 Conducting detailed geotechnical investigations and topographical survey of the total area, and initial load tests for piles including submission of test reports

5.1.2 Clearing plant site and TL corridor by cutting of trees, bushes and shrubs including disposal of waste material

5.1.3 Earthwork for site levelling & grading including dozing off the ground to make it fairly flat including compaction

5.1.4 Slope protection works for existing drain along the side of Gulf of Mannar and drain at bus station end

5.1.5 Construction and erection of perimeter & transformer yard fence, main gate, security room etc. (refer Annexure: Site details)

5.1.6 Construction of foundation for various facilities like MMS structures, compact sub-station, control room, TL structures, transformer, weather monitoring station, SMU, street light poles etc. (refer Annexure: Site details)

5.1.7 Manufacture, packaging, transport and installation of MMS structure for SPV panels

5.1.8 Construction of approach road, peripheral road and internal roads with WBM base including associated culverts at plant drainage (refer Annexure: Site details)

5.1.9 Construction of Control building with SCADA cum supervisor room, pantry, wash room, store room etc. along with requisite furniture, workstations, air conditioning, internal and external illumination & finishing, other equipment etc. as per the specifications (refer Annexure: Site details)

5.1.10 Watchman cabin (s) at strategic locations inside the boundary.

5.1.11 Suitable arrangement of water shall be ensured to cater to day-to-day requirement of drinking water and permanent water supply for module cleaning and other needs of SPV

power Plant during entire O&M period (refer Annexure: Site details)

5.1.12 Water storage tank for storage of water for drinking and module cleaning system

5.1.13 Suitable Communication System for SCADA with remote monitoring capabilities and internet facility.

5.1.14 Construction of storm water drainage & sewage, water supply and module cleaning system, rain water harvesting.

5.1.15 Erection of Perimeter lighting along with all accessories and cabling

5.1.16 Laying of underground / over ground Cables (all types) with proper arrangements along with appropriate sized ferrules, lugs, glands and terminal blocks. Laying of cables inside the building trench and other locations as required shall be over GI cable trays with proper support and accessories

5.1.1 Construction of transmission line and laying of cable as per the evacuation route plan, from take-off point at plant to the delivery point at STU/DISCOM substation including laying of UG cable at railway siding of SPIC chemical factor through 250 dia. GI pipe to be laid (top of pipe at min. 1.0m below the rail sleeper) through horizontal drilling technology.

5.1.2 Suitable earthing for plant along with earth pits as per standards

5.1.3 All approvals, for equipment, items and works, which are not otherwise specifically mentioned in this document but are required for successful completion of the work in all aspects, including construction, commissioning, O&M of Solar PV Power Plant and guaranteed performance are deemed to be included in the scope of the contractor.

6 Statutory Approvals

6.1 Obtaining statutory approvals /clearances on behalf of the Employer from various Government Departments, not limited to, the following:

6.1.1 Pollution control board clearance, if required

6.1.2 Mining Department, if required

6.1.3 Forest Department, if required

6.1.4 All other approval, as necessary for setting up of a solar power plant including CEIG/ CEA, connectivity, power evacuation, railways, PTCC etc. as per the suggested guidelines

6.1.5 All other statutory approvals and permissions, not mentioned specifically but are required to carry out hassle free Construction and O&M of the plant prevailing at Site.

6.1.6 Adequate and seamless insurance coverage during EPC and O&M period to mitigate all risks related to construction and O&M of the plant to indemnify the Employer.

6.2 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.

7 Operation and Maintenance

7.1 Total Operation & Maintenance of the Plant and Equipment shall be with the Contractor, after commissioning of the plant till final acceptance which shall include deployment of engineering personnel, technicians and security personnel.

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

7.3 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.

7.4 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.

7.5 To maintain accurate and up-to-date operating logs, records and monthly Operation & Maintenance reports at the facility. Contractor shall keep the measured daily data at regular intervals and provide the same to Employer in electronic form, compatible in CSV format. The right to use the data shall remain with the Employer.

7.6 Procurement of spare parts, overhaul parts, tools & tackles, equipment, consumables, etc. required for smooth operation and maintenance of the Plant and Equipment as per prudent/ standard utility practices, OEM recommendations and warranty clauses for the entire O&M period

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

7.8 To carry out periodic overhauls or maintenance required as per the recommendations of the original equipment manufacturer (OEM) and to furnish all such periodic maintenance schedules at the time of plant commissioning/ start of O&M contract.

7.9 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.

7.10 Availability of vehicles for Employer 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.

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

- Deputation of qualified and experienced engineers and technicians at the facility.
- Deputation of Security personnel for the complete security of plant (including each site).
- 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.
- Replacement of Modules, Inverters/ PCU's and other equipment as and when required during the O&M period without additional cost to Employer.

7.12 Continuous monitoring the performance of the Plant and Equipment 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.

7.13 Preventive and corrective O&M of the Plant and Equipment 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.

7.14 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 Plant and Equipment 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 period of minimum 10 (ten) years.

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

7.16 The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his or his sub-contractor or Employer's Workmen. This will include procurement of all

safety gadgets during Construction and O&M period including but not limited to, rubber mats of appropriate grade, PPE, rubber gloves and shoes etc.

8 Operation and Performance Monitoring

8.1 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.

8.2 Daily work of the operation and maintenance in the Solar Photovoltaic Power Plant involves periodic cleaning of Modules, 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 for SPV plant.

8.3 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.

8.4 A maintenance record is to be maintained by the operator/engineer-in-charge to record the regular maintenance work carried out as well as any breakdown maintenance along with the date of maintenance reasons for the breakdowns steps have taken to attend the breakdown duration of the breakdown etc.

8.5 The 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. An information shall be provided to Engineer-in-charge for such operation prior to start.

8.6 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) at O&M period, the Contractor shall immediately report the accidents, if any, to the Engineer In-charge showing the circumstances under which it happened and the extent of damage and or injury caused.

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

8.8 If negligence / mal operation of the contractor's operator results in failure of equipment such equipment should be repaired replaced by contractor at free of cost.

9 Security services

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 individual site. 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.

All the information shown here is indicative only and may vary as per design and planning by the Contractor. The Contractor must provide the BOM of the plant as per the design during the time of bidding.

Annexure – A

Pre-dispatch Inspection Protocol for Crystalline PV Modules by Employer or Employer Deputed Agency

On behalf of

By:

SOLAR ENERGY CORPORATION OF INDIA

(A Government of India Enterprise)

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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. Standard:

Sampling for determining Acceptance Quality Level (AQL) shall follow ISO2859-1:1999.

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 7 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: • EVA • PV Module Back sheet • Sealant and potting material (Silicone)	1. 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-II. 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 calibrated as per Calibration Reference .Reference should calibrated against Calibration Reference tested from reputed testing lab TUV / Fraunhofer etc. Testing of modules will be done at STC condition, AM=1.5

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)

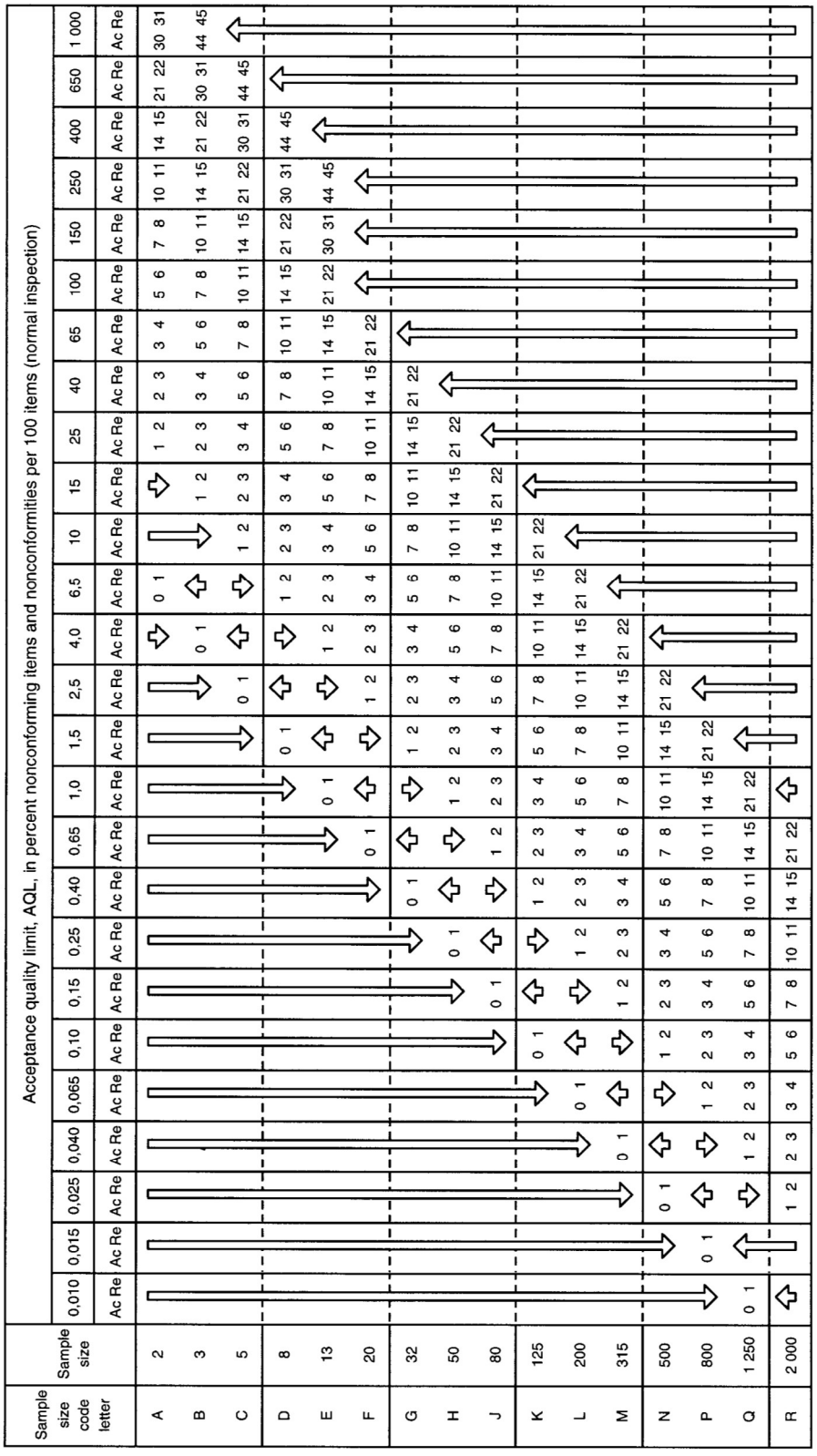


Table 2-B — Single sampling plans for tightened inspection (Master table)

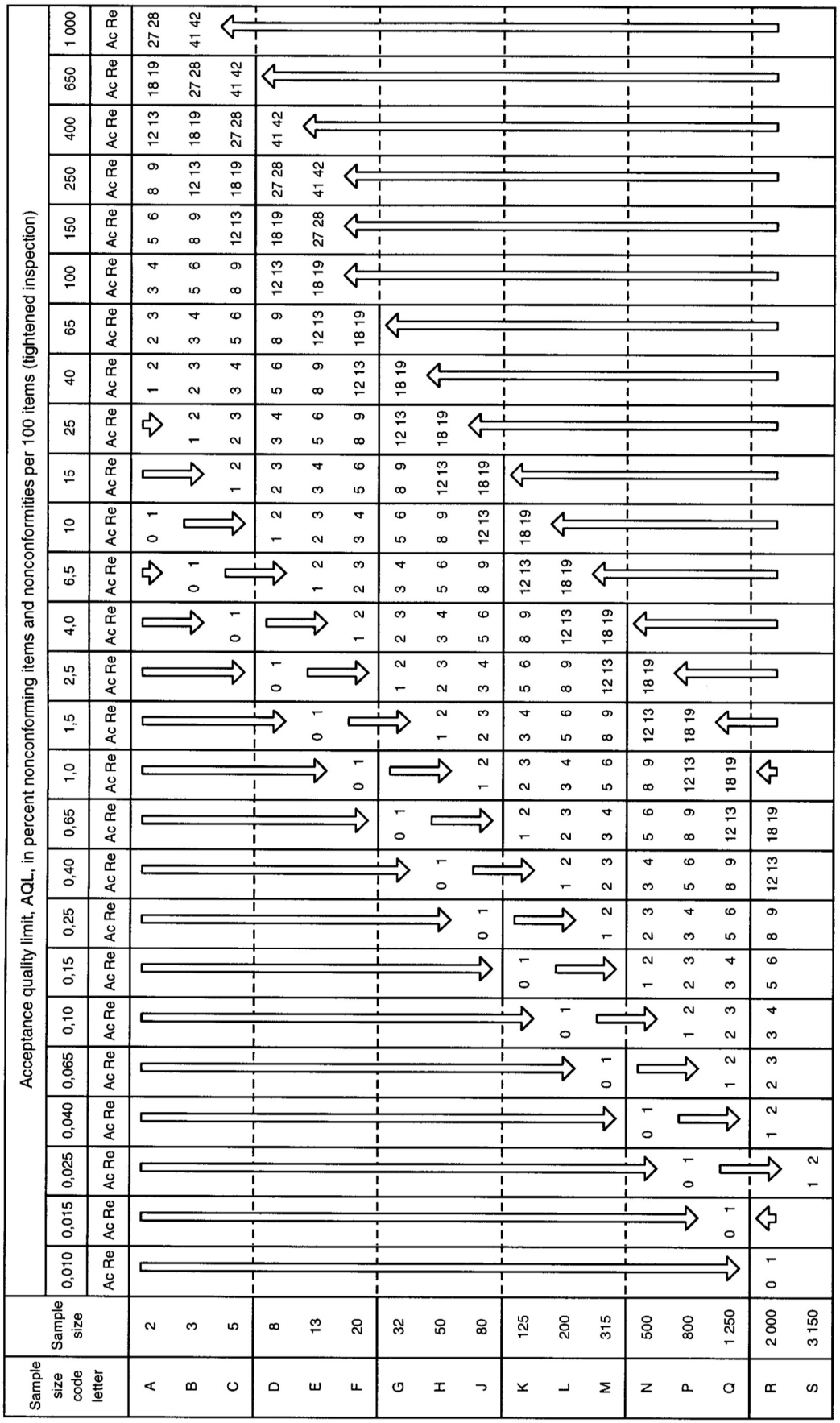


Table 2-C — Single sampling plans for reduced inspection (Master table)

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	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

PG Test Procedure

On behalf of

By:

SOLAR ENERGY CORPORATION OF INDIA

(A Government of India Enterprise)

I[st] floor, Wing A, Religare Building, D – 3, District Centre, Saket, New Delhi – 17

Tel: 011 – 71989224, Fax: 011 – 71989241

Doc. Ref. No. SECI/SD/PV/PGT v 2.0

PERFORMANCE GURANTEE TEST PROCEDURE

Project:

Employer:

TABLE OF CONTENTS

1 INTRODUCTION

This document lays down the procedures and requirements for conducting Performance 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 best practices.

Performance Guarantee (PG) test period would be continuous measurement of 30 consecutive days. The procedure of PG testing is described further in Section 5.

The report shall contain all the measured energy and Met data values, calculations, results and conclusions.

2 PERFORMANCE RATIO

The Efficiency or performance ratio (PR) of the PV Plant is calculated as follows (according to IEC 61724 Ed.2)

Performance Ratio:

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

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

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

Where,

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

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

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

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

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

IR_{STC} = Irradiance at STC (kW/ sq. m); 1000W/m^2

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

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

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

3 GENERAL REQUIREMENT

- The PG test of power supply facility shall be carried out for a period of 30 consecutive days.
- 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 plant individually over 30 days, by the way of the performance ratio based on the reading of the energy produced and delivered to the grid and the average incident solar radiation.
- PR is calculated as per the formula given in Clause no. 2 and recorded as per the format provided at ***Annexure 1***.
- All the end of each day, the filled-in format shall be signed by both the parties and each party will keep one copy for record. **The same will continue for 30 consecutive days and at the end of PG test period, the average of all the days will be calculated.**
- During this PG test, equipment failure/interruption of any kind will be considered and that day or part thereof will not be part of PG test period. The test will be continued once the complete system will be rectified and working properly. The test will extend exactly as number of breakdown days.

4 Pre-PG TEST

The EPC Contractor shall perform the PG start-up tests incorporating both visual inspection and functional testing. Such testing shall be conducted under the SECI's supervision. The test results shall be recorded as part of a signed-off commissioning record.

Preliminary Test Check:

The preliminary checks includes all the warranty certificates for the major equipment, pre – commissioning test reports, field quality checklists verified through the FQP documents of all equipment and works along with the calibration reports of all the instruments and sensors, wherever applicable.

Visual /Mechanical Test

Visual checks shall be done on all the components that form part of the plant including the grid connection equipment in compliance with the field quality plans. The following critical elements as a minimum shall be subjected to visual inspection:

- Module mounting structure and foundations.
- PV module and DC installation.
- Inverters.

- Transformers.
- Switchgear.
- Lightning protection systems.
- Earthing protection systems.
- Electrical protection systems, junction boxes and cabling.
- Grid connection compliance protection and disconnection systems.
- Monitoring systems (including meteorological sensors).

Electrical Tests

Subsequent to mechanical completion and visual testing of the plants, following functional electrical tests shall be performed. These tests also referred as start-ups tests shall be the first step for PG guarantee of the plant. These tests shall essentially include:

Open circuit voltage (V_{OC}) test.

This test verifies that strings are properly connected (module and string polarity) and that all modules are producing the expected voltage according to the module data sheet. To measure Voc, the following procedure shall be used;

- DC string combiner box is opened; fuses leading to the sub main junction box are removed.
- The voltage is measured with a calibrated, industry accepted instrument from the negative bus bar to the string positive lead.

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

DC Side Voltage Drop: Maximum voltage-drop at full power from the PV modules to inverter should be less than 1.5% (including diode voltage drop). The detailed measurements and calculations shall be provided by the EPC Contractor.

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.

5 PG *TEST* PROCEDURE

The date of commencement of the PG Test Procedure 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 only) for the purpose of conducting performance guarantee test shall be mutually discussed and agreed between SECI and EPC Contractor. It shall comprise of the following procedures:

Pre-test Procedure

1. Before the commencement of PG test, the plant shall have achieved visual/mechanical/Electrical completion and DC Voltage Drop functional requirements as per Clause 4 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. If and once the 7 day trial run is passed, the 30 day PR test will commence after communication from SECI in this regard. If the trial run fails, the trial run will start again after rectification and restoration of the system. The practice for trial run can follow for 3 times before the PR to continue. In case the contractor fails to achieve even trial run, the further action shall be taken as per the provisions of contract.
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. All the calibration certificates for each measuring instruments which shall be used for PG test shall be checked and ensure that these certificates are up to date.

Following the completion of the pre-test procedures, Performance Guarantee Test of plant shall commence in accordance with the procedures, conditions and requirements provided in the next section.

General Procedure for the PG Test

The PG Test Procedure shall include the following components:

5.1.1 **Data Collection:** PV Power Plant test related parameters are collected in one-minute and 15 intervals for the 30 (Thirty) days (consecutive) 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)
- Other Met Data received from installed WMS ; (Source: SCADA, Temporal Resolution: 1 minute)
- Energy generated at Plant (kWh) (Source: Plant MFM Meter from SCADA, Temporal Resolution: 1 minute)
- Energy injected into grid (kWh) (Source: Plant ABT Meter at GSS/injection point, Temporal Resolution: 15 minute)
- PV Module Temperature recorded from the temperature Sensors (°C) (Source: SCADA, Temporal Resolution: 1 minute)

5.1.2 **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 including required 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.
- **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 condition
- **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.

6 DETERMINATION OF PG TEST

Daily PR shall be calculated as the average of valid (i.e. time blocks not filtered as per 5.2.2) 15 minute time blocks for the 30 day duration. If the EPC Contractor is not able to demonstrate PG test during these this period they will be given one more chance to demonstrate the PG test after incorporation of suitable corrective measures. In that case the steps for PG test shall be repeated again as above.

The test shall be repeated for 30 days in case of any outage of following equipment for more than 1 day.

- Power Transformer
- Power Conditioning Unit
- SCADA and data logger combined
- Tilted pyranometer
- Other WMS sensors.

7 RAW DATA *FORMATS* AND REPORTS

The EPC Contractor shall submit to SECI raw data from the Plant SCADA on a daily basis in the following format, at a minimum.

Temporal Resolution: 1 Minute:

Date & Time Dd/mm/yyyy hh:mm:ss format	**Wind Speed (m/s)**	**Module Temp. (° C)**	**Ambient Temp. (° C)**	**POA Radiation (K-Wh/m²)**	**POA Irradiance (W/m²)**	**Horizontal Irradiance (W/m²)**	**Humidity (%)**	**Wind Direction (°)**	**Generation(KW-h) (Source: MFM)**

Temporal Resolution: 15 Minute (Every 15th Min record from the 1 Min Data at 7.1):

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

										Meter)		

* 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 at Annexure 1 after data filtering as per criteria laid out in 5.2.2. The Report shall be contain the signature of both representatives (SECI/Employer & EPC Contractor).

Annexure 1

Reports

1. Project Overview

S. No.	Parameter		Details
1	Solar PV plant Co ordinates		Latitude Longitude
2	Plant AC capacity		
3	Plant DC Capacity		
4	PV Module Fixing Configuration		
5	PV Module Tilt Angle		
6	PV module Pitch Details		
7	Solar PV Module Ratings		
8	No of PV Module in Series per String		
9	Total no of Strings		
10	No of SMB		
11	String Monitoring Box Config		
12	Solar Inverter Technology		
13	Solar Inverter Ratings		
14	EPC Contractor		

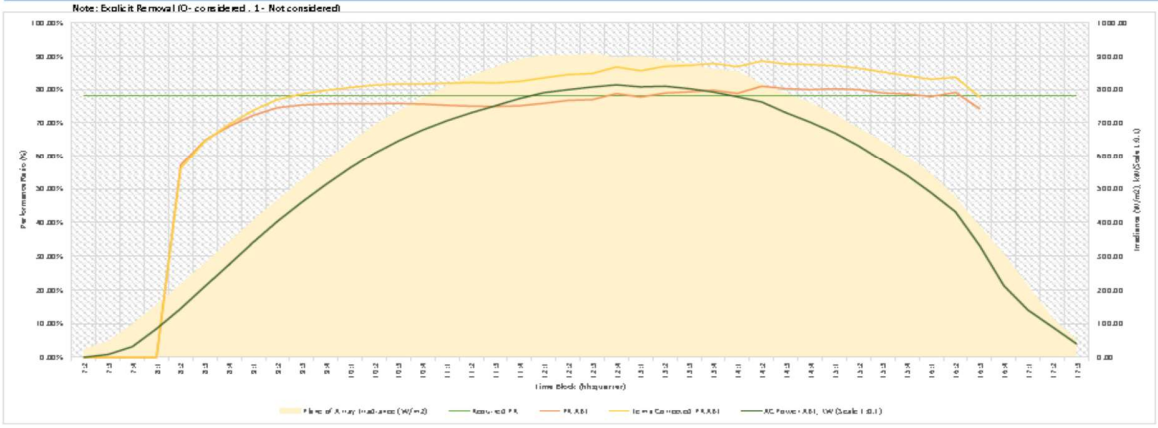
2. Sample Report

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 irradience is greater then 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	49.79	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	49.39	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	49.55	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	57.76%	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]

Annexure – C

Special Technical Conditions

On behalf of

By:

.

SOLAR ENERGY CORPORATION OF INDIA

(A Government of India Enterprise)

I[st] floor, Wing A, Religare Building, D – 3, District Centre, Saket, New Delhi – 17

Tel: 011 – 71989224, Fax: 011 – 71989241

1 Site Details and Works:

1. Preliminary geotechnical investigations have been conducted by the Employer with 3 nos. of boreholes drilled at locations indicated in the site map attached with the Geotechnical information.
2. The soil at VoCPT site predominantly comprise of non-cohesive brown coloured sand with some clay contents at top layer.
3. The water table is observed at shall depth at the time of drilling the borehole.
4. Considering the type of soil and very high water table, the contractor shall adopt suitable foundation system for MMS structure.
5. The bore log data and lab test results on DS samples are attached with this Annexure only for reference and general information of the Bidder. No warranty is expressed or implied that such information, given in good faith, will present a complete or accurate picture of the whole of the Site.
6. The Piling Contractor shall be responsible for any inference it may draw from information made available to it.
7. The Bidder is advised to inspect the site and study the nature of soil to decide the foundation system to be provided before submission of the Bid.
8. The Employer shall not be responsible for any variations in soil characteristics, if observed during detailed soil investigation 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.
9. The min. dimensions of different pile types shall be as follows:

Type of pile	**Dia. (mm)**	**Length below cut-off (mm)**
Driven pre-cast or bored cast-in-situ concrete piles	300	3000
Under reamed pile with 1 bulb	350	3000
Helical pile (6mm thick central shaft and 2 no. 8mm thk helix 450 dia.)	150 (Internal dia. of shaft)	3500

10. All drains except peripheral drain shall be of RCC or masonry construction. Min. thickness of lining for Peripheral drain (trapezoidal section) shall be 250mm thick with stone pitching.
11. The min. details of WMB road section shall be as follows:

Topping: Surface dressing, compacted 75mm thick with murrum blended with WBM Grade-III, as applicable.

WBM (CBR>100%):	Compacted 125mm thick, Grade III
WBM (CBR>100%):	Compacted 125 mm thick, Grade II
Granular sub-base (CBR>15%):	Compacted 350 mm thick,
Compacted subgrade:	300mm thick top layer of subgrade to be compacted up to 98% of standard proctor density
Shoulders:	Compacted 150mm thick, murrum blended with WBM Grade-III

12. The design basic wind speed '$\mathbf{V_b}$' = 39m/sec
13. Seismic zone – 2
14. Design rainfall intensity for storm water drainage – 92mm/hr
15. The slopes of the existing drains (on side of Gulf of Mannar and near the Bus stop end of the project shall be stabilized by flattening existing slope to 20^o and protected against erosion by providing dry stone pitching of min. 300 mm thickness. Suitable intermediate surface drains shall be provided to facilitate flow of rain water over the slope in to the drain. If required, as per soil conditions, a layer of geotextile may be laid below the stone pitching for protection of soil against erosion.
16. All exposed steel surfaces (expected galvanized) shall be painted with min. 2 coats of PVF2 paint over two coats of suitable primer. Total DFT of painting system shall not be less than 150 microns
17. The min plinth height (FFL) for all buildings and open installations shall be 1000mm above FGL
18. Peripheral and Transformer yard fence shall be of Poly coat chain link fencing with GI wire and precast concrete posts.
19. Cement – Considering high Chloride & Sulphate contents in ground water, Ordinary Portland cement – 43 grade with C_3A contents<5% conforming to IS: 8112 or Portland slag cement with slag>50% conforming to IS:455 shall be used.
20. As the ground water contains high concentration of chlorides, it is not suitable for construction and module cleaning purposes. Suitable water for construction and module cleaning purposes (during plant operation) including its storage shall be arranged by the bidder.
21. Building:
    a. Compact sub – station, as per specification is proposed, in this case, the building shall comprise of following:
        i. SCADA cum Supervisor cabin and office area (approx. carpet area 20 m^2)

ii. Pantry - with service platform and utensil washing facilities (approx. carpet area 5 m2)

iii. Toilet block with separate gents and ladies wash room facilities (approx. total carpet area 12 m^2)

b. Other specifications shall be with respect to the technical specifications.

c. Building for housing any/all electrical equipment, wherever proposed by the Bidder, shall be as per the CRZ regulations.

22. CCTV Camera - The CCTV connectivity is to be linked with surveillance monitoring system of VOCPT Admin Building. All necessary communication cables, network switches etc., including routing required for establishing the same shall be determined in consultation with the Owner.
23. Water storage tank shall be of Overhead water type.
24. While laying of the overhead line and UG line as proposed, the existing lines/ cables shall not be disturbed. In case any damage happens to these cables, while working, the contractor must repair/ rectify the cable/line /other at his own cost.
25. The crossing of railway line shall be through horizontal drilling method and cable should be laid strictly as per the approving authority. The work should not disturb the operations of the railway line.
26. Power Evacuation System:
    a. Overhead Line shall have 33KV Silicone Polymeric Composite insulators suitable for operation in the Site conditions and shall be designed to meet the high quality, safety and reliability capable of withstanding a wide range of environmental conditions.
    b. The Polymeric Insulators shall consist of three parts, at least two of which are insulating parts:- (a) Core- the internal insulating part (b) Housing- the external insulating part (c) Metal end fittings (dimensions as per IEC: 60120/IS: 2486 - Part-II /1989).
    c. Tests and Standards:

       The tenderer shall furnish detailed type test reports as per IEC 61109 of the offered composite Insulators from an NABL approved laboratory during detailed engineering. At least Following Type test shall be conducted on a suitable number of individual insulator units, components, materials or complete strings:

       i. Dry lightning impulse withstand voltage test
       ii. Wet power frequency test
       iii. Mechanical load-time test

iv. Radio interference test
v. Recovery of Hydrophobicity test
vi. Chemical composition test for silicon content
vii. Brittle fracture resistance test

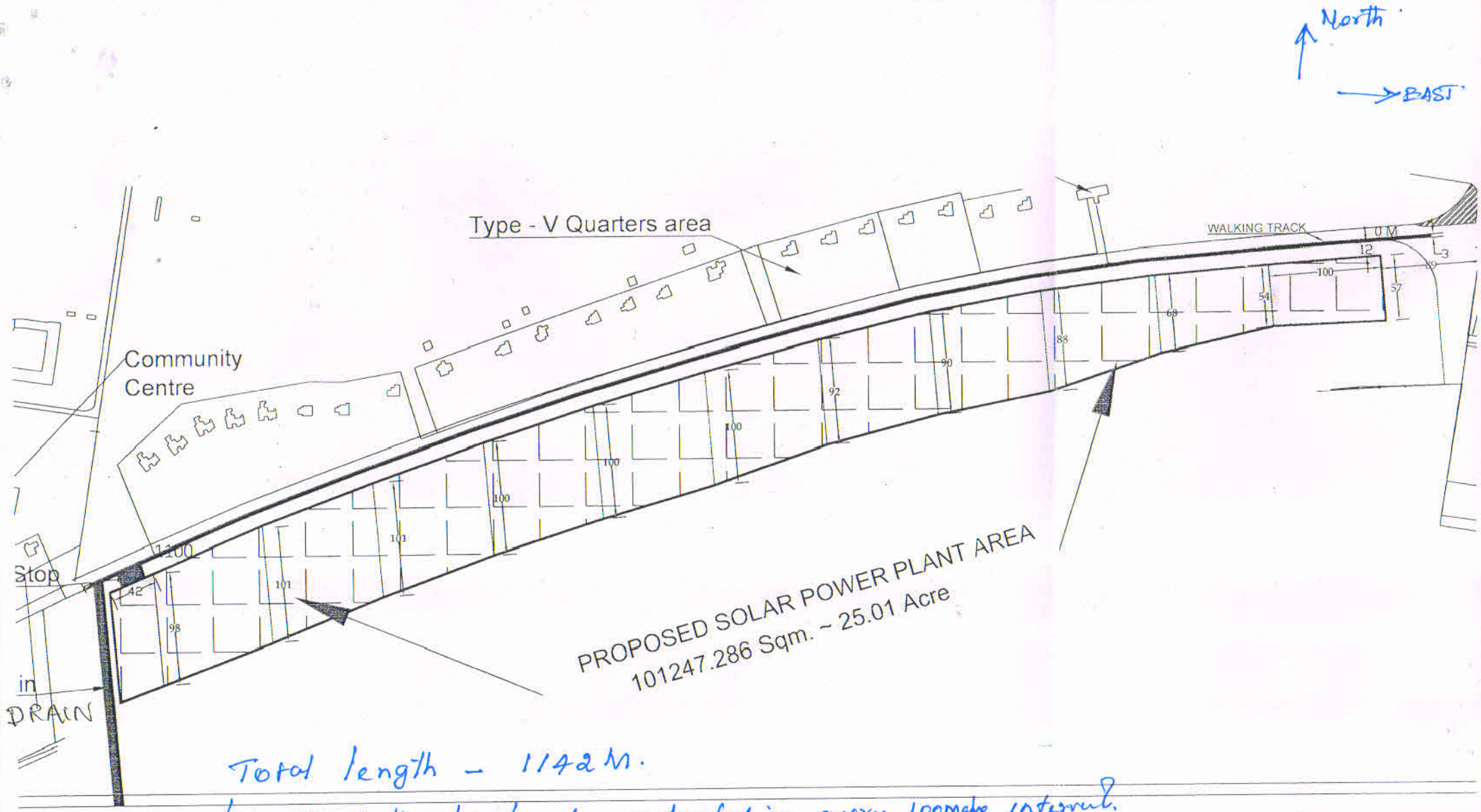
These Type Tests, should have been carried out within five years prior to the date of opening of the tender.

Following Routine Tests (as per IEC 61109) shall be applicable:

i. Identification of marking
ii. Visual Inspection
iii. Mechanical routine test

d. The evacuated power has to be connected through 22KV out door VCB at Auto Sub-station., Muthiahpuram. For installing VCB at Auto SS, approximately 11% of the VCB cost and 50% VCB cost shall be provided to TANGEDCO as supervision and maintenance charges respectively.

27. For data connectivity to jurisdiction LD centre, bidder has to pay Rs. 2 lakhs/-(Rupees Two lakhs only) to TANTRANSCO towards terminal equipments to be provided by TNED at JLDC.
28. The speech communication to adjacent stations shall be provided either by land line or PLCC depending on the infrastructure available at V.O.CPT premises.
29. All fasteners in connections of MMS members shall be SS 316 Class A-70



Total length - 1142 M.

breadth of the plot have been indicated in every 100metre interval.

CHIEF ENGINEER (MECHANICAL)
வ.ஓ.சிதம்பரனார் பத்தன நாஸ
V.O.CHIDAMBARANAR PORT TRUST
தூத்துக்குடி TUTICORIN - 628 004

SECTION - VII

B.TECHNICAL SPECIFICATIONS

Contents

DISCLAMIER:

1. Though adequate care has been taken while preparing the Bidding documents, the Bidders/Applicants shall satisfy themselves that the document is complete in all respects. Intimation of any discrepancy shall be given to this office immediately. If no intimation is received from any Bidder within twenty (20) days from the date of notification of NIT/ Issue of the NIT documents, it shall be considered that the NIT documents are complete in all respects has been received by the Bidder.
2. Solar Energy Corporation of India Limited (SECI) the Employer, reserves the right to modify, amend or supplement this NIT documents including all formats and Annexures.
3. While this bidding documents have been prepared in good faith, neither Employer or its authorized representatives nor their employees or advisors make any representation or warranty, express or implied, or accept any responsibility or liability, whatsoever, in respect of any statements or omissions herein, or the accuracy, completeness or reliability of information, and shall incur no liability under any law, statute, rules or regulations as to the accuracy, reliability or completeness of this bidding documents, even if any loss or damage is caused by any act or omission on their part.
4. The specifications mentioned for all the equipment which include Solar modules, PCU, combiner boxes, DC cables, module mounting structures, transformer, CT, PT, LT/ HT cables, interfacing panels, switch gears & other associated equipment 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 authorised representatives.

Place:

(Signature)

Date: Name and Designation of bidder

1 Design Philosophy

1.1 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.

1.1.1 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.

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

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

1.1.4 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.

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

1.1.6 The plant instrumentation 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.

1.1.7 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.

1.1.8 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.

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

1.2.1 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.

1.2.2 SPV arrays are commonly fixed at an optimum tilted angle facing the equator. Trackers can also be used for tracking the sun on daily or seasonal basis. In case of fixed tilt, the tilt angle shall be defined in such a way that optimum generation is achieved at all times.

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

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

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

spares.

1.2.6 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.

1.2.7 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.

1.2.8 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.

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

1.2.10 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.

1.3 All documents and drawings shall be submitted to the Employer both in soft as well as hard copies (3 nos.) 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, 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-IVR: 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)

1.4 After LOA, the Contractor shall submit complete Master Document & Drawing list (MDL) to the Employer within 1 week. 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.

1.5 The construction shall be done only as per drawings approved under Category – I, II & IV.

1.6 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.

Detailed Specifications: Electrical system (DC & AC systems)

2 Photovoltaic Modules

2.1 Standards and Codes

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

Standard	Description
IEC 61215 Ed.2	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval
IEC 61730-1 Ed.1.2	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
IEC 61730-2 Ed.1.1	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
IEC 61701 Ed.2	Salt mist corrosion testing of photovoltaic (PV) modules (Applicable for coastal and marine environment)
IEC 62716 Ed.1	Photovoltaic (PV) modules - Ammonia corrosion testing
IEC TS 62804-1 Ed.1	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon

2.2 Technical Requirements

Parameter	Specification
Cell type	Mono-crystalline or Multi-crystalline
Rated power at STC	Minimum 250 Wp No negative tolerance is allowed.
Module Efficiency	More than 18% for mono-crystalline More than 16% for multi-crystalline
Temperature co-efficient of power	Not more than 0.45%/°C
Ambient temperature	-10°C to +50°C
Relative humidity	Up to 85%

Wind speed	Suitable for site condition
Application Class as per IEC 61730	Class A

2.3 Component Specifications

2.3.1 The glass used to make the PV modules shall be toughened low iron glass with minimum thickness of 4.0 mm for 72 cell module and 3.2 mm for 60 cell module. The glass used shall have transmittance of above 90%.

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

Parameter	**Value**
Material thickness	≥ 300 micron
Water vapour transmission rate	< 2 g/m^2/day
Partial discharge test voltage	≥ 1000 V
Elongation at break	> 100%
Adhesion strength with encapsulant	> 70 N/cm
Interlayer adhesion strength	> 5 N/cm

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

2.3.3 The encapsulant used for the PV modules should be UV resistant in nature. No yellowing of the encapsulant with prolonged exposure shall occur. The encapsulant shall have the following properties.

Parameter	**Value**
Gel content	> 75%
Volume resistivity	> 1×10^{15} Ω.cm
Peeling strength with glass	> 60 N/cm

2.3.4 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.

2.3.5 The module frame shall be made of anodized Aluminium, which shall be electrically & chemically compatible with the structural material used for mounting the modules. It is required to have provision for earthing to connect it to the earthing grid. The anodization thickness shall not be less than 15 micron.

2.3.6 The material used for junction box shall be UV resistant to avoid degradation during module life. The degree of protection of the junction box shall be at least IP67. Minimum three number of

bypass diodes and two number of MC4 connectors with appropriate length of TUV 2Pfg 1169/08.2007 certified 4 sq.mm Cu 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.

2.3.7 Each PV Module shall be provided a bar code which is embedded inside the module lamination and must be able to withstand harsh environmental conditions. The bar code data base shall contain the following information. Bar code scanner and database of all the modules containing the following information shall also be provided.

(i) Name of the manufacturer of PV Module
(ii) Name of the Manufacturer of Solar cells
(iii) Type of cell: Mono / Multi
(iv) Month and year of the manufacture (separately for solar cells and module)
(v) Country of origin (separately for solar cells and module)
(vi) I-V curve for the module
(vii) Peak Wattage, I_m, V_m and FF for the module
(viii) Unique Serial No. and Model No. of the module.
(ix) Date and year of obtaining IEC PV module qualification certificate
(x) Name of the test lab issuing IEC certificate

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

2.4 Warranty

2.4.1 PV modules must be warranted with linear degradation rate of power output except for first year and shall guarantee 80% of the initial rated power output at the end of 25 years.

2.4.2 The modules shall be warranted for minimum of 10 years against all material/ manufacturing defects and workmanship.

2.5 Approval

2.5.1 The Contractor shall provide commercial datasheet and Guaranteed Technical Particular datasheet

2.5.2 The Contractor shall provide the 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. The Contractor shall also provide complete test reports and certifications for the module proposed as per above. The BOM proposed shall be the subset of Constructional Data Form (CDF)'s of all the test reports.

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

2.6 Manufacturing and Inspection

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

2.6.2 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.

2.6.3 The Manufacturing shall start only after the clearance by the Employer after the material inspection.

2.6.4 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.

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

2.6.6 Current binning of modules shall be employed so that current mismatch of modules in a pallet does not exceed 2% of current at Maximum Power (Imp). Different colour codes shall be provided on the modules as well as pallet for identification of different bins.

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

2.7 Transportation, Handling, Storage and Installation

2.7.1 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.

2.7.2 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.

2.7.3 The stacked modules, in any case, shall be stacked as per the manufacturer's recommendation only and shall be covered with tarpaulin sheet.

3 String Monitoring Unit

3.1 Standards and Codes

Standard/Code	Description
IEC 60529	Enclosure Ingress Protection
IEC 62262	Enclosure Impact Protection
IEC 60296	Fuse
IEC 61643-12	Surge Protection Device
IEC 62852 or EN 50521	Solar cable connector

3.2 Construction

3.2.1 Enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP65 and mechanical impact resistance shall be at least IK07.

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

3.2.3 Every SMU input shall be provided with fuses on both positive and negative side. 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. It should also have a reverse blocking diode at either of the incomer.

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

3.2.5 Type-II surge protective device (SPD) conforming to IEC 61643-12 shall be connected between positive/negative bus and earth.

3.2.6 Resistance Temperature Detector (RTD) type or semiconductor type temperature sensor shall be provided to monitor the cabinet temperature.

3.2.7 MC4 connector conforming to IEC 62852 or EN 50521 shall be provided at each SMU input. Cable gland (double compression metallic) of suitable size for DC cables shall be provided at the SMU output.

3.2.8 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.

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

(i) String current
(ii) Bus voltage
(iii) Output current
(iv) Cabinet temperature
(v) DC disconnector switch ON/OFF status
(vi) SPD operating status

3.3 Warranty

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

3.4 Approval

3.4.1 Documents/Drawings

(i) Guaranteed Technical Particular (GTP) Datasheet.
(ii) Bill of Materials for the proposed SMU along with the datasheet of each component
(iii) General Arrangement (GA) drawing

3.4.2 Quality Assurance Plan (QAP)

3.4.3 Test Certificates/Reports

(i) Test certificates of fuse, SPD and solar cable connector

(ii) Enclosure ingress protection and impact protection test certificates

3.5 Tests

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

4 Solar and DC Cables

4.1 Standards and Codes

Cable	From	To	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SMU	Copper/ XLPO	1.1 kV DC	TUV 2 PfG 1169/08.2007
DC Cable	SMU	Power Conditioning Unit	Copper or Aluminium/ XLPE	1.1 kV DC	IS 7098 Part I
* Cable used for module interconnection shall also be referred as solar cable.					

4.2 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.

4.3 DC cables shall be single core, armoured, Flame Retardant Low smoke (FRLS), PVC outer sheath conforming to IS 7098-I. DC cable with positive polarity should have marking of red line on black outer sheath.

4.4 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 'FRNC/ FRLS' (as applicable) at every metre

Sequential marking of length of the cable in metres at every metre

4.5 Cables shall be sized based on the following considerations:

(i) Rated current of module

(ii) The average voltage drop in the cables (Modules to Inverter) shall be limited to 1.5 % of the rated voltage. Contractor shall provide voltage drop calculations in excel sheet.

(iii) Short circuit withstand capability

(iv) De-rating factors according to laying pattern

4.6 Warranty

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

4.7 Approval

4.7.1 Documents/Drawings

(i) Guaranteed Technical Particular (GTP) Datasheet.

(ii) Solar and DC Cable sizing calculation

(iii) Quality Assurance Plan (QAP)

4.7.2 Test Certificates/Reports

(i) Solar cable type test certificate as per TUV 2 PfG 1169/08.2007

(ii) DC cable type test certificate as per IS 7098-1

4.8 Tests

Routine test and acceptance tests requirements shall be as per TUV specification 2Pfg 1169/ 08.2007 for solar cables and IS 7098-1 for DC cables.

4.9 Installation

4.9.1 Cable installation shall be as per IS 1255.

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

4.9.3 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.

4.9.4 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.

4.9.5 Solar cables, wherever exposed to direct sunlight and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.

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

4.9.7 A.C and D.C cables shall be kept in separate trenches.

4.9.8 The horizontal and vertical clearances between power and communication cable shall not be less than 300mm.

5 Power Conditioning Unit

5.1 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
EN 50530:2010 with 2013 Amendment 1	Overall efficiency of grid connected photovoltaic inverters
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
IEEE 1547:2003 with 2014 Amendment 1	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 Amendment	

5.2 Technical Requirements

Parameter	**Specification**
Rated AC power	As per design
Maximum input voltage	1000 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	IP 54 (Outdoor)

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

5.2.2 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.

5.2.3 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.

5.3 Construction

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

5.3.2 Every DC input terminal of PCU shall be provided with fuse of appropriate rating. The combined DC feeder shall have suitably rated isolators for safe start up and shut down of the system.

5.3.3 Type-II surge protective device (SPD) conforming to IEC 61643-12 shall be connected between positive/ negative bus and earth.

5.3.4 In case external auxiliary power supply is required, standalone UPS shall be used to meet auxiliary power requirement of PCU. It shall have a backup storage capacity of 2 hours.

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

5.3.6 The PCU shall be tropicalized and the design shall be compatible with conditions prevailing at site. Suitable number of exhaust fan with proper ducting shall be provided for cooling keeping in mind the extreme climatic condition of the site as per the recommendations of OEM to achieve desired performance and life expectancy.

5.3.7 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.

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

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

5.4 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.

5.5 Standby Mode

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

5.5.1 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.

5.5.2 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.

5.6 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
(x) Cooling fan failure
(xi) Auxiliary supply failure

5.7 Grid Support Functions

5.7.1 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.

5.7.2 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.

5.7.3 Voltage Ride Through

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

5.8 Warranty

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

5.9 Approval

5.9.1 Documents/Drawings

i) Guaranteed Technical Particular (GTP) Datasheet.
ii) General Arrangement (GA) drawing and Foundation details
iii) Single Line Diagram and Bill of Materials
iv) Transformer Requirements
v) Quality Assurance Plan (QAP)

5.9.2 Test Certificates/Reports

All the test certificates as per the standards mentioned above shall be submitted for approval. The tests should have been conducted at a test laboratory compliant with ISO 17025 for testing and calibration and accredited by an ILAC member signatory. 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.

5.10 Tests

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

6 Compact Sub-Station (CSS)

6.1 Standards and Codes

Compact Sub-Station (CSS) shall comply with the latest edition of the following standard including amendments.

Standard/Code	Description
IEC 62271-202	High-voltage/ low-voltage prefabricated substation

6.2 Design Criteria

6.2.1 Compact Sub-Station shall consist of 2.5 MVA, PCU output voltage/22 kV, dry type inverter duty transformer, 22kV SF_6 insulated Ring Main Unit (RMU), 415V LT switchgear with all accessories, interconnections, fittings and auxiliary equipment. The Contractor may propose to keep PCU also inside the CSS. The complete unit shall be installed on a substation plinth (base) as Outdoor substation.

6.2.2 The pre-fabricated compact substation shall be designed for

(a) Compactness

(b) Fast installation

(c) Maintenance free operation

(d) Safety for operator & public.

6.2.3 For continuous operation at specified ratings, temperature rise of the all the components of CSS shall be limited to permissible values stipulated in the relevant standard and / or this specification.

6.2.4 Service Conditions

The Package substation shall be suitable for continuous operation under the basic service conditions indicated below.

i) Ambient Temperature 50°C

ii) Relative Humidity Up to 95%

iii) Altitude Up to 1000 m

6.3 Construction

6.3.1 The CSS shall have separate compartments for transformer, RMU and LT switchgear with suitable safety barriers. Each compartment shall be provided with doors and pad-locking arrangement. All doors shall have proper interlocks for safety of the operator.

6.3.2 High Voltage terminals of the transformer shall be connected to circuit breaker using Aluminium cable/flexible busbar.

6.3.3 The CSS Enclosure shall be made of sheet steel tropicalized to local weather conditions. Degree of protection of the enclosure shall be NEMA 4X or IP 66 for HT & LT switchgear compartment and NEMA 3 (or IP 54) for transformer compartment.

6.3.4 The Enclosure shall be painted with the colour approved by the Employer. The paint shall be carefully selected to withstand tropical heat, rain and salt mist. The paint shall not scale off or

crinkle or be removed by abrasion due to normal handling.

6.3.5 All enclosures/metal frames of CSS, transformer, RMU and LT switchgear shall be properly earthed. The continuity of the earth system shall be ensured taking into account the thermal and mechanical stress caused by the current it may have to carry.

6.3.6 Adequate ventilation arrangement shall be provided for natural ventilation of the CSS.

6.3.7 Internal lighting with door operated switch shall be provided for each compartment separately.

6.3.8 The CSS shall contain all safety accessories like voltage detection rod, fire extinguishers, gloves etc.

6.3.9 Danger boards, Safety notices, Manufacturer's operating instructions, etc. shall be durable and clearly legible.

6.3.10 The CSS shall be completely assembled at factory. No site assembly is allowed.

6.4 Inverter Transformer

6.4.1 Standards and Codes

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

Standard	**Description**
IS:2026, IEC:60076	Specification of Power Transformers
IS: 11171, IEC 60076-11	Specification for Dry-type 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
CBIP publication no. 295	
Indian Electricity rules and other statutory regulations	

6.4.2 Technical Requirements

Parameters	**Specification**
VA Rating	2.5 MVA
Voltage Ratio	22 kV/ Inverter output voltage
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Indoor)
No. of Windings	As per system design requirement
Frequency	50 Hz
Nos. of Phase	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement
Cooling	AN

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	50°C
Winding	55°C
SC withstand time (thermal)	2 second
Short Circuit Apparent Power	500 MVA
Termination	HV side - 24 kV porcelain bushings LV side – 1.1 kV porcelain bushings
Bushing rating	As per system requirement and SLD
Rated Short Duration Power Frequency Withstand Voltage (rms)	50 kV
Rated Lightning Impulse Withstand Voltage (peak)	125 kV
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 CBIP

6.4.3 Construction

6.4.3.1 Inverter transformer shall be either vacuum pressure impregnated (VPI) dry type or cast

resin (encapsulated) dry type transformer.

6.4.3.2 It is the responsibility of the Contractor to ensure that the inverter transformer comply with all the requirements of inverter provided by the inverter manufacturer.

6.4.3.3 Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.

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

6.4.3.5 Inverter Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from tank through shield bushing and the same shall be brought down to the bottom of the tank using copper flat and support insulator for independent grounding.

6.4.3.6 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”. Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.

6.4.3.7 Transformer shall have winding temperature sensors and Winding Temperature Indicator (WTI) with requisite set of remote signalling contacts for alarm and trip operations.

6.4.3.8 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.

6.4.3.9 All external surface of the transformer shall be painted with two coats of epoxy based paint of colour shade as decided by the Employer. 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.

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

6.4.3.11 Transformer shall be provided with CRCA sheet steel enclosure having thickness of minimum 3mm for structural members and 2 mm for door/cover. The enclosure shall have minimum IP33 degree of protection. Door shall be provided with mechanical interlocking to avoid accidental access to transformer in energized condition.

6.4.3.12 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.

6.4.3.13 Danger plate indicating “entry prohibited under energized condition” of the transformer.

6.4.3.14 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.

6.4.4 Warranty

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

6.4.5 Approval

6.4.5.1 Documents/Drawings

(i) Guaranteed Technical Particular (GTP) Datasheet.

(ii) General Arrangement (GA) Drawing of complete transformer, cable boxes, marshalling box

(iii) Rating plate and Valve schedule plate

(iv) Marshalling box wiring diagram

(v) Manufacturer acceptance for inverter requirements

(vi) Quality Assurance Plan (QAP)

6.4.5.2 Test Certificates/Reports

Type test and Special test reports as mentioned in the following clause shall be submitted for approval.

6.4.6 Testing and Inspection

6.4.6.1 Type Tests and Special Tests

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

A. Type Tests

(i) Separate-source voltage withstand test

(ii) Induced overvoltage withstand test

(iii) Measurement of no-load loss and current

(iv) Measurement of impedance voltage, short circuit impedance and load loss

(v) Measurement of voltage ratio and check of voltage vector relationship

(vi) Measurement of winding resistance

(vii) Lightning impulse test

(viii) Temperature Rise test at a tap corresponding to maximum losses

B. Special Tests

(i) Partial discharge measurement

(ii) Measurement of acoustic sound level

(iii) Short-circuit test

(iv) Mechanical tests: IP test on enclosure

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.

6.4.6.2 Routine Tests

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

(i) Measurement of winding resistance at each tap

(ii) Measurement of voltage ratio between HV and LV windings at each tap

(iii) Check of vector group

(iv) Measurement of no-load loss and no-load current

(v) Measurement of short-circuit impedance and load loss

(vi) Magnetic balance test as per CBIP manual publication no. 295

(vii) Separate source voltage withstand test

(viii) Induced over voltage withstand test

(ix) Measurement of insulation resistance

(x) Marshalling box functional test

(xi) IR Measurement on wiring of marshalling box

6.4.6.3 Tests at Site

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

(i) Measurement of voltage ratio

(ii) Check of vector group

(iii) Magnetic balance test

(iv) Measurement of insulation resistance

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.

6.5 Ring Main Unit

6.5.1 Standards and Codes

All equipment provided under Ring Main Unit (RMU) shall comply with latest edition and amendments of the relevant IEC standards and IS codes. In particular, the RMU shall comply with the following standards and codes.

Standard/Code	Description
IEC 62271-1	Common specifications for alternating current switchgear and control gear
IEC 62271-100	AC Circuit Breakers
IEC 62271-102	AC Disconnectors and Earthing Switches
IEC 62271-200	AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 62271-206	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 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 Watt-hour and Var-hour Meters, Class 0.2S and 0.5S

6.5.2 Technical Requirements

Parameter	Specification
System Parameters	
Nominal system voltage	22 kV rms
Highest system voltage	24 kV rms
Number of phases	3
Frequency	50 Hz

Short duration power frequency withstand voltage	50 kV rms
Lightning impulse withstand voltage	125 kVp
Short circuit current rating	13.1 kA for 3 s or System requirement whichever is higher
Circuit Breaker	
Type	Vacuum
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Short circuit breaking current	13.1 kA for 3 s or System requirement whichever is higher
Short circuit making current	2.5 times the 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 requirement
Insulation class	Class E or better

6.5.3 Construction

6.5.3.1 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.

6.5.3.2 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 2X. 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.

6.5.3.3 Circuit Breaker

6.5.3.3.1 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.

6.5.3.3.2 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.

6.5.3.3.3 The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

6.5.3.3.4 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.

6.5.3.3.5 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.

6.5.3.3.6 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.

6.5.3.4 Load Break Switch

6.5.3.4.1 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.

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

6.5.3.4.3 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.

6.5.3.5 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.

6.5.3.6 Relays

Relays shall comply with Clause 7.5 of Technical Specifications.

6.5.3.7 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.

6.5.3.8 Earthing

All metal parts of RMU 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.

6.5.3.9 Interlocks

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

6.5.3.10 Voltage Presence Indicating System

The RMU 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.

6.5.3.11 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.

6.5.4 Warranty

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

6.5.5 Approval

6.5.5.1 Documents/Drawings

(i) Guaranteed Technical Particular (GTP) Datasheet

(ii) General Arrangement (GA) Drawing

(iii) Schematic diagram

(iv) Bus bar sizing calculation

(v) Bill of Materials

(vi) Quality Assurance Plan (QAP)

6.5.5.2 Test Certificates/ Reports

Type test reports as mentioned in the following clause shall be submitted for approval.

6.5.6 Testing and Inspection

6.5.6.1 Type Tests

The Ring Main Unit shall be of type tested design. Type test reports of RMU, 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.

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.

6.5.6.2 Routine Tests

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

6.6 LT Switchgear

6.6.1 Standards and Codes

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

Standard/Code	Description
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers
IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units

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

6.6.2 Technical Parameters

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

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

6.6.3 Constructional Details

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

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

6.6.3.3 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.

6.6.3.4 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.

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

6.6.3.6 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.

6.6.3.7 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.

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

6.6.3.9 240 V, 15 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each

panel.

6.6.3.10 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.

6.6.3.11 Suitable lifting hooks shall be provided for each panel.

6.6.3.12 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.

6.6.3.13 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.

6.6.4 Warranty

Distribution panels (ACDB and DCDB) shall be warranted for minimum of 1 (one) year against all material/ manufacturing defects and workmanship

6.6.5 Approval

Schematic diagram and General Arrangement (GA) drawing shall be submitted for approval.

6.6.6 Testing

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

6.7 Warranty

The Compact Sub-station shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

6.8 Approval

6.8.1 Documents/Drawings

(i) General Arrangement (GA) Drawing

(ii) Foundation Details

(iii) Quality Assurance Plan (QAP)

6.8.2 Test Certificates/Reports

Type test reports as mentioned in the following clause shall be submitted for approval.

6.9 Testing and Inspection

6.9.1 Type Tests

The CSS shall be of type tested design. Type test reports as per IEC 62271-202 shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

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.

6.9.2 Routine Tests

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

7 HT Switchgear

7.1 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
IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3:

	Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

7.2 Technical Parameters

Parameter	**Specification**
System Parameters	
Highest system voltage	24 kV
Rated system voltage	22 kV
Rated frequency	50 Hz
Number of phases	3
Power frequency withstand voltage	50 kV (r.m.s.)
Lightning impulse withstand voltage	125 kV (peak)
System fault current	13.1 kA for 3s or System requirement whichever is higher
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Rated normal current	As per system design
Short circuit breaking current	13.1 kA for 3s or System requirement whichever is higher
Short circuit making current	2.5 times the 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
Voltage Transformer	

Accuracy class	0.2 for metering 3P for protection
Rated VA burden	As per requirement
Insulation class	Class E

7.3 Switchgear Panel

7.3.1 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.

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

7.3.3 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.

7.3.4 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.

7.3.5 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.

7.3.6 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.

7.3.7 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.

7.3.8 Degree of protection of the switchgear panel shall not be less than IP 55 as per IEC 60529.

7.3.9 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.

7.3.10 Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply

through suitable switch and fuse.

7.3.11 240 V, 15 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.

7.3.12 Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.

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

7.3.14 Suitable lifting hooks shall be provided for each panel.

7.4 Circuit Breakers

7.4.1 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.

7.4.2 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.

7.4.3 The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

7.4.4 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.

7.4.5 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.

7.4.6 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.

7.5 Relays

7.5.1 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.

7.5.2 Auxiliary voltage of the relays shall be 110 VDC and the relays shall be capable of operating

continuously between 80 – 120% of auxiliary voltage.

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

7.5.4 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.

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

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

7.5.7 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

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

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

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

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

(i) Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.
(ii) Event record – At least 200 events with date and time stamp.

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

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

7.5.13 The numerical relay shall have RS-232/RS-485/RJ-45/USB ports on front side for local communication with PC and on rear side for remote communication to SCADA system.

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

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

7.6 Instrument Transformers

7.6.1 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.

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

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

7.6.4 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.

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 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.

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.

7.7.7 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.

7.7.8 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.

7.8 Bus bar

7.8.1 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.

7.8.2 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.

7.8.3 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.

7.8.4 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.

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

7.9 Measuring Instruments

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

7.9.2 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.

7.9.3 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)

7.10 Wiring and Terminal blocks

7.10.1 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.

7.10.2 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.

7.10.3 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.

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

7.10.5 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.

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

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

7.11 Warranty

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

7.12 Approval

7.12.1 Documents/Drawings

(vii)Guaranteed Technical Particular (GTP) Datasheet

(viii) General Arrangement (GA) Drawing and Foundation details

(ix) Schematic diagram

(x) Bus bar sizing calculation

(xi) Bill of Materials

(xii)Quality Assurance Plan (QAP)

7.12.2 Test Certificates/ Reports

Type test reports as mentioned in the following clause shall be submitted for approval.

7.13 Testing and Inspection

7.13.1 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.

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
Electromagnetic Compatibility tests	IEC 61869-3	7.2.5
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.

7.13.2 Routine Tests

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

8 AC Cables

8.1 Standards and Codes

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

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

8.2 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.

8.3 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.

8.4 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

8.5 Cables shall be sized based on the following considerations:

(i) Rated current the equipment

(ii) Maximum voltage drop in LT cable (from inverter to inverter transformer) shall be limited to 0.5% of the rated voltage. For HT cables (from inverter transformer to interconnection point), maximum voltage drop shall be limited to 0.5 % of the rated voltage. Successful Bidder 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

8.6 Warranty

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

8.7 Approval

8.7.1 Documents/Drawings

(i) Guaranteed Technical Particular (GTP) Datasheet

(ii) Cable sizing calculation

(iii) Quality Assurance Plan (QAP)

8.7.2 Test Certificates/ Reports

Type test certificates as per the standards mentioned above shall be submitted for approval.

8.8 Testing

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

8.9 Installation

8.9.1 Cable installation shall be as per IS 1255.

8.9.2 LT cable (from inverter to inverter transformer) shall laid through RCC cable trench with supports.

8.9.3 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.

8.9.4 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.

9 Auxiliary supply system

9.1 Scheme for Auxiliary supply system shall be submitted by contractor during detailed engineering for the approval by Employer.

9.2 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.

9.3 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

10 Auxiliary Transformer

10.1 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:2099, IEC:60137	Bushings for alternate voltage above 1000 V
IS: 335, IEC 60296	Insulating oil
IS: 3639	Fittings and Accessories for Power Transformers

10.2 Technical Requirements

Parameters	Specification
VA Rating	As per system requirement
Voltage Ratio	22 kV/0.415 kV
Duty, Service & Application	Continuous application (Outdoor/Indoor)
Winding	2
Frequency	50 Hz
Nos. of Phase	3
Vector Group & Neutral earthing	Dyn11
Cooling	ONAN/ AN
Tap Changer	OCTC, No. of steps shall be as per the SLD and system requirement
Impedance at 75°C	As per system requirement and SLD
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)	
Top Oil	50°C
Winding	55°C
SC withstand time (thermal)	2 second
Fault Level & Bushing CT	13.1 kA for 3 second or System requirement whichever is higher
Termination	As per system requirement
Bushing rating, Insulation class (Winding & bushing)	HV side – 24 kV porcelain bushings LV side – 1.1 kV porcelain 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 CBIP

10.3 Construction

10.3.1 The auxiliary 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.

10.3.2 The auxiliary 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.

10.3.3 Neutral bushing of the auxiliary transformer shall be brought outside the tank for earthing.

10.3.4 The auxiliary 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 class of ±2 degree.

10.3.5 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.

10.3.6 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.

10.3.7 Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting

arrangement and diaphragm type explosion vent shall be provided.

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

10.3.9 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 micron.

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

10.3.11 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.

10.3.12 Rain hoods to be provided on Buchholz relay and MOG. Entry points of wires shall be suitably sealed.

10.3.13 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.

10.4 Warranty

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

10.5 Approval

10.5.1 Documents/Drawings

(vii) Guaranteed Technical Particular (GTP) Datasheet

(viii) General Arrangement (GA) Drawing of complete transformer, cable boxes, marshalling box

(ix) Foundation details

(x) Rating plate and Valve schedule plate

(xi) Marshalling box wiring diagram

(xii) Quality Assurance Plan (QAP)

10.6 Testing and Inspection

10.6.1 Routine Tests

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

(xii) Measurement of winding resistance at each tap

(xiii) Measurement of voltage ratio between HV and LV windings at each tap

(xiv) Check of vector group

(xv) Measurement of no-load loss and no-load current

(xvi)Measurement of short-circuit impedance and load loss

(xvii) Magnetic balance test as per CBIP manual publication no. 295

(xviii) Separate source voltage withstand test

(xix)Induced over voltage withstand test

(xx) Measurement of insulation resistance

(xxi)Marshalling box functional test

(xxii) IR Measurement on wiring of marshalling box

(xxiii) Breakdown voltage test on transformer oil as per IS 335

(xxiv) Oil leakage test on completely assembled transformer along with radiators

10.6.2 Tests at Site

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

(v) Measurement of voltage ratio

(vi) Check of vector group

(vii)Magnetic balance test

(viii) Measurement of insulation resistance

(ix) Breakdown voltage test on transformer oil

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

11 Uninterrupted Power Supply (UPS)

11.1 Standards and Codes

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

11.2 General Requirements

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

(i) Data logger / SCADA

(ii) Fire Detection/ Alarm Panel

(iii) HMI of SCADA

(iv) Emergency Lighting

(v) Inverter's Auxiliary supply (if applicable)

(vi) HT panel auxiliary

(vii) CCTV

11.2.2 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.

11.3 System Description

11.3.1 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

11.3.2 The UPS shall meet the following minimum specifications.

Parameter	**Specification**
Topology	Online double conversion UPS
Input	
Voltage	415V ± 10% AC
Frequency	50 ± 5 Hz
Power factor	0.95
Output	
Voltage	230V ± 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Sealed, Maintenance-Free (AGM) battery
Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED 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-232 & RS-485 Interface Port
Overall efficiency	>90%
Electrical Protection	Input/ output under voltage, over temperature, overload, Short circuit, battery low trip

11.3.3 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.

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

11.4 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

11.5 Approval

11.5.1 Documents/Drawings

(i) Technical Datasheet
(ii) UPS sizing calculation
(iii) Single line diagram
(iv) General Arrangement (GA) drawing
(v) Quality Assurance Plan

11.5.2 Test Certificates/Reports

Type test certificates as per the standards mentioned above shall be submitted for approval.

11.6 Tests

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

11.6.2 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.

12 Battery and Battery Charger

12.1 Standards and Codes

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

12.2 General

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

(i) Sealed Maintenance Free (VRLA) Battery complete with racks & accessories.

(ii) One No. Float charger.

(iii) One No. Float cum Boost charger.

(iv) DC Distribution Board (DCDB)

12.3 Battery

12.3.1 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 circuit breaker

(iii) Annunciator and Indication circuit of HT panel

(iv) Auxiliary supply to protection relays

12.3.2 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%.

12.3.3 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.

12.3.4 Battery voltage – 220V dc or 110V dc

12.4 Battery charger

12.4.1 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.

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

12.4.3 Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage and current to 2 % and 5 % respectively.

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

12.4.5 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.

12.4.6 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.

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

12.5 DC distribution board (DCDB)

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

12.5.2 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.

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

12.6 Warranty

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

12.7 Approval

12.7.1 Documents/Drawings

i) Technical Datasheet

ii) Battery sizing calculation

12.7.2 Test Certificates/Reports

Type test certificates as per the standards mentioned above shall be submitted for approval.

12.8 Tests

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

13 Metering System

13.1 Standards and Codes

Standard/Code	Description
IEC 62052-11:2003	Electricity metering equipment (AC) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053-22:2003	Electricity metering equipment (AC) - Particular Requirements - Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)
IS 14967	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2 S and 0.5 S

13.2 ABT energy meter shall be provided as approved by state DISCOM under the metering scheme, to measure the delivered quantum of energy to the grid for sale. The responsibility of arranging for the meter, its inspection/ calibration/ testing charges etc. rests with the Contractor. All charges incurred on Meter testing, shall be borne by the Contractor. ABT energy metering system is to be approved by state DISCOM.

13.3 Meter must be provided with the necessary data cables.

13.4 The Contractor shall provide ABT compliant meters at the interface points.

13.5 Interface metering shall conform to the CEA (Installation and Operation Meters) Regulation 2006 and amendment thereof Commercial settlement of solar Photovoltaic Grid Interactive based power project.

13.6 Meter shall be suitable for interfacing for synchronizing the built-in clock of the meter by GPS time synchronization equipment existing at the station either through a synchronization pulse received from the time synchronization equipment or through a remote PC synchronized to GPS clock shall also be in the scope of Contractor.

13.7 All charges for testing and passing of the meter with relevant government agency shall be borne by Contractor, the Employer will assist Contractor for necessary document as and when required. Contractor has to intimate the required documents at least 7 days prior of such requirements.

13.8 ABT compliant Energy Meters shall have technical specification as given below (not limited to specified requirement, Contractor can provide Meter with latest facilities).

13.8.1 Meters shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4-wire principle suitable for balanced/ unbalanced 3 phase load.

13.8.2 Meters shall have an accuracy of energy measurement of at least Class 0.2S for active energy and at least Class 0.5 for reactive energy, and shall be connected to Class 0.2 CT cores and Class 0.2 VT windings or as per state grid regulations. The active and reactive energy shall be directly computed in CT & VT primary ratings.

13.8.3 Meters shall compute the net MWh and MVArh during each successive 15-minute block metering interval along with a plus/ minus sign, instantaneous net MWh, instantaneous net MVARh, average frequency of each 15 minutes, net active energy at midnight, net reactive

energy for voltage low and high conditions at each midnight.

13.8.4 Each energy meter shall have a seven digit display unit. It shall display the net MWh and MVARh with a plus/minus sign and average frequency during the previous metering interval; peak MW demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with a plus/minus sign, date and time; and instantaneous current and voltage on each phase.

13.8.5 All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable. All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.

13.8.6 At least the following data shall be stored before being over-written for the following parameters.

S. No.	Parameters	Details	Min. No. of days
1	Net MWh	15 min. block	90 days in meter
2	Average Frequency	15 min. block	90 days in meter
3	Net MVARh for > 103%	15 min. block	90 days in meter
4	Cumulative net MWh	At every mid night	30 days in meter/ 90 days in PC
5	Cumulative net MVARh for >103%	At every mid night	30 days in meter/ 90 days in PC
6	Date & time blocks for VT failure on any phase		

13.8.7 The meter shall have a built in clock and calendar with an accuracy of less than15 seconds per month drift without assistance of external time synchronizing pulse.

13.8.8 Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment existing at the station provided by Contractor.

13.8.9 The meter shall be suitable to operate with power drawn from the VT supplies. The burden of the meters shall be less than maximum 2VA.

13.8.10 The power supply to the meter shall be healthy even with a single- phase VT supply. An automatic backup, in the event of non-availability of voltage in all the phases, shall be provided by a built in long life battery and shall not need replacement for at least 10 years with a continuous VT interruption of at least 2 years. Date and time of VT interruption and restoration shall be automatically stored in a non-volatile memory.

13.8.11 Even under the absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meters.

13.8.12 Meters shall have an optical port on the front of the meter for data collection from either a hand held meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software.

13.8.13 The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ

and test terminal blocks shall be provided for the same.

13.9 The Employer/ Owner shall have the right to carry out surprise inspections of the Metering Systems from time to time to check their accuracy.

13.10 The Contractor must comply with the relevant grid regulations, DISCOM's, State TRANSCO's & CEA's guidelines with respect to all the works corresponding to power evacuation, transmission, termination along with metering at DISCOM's substation.

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
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 resistivity value obtained from geo-technical investigation report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.

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. Earthing conductor shall be buried at least 2000 mm outside the fence of electrical installations.

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

14.2.6 Every alternate post of the 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 PV array field

14.3.1 All PV Modules, Module Mounting Structures (MMS) and String Monitoring Unit (SMU) structures in the PV array field shall be bonded to the earthing system by two distinct connections.

14.3.2 Each PV Module frame shall be earthed using copper wire of sufficient cross section. The copper wire shall be connected to the earth hole provided in the module frame using suitable arrangement in line with the manufacturer recommendation. The earthing arrangement shall use stainless washers to prevent galvanic corrosion between aluminium frame and copper wire. In order to achieve effective earthing, serrated washers shall be employed to penetrate the anodization layer of the module frame.

14.3.3 Continuous copper earthing wire shall be run to connect a group of modules and both ends of the loop shall be bolted to the DC earth grid using bimetallic lugs and stainless-steel fasteners. The copper earthing wire shall be routed in such a way to avoid physical contact with the module aluminium frame.

14.3.4 The connection between MMS and DC earth grid shall be bolted or welded. Portion of the MMS which undergoes welding at site shall be coated with two coats of cold galvanising and anti-corrosion paint afterwards.

14.3.5 Earth electrodes of the DC earth grid shall be uniformly distributed throughout the PV array field so that optimum earth resistance is offered to leakage current flowing from any module frame or MMS.

14.3.6 SMU equipment earthing point shall be connected to the DC earth grid using flexible copper cable of sufficient cross section as recommended by the manufacturer. The connection with the DC earth grid shall be done using suitable bimetallic lugs and stainless-steel fasteners.

14.4 PCU Earthing

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

14.5 Transformer Earthing

14.5.1 Inverter transformer neutral shall be floating, not to be earthed. Transformer tank, cable box,

marshalling box and all other body earth points shall be earthed.

14.5.2 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.

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

14.6 Inverter Room and Main Control Room Earthing

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

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.

14.8 Approval

14.8.1 Documents/ drawings

(i) Technical datasheet

(ii) Earthing Design calculation

14.9 Tests

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 for entire plant against direct lighting strokes shall be provided with Early Streamer Emission (ESE) Air Terminal as per NFC 17-102:2011.

15.2 Protection Level for the entire plant shall be level – I.

15.3 Each ESE air terminal shall be provided with following accessories.

(i) Highly insulated poly-plastic adaptor to fix the ESE air terminal with the FRP mast

(ii) Fiberglass Reinforced Plastic (FRP) mast

(iii) Coupler to connect FRP mast with GI mast

(iv) Galvanized Iron mast with base plate and guy wire kit

(v) Down-conductor: PVC insulated flexible copper cable of suitable size complying with EN 50164-2 or equivalent standard. It shall be routed along the mast with suitable fixings and connecters. .

(vi) Test joint with each down conductor

(vii) Lightning event counter complying with EN 50164-6 or equivalent standard. It shall be fixed at suitable height in series with the down conductor.

(viii) Earth termination system in accordance with NFC 17-102. Earth electrodes shall comply with the EN 50164-2 or equivalent standard. Earth enhancing compounds complying with EN 50164-7 or equivalent standard, may be used where soil resistivity is higher and making it impossible to achieve system resistance within specified limit.

15.4 Accessories listed above are indicative only and any other fittings or accessories, which are usual or necessary for satisfactory operation of the lightning protection shall be provided by the Contractor without extra charges.

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

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

15.7 Type test reports as per NFC 17-102:2011 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 underground with suitable HDPE ducts.

17 SCADA

17.1 General Requirements

17.1.1 The Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire solar plant and its auxiliary systems.

17.1.2 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.

17.1.3 SCADA System shall have the provision to perform the following functions.

(i) Real-time acquisition and display of data, status, alarms and trends.

(ii) Display of status of major equipment in Single Line Diagram(SLD) format with string level monitoring capability

(iii) Display and storage of measured values

(iv) Display and storage of derived/ calculated/ integrated values

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

(vi) Remote monitoring of essential parameters on the web using standard modem (Internet connection for transferring data to web shall be taken by Contractor in the name of Employer for O&M period).

17.1.4 It shall be possible to remove/ replace redundant controller or various modules (like any I/O module, interface module, etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack without releasing any spurious signal to controller and causing disturbance or loss of controller functions for other controller.

17.1.5 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.

17.2 Programmable Logic based control system at Main Control Room

17.2.1 Bidder shall provide PLC based SCADA at Main Control Room. For other locations such as Inverter room, Sub Pooling Switchgear Room (if applicable) bidder may offer IO modules/ RTU/

PLC for completeness of SCADA.

17.2.2 PLC Processor

The processor unit shall be capable of executing the following functions.

(i) Receiving binary and analog signals from the field to server.

(ii) Implementing all logic functions for protection and annunciation of the equipment and systems.

(iii) Providing supervisory information for alarm, various types of displays, status information, trending, historical storage of data etc.

17.2.3 The SCADA shall be OPC version 2.05a compliant and implement an OPC- DA 2.05a server as per the specification of OPC Foundation. All data should be accessible through this OPC server. SCADA shall have OPC connectivity for other systems.

17.3 Human Machine Interface System (HMIS)

17.3.1 Graphical Interface Unit (GIU) / Operator work station (OWS) shall perform monitoring and operation of all devices interacting with PLC based system.

17.3.2 The system shall have built-in safety features that will allow/ disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. The system security shall contain various user levels with specific rights as finalized by the Employer during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

17.3.3 Bidder has to provide suitable hardware and software based firewall for network security to restrict unauthorized access to HMI/Solar SCADA PCs and system.

17.4 Programming Functionalities

Programming of the PLC Processor / controller as well as programming of HMIS shall be user friendly with graphical user interface. All programming functionalities shall be password protected to avoid unauthorized modification.

17.5 Software Requirements

17.5.1 All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided.

17.5.2 Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry shall be provided. SCADA system shall support following standard protocols (included but not limited to) to communicate with different sub system/Devices:

(i) Modbus (TCP/IP, RTU, ASCII)

(ii) Sub Station Protocol like IEC-61850

(iii) IEC 60870 – 5 – 101/ 104

(iv) Any other protocol on which the offered equipment (by Contractor) will communicate with SCADA.

17.5.3 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.

17.6 System Spare Capacity

17.6.1 Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity of 10% along with the necessary hardware/equipment/accessories to meet the future expansion requirement.

17.7 Data Communication System (DCS)

The DCS shall have the following minimum features.

17.7.1 Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator work station.

17.7.2 The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.

17.7.3 Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bump less and the same shall be suitably alarmed/logged.

17.7.4 Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 20% spare capacity shall be available for future expansion.

17.7.5 Contractor shall employ redundant Fiber optic backbone for data communication between Inverter rooms and main control room.

17.7.6 The Contractor shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.

17.8 Operator Interface Displays/Logs/Reports

Suitable Operator Interface Displays/Logs/Reports for control operation & monitoring shall be provided. The details shall be furnished and finalized during detailed engineering stage.

17.9 Historical Storage and Retrieval System (HSRS)

17.9.1 The HSRS shall collect, store and process system data from man-machine interface system and plant information system (MMIPIS) data base. The data shall be saved online on hard disk and automatically transferred to erasable long-term storage media once in every 24 hours periodically for long term storage. Provision shall be made to notify the operator when hard disk is certain percentage full. The disk capacity shall be sufficient to store at least seven days

data.

17.9.2 The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports. The data/information to be stored and frequency of storage and retrieval shall be finalised during detail engineering stage.

17.10 Control and Power Supply Scheme

Contractor shall provide the UPS/DC Power supply of suitable rating to cater all the load requirements of SCADA system and its auxiliaries. The power backup for the entire system should be at least for 02 hours.

17.11 Control Cabinets / Panels / Desks at Main Control Room

17.11.1 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.

17.11.2 The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications.

17.12 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.

17.13 Hardware at Main Control Room

17.13.1 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.

17.13.2 All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by Employer during detailed engineering. The LAN to be provided shall support TCP/IP protocol (Ethernet connectivity) with OPC RDI for interface with PLCs/other systems and shall have data communication speed of min. 100 Mbps. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

Processor	**64 Bit**
Hard disk	1 TB - RAID 1
Memory	8 GB RAM upgradable to 16 GB
Monitor	Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. Communication port-2 Serial bus, one parallel Dual 10/100/1000 Mbps. Ethernet Graphic Memory=16 MB Expansion slot=3
Screen display unit	Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen

Removable bulk storage drive (DVD / DAT)	6 GB (minimum)
Removable Bulk Storage Media for above (with each server/ work-station)	10 nos.
DVD R/W	16x or higher
Intelligent UPS (on line) with remote monitoring for each workstation/ server	1 no. with 30 mins. Battery backup on machine load
Keyboard	ASCII
Pointing Device	Mouse
Colour Laser Printer	Heavy duty type with resolution of 600 dpi Resolution

17.14 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.

18 Illumination

18.1 Standards and Codes

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

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

18.2 General specification

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

18.2.2 All indoor LED luminaires shall be supplied with proper diffuser to avoid direct visibility of LED with thermal management for longer life.

18.2.3 The contractor shall furnish Guaranteed Technical Particulars of the LED luminaires, from renowned brands available in the market for approval of Employer.

18.2.4 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.

18.2.5 Lighting system shall work on the auxiliary supply and same shall be incorporated in auxiliary loads. 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.

18.2.6 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.

18.2.7 Lighting panels shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. Cable armour shall be connected to earthing system at both the ends. Proper earthing of street light poles shall be ensured.

18.2.8 Junction box for lighting shall be made of fire retardant material. The degree of protection shall be IP55 for outdoor JB.

18.2.9 Cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.

18.3 Lighting Levels

18.3.1 The average LUX level of 10 lm is to be maintained in switchyard. However, a lux level of 20 lm ((10+10) additional switchable on requirement only) is to be maintained in switchyard on transformer.

18.3.2 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	500
Office	300
Battery & other rooms	150
Other areas including periphery wall	10
Transformer yard	20
H – pole and metering point	10

18.3.3 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.

18.4 LED Luminaire

18.4.1 LED luminaires shall meet the following parameters:

Parameter	**Specified Value**
Input voltage	170-260 V
Input Frequency	50 HZ +/-1 HZ

Power Factor	0.95 (Minimum)
Power Efficiency	>96%
LED chip efficacy	>130 lumens per watt
Luminaire efficacy	>90 lumens per watt
Dispersion Angle	Minimum 120°
Total Harmonic Distortion	< 15 %
Working Temperature	-5° to +50° C
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	5700o K (cool day light)
Colour Rendering Index	>75
Electrical Connector	Lead wire with 2 meter long – or as required by the customer at site.
Moisture protection in case of casing damage	IP 65 (driver unit shall preferably be totally encapsulated)

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

18.4.3 The LED luminaire 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.

18.4.4 The luminaire should be provided with in built power unit and electronic driver. The luminaire should be should be so constructed to ensure that the driver and LED modules are replaceable, if required.

18.4.5 The luminaire should be suitable for both standard street light poles with a typical pole diameter of 50 mm – 60 mm and should be suitable for side entry and bottom entry (post top).

18.5 Warranty

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

18.6 Approval

18.6.1 Documents/ drawings

(i) Lux level calculations

(ii) Building and street lighting layout

(iii) Luminaire data sheet

(iv) Test certificates

19 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.

19.1 Pyranometer

19.1.1 The Contractor shall provide minimum 4 (four) number of secondary standard pyranometers (ISO 9060 classification) along with necessary accessories for measuring the incidental solar radiation at horizontal and inclined plane of array.

19.1.2 Specification of the pyranometer shall be as follows.

Parameter	**Specification**
Spectral Response	0.31 to 2.8 micron
Sensitivity	Minimum 8 micro-volt/W/m^2
Time response (95%)	Maximum 15s
Nonlinearity	±0.5%
Temperature Response	±2%
Tilt error	<±0.5%
Zero offset thermal radiation	±7 W/m^2
Zero offset temperature change	±2 W/m^2
Operating temperature range	0°C to +80°C
Uncertainty (95% Confidence Level)	Hourly Max-3% Daily Max-2%
Non-stability	Maximum ±0.8%
Resolution	Minimum +/- 1W/m^2
Input Power for Instrument & Peripherals	230V AC (If required)

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

19.2 Temperature Sensor

The Contractor shall provide minimum 6 (six) temperature sensors (1 (one) for ambient temperature measurement with shielding case and 5 (five) for module temperature measurement). The temperature sensor shall be Resistance Temperature Detector (RTD)/ Semiconductor type with measurement range of 0ºC to 80ºC. The instrument shall have valid calibration certificate.

19.3 Anemometer

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

Details	Values
Velocity range with accuracy limit	0-60m/s with +/-2% accuracy @12 m/s; Resolution: 0.01m/s
Wind direction range with accuracy limit	0 to 360° (No dead band) with +/-2° accuracy @12 m/s; Resolution: 1°
Mounting Bracket	Anodized Aluminium bracket to reduce corrosion, all mounting bolts of SS
Protection Class	IP66
Output	RS232 and RS485

19.4 Data logger and Data Acquisition System

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

19.4.1 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:

- Built-in GSM/ GPRS modem for wireless data transmission to SCADA/ cloud server (procurement of GPRS enabled SIM Card and connection subscription to be the responsibility of Contractor). It should be possible to remotely communicate with the device for configuration settings.
- RS485 MODBUS interface for data collection and storage on SCADA
- Web interface with provision for user login to enable viewing and downloading of weather data in XLS/ CSV format
- 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: IP65

20 CCTV Camera

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

(i) Main entry: Covering all the entry/exit 24 hours

(ii) Along the Plant Perimeter: Covering complete perimeter of Plant Area to capture all possible intrusion

(iii) Control Rooms: Covering Entry/Exit and activities within Control Rooms

The Contractor has to propose the locations and number of cameras required for the Plant during bidding, however Employer's decision on number of cameras shall be final.

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

20.3 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.

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

20.5 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.

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

(i) Video motion detection

(ii) Object tracking

(iii) Object classification

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.

21 Fire alarm System

21.1 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 2005	

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

21.3 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.

21.4 Minimum two numbers of fire extinguishers (CO_2 and Foam type each, of capacity 10 kg having BIS certification marking as per IS: 2171) shall be provided at every building/ encloser, transformer yard and switchyard. However, contractor must comply with existing building code for fire protection and relevant IS codes.

21.5 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.

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

21.7 Contractor shall submit the plan for fire and smoke detection system for the Employer's approval.

22 Testing Instruments

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

22.1 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)	
Three cable reels with cable length up to 20 m	
Carry Case-1 (capable of handling tester along with accessories)	
1 set of spare battery	

22.2 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	
1 set of spare battery	

22.3 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
Insulation Test Current	1 mA nominal
Auto Discharge	Discharge time< 0.5 Second for C = 1
Open Circuit test Voltage	>4 V, <8 V

Accessories
Heavy duty Test Lead Set – 4 Nos.
Carry Case with sufficient space for accommodating accessories.

22.4 Digital Multimeter

Parameter	Specification
Display	Backlit LCD or LED display; Minimum resolution: 5 ¾ places for DC , 4 ¾ places for AC
Measuring Category	1000V CAT III as per IEC Standard 61010-1; wave shape independent RMS measurement (True RMS) suitable for operation in the site conditions.
Additional Functions	Resistance (Ω), Temperature (°C), Continuity, Diode , Capacitance, Frequency, Duty cycle measurement
22.4.1 Accessories	
Temperature Probe	
Silicon Test Lead	
Alligator Clip	
Carry Case with sufficient space for accommodating accessories.	

22.5 Clamp meter

Parameter	Specification
Display	Backlit LCD or LED display
Measuring Category	1000V CAT III as per IEC Standard 61010-1; wave shape independent RMS measurement (True RMS) suitable for operation in the site conditions.
Current Range	AC&DC Current up to 1000A/400 A
Voltage range	AC&DC Voltage upto 1000V
Additional Functions	Resistance, continuity, diode and non-contact voltage detection, Active, Reactive and Apparent Power, THD, PF

22.5.1 Accessories
Test leads
Electrical test leads
Probe light & extender
Carry Case with sufficient space for accommodating accessories.

22.6 Infra-red thermal imaging camera

Parameter	**Value**
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
Photo camera resolution	Approx. 30 times of IR camera resolution
Absolute error of measurement	< ± 2 K
Adjustable parameters	Emissivity, ambient temperature
Adjustable functions	Focus, temperature level and span
Measurement functions	Measuring spot, measuring area with average and maximum temperature
Calibration	The measuring system (Camera, lens, aperture and filter): The camera has to be traceably calibrated at least every two years. The calibration has to be documented. If the camera is not compliant, it has to be readjusted by the manufacturer.
Documentation	Storing of the infrared picture with the radiometric data

22.7 Digital lux meter

Parameter	Specification
Range	0 – 1000 lux
Accuracy	± (2% + 5)
Resolution	1 lux
Display	3½ digits, Backlit LCD/LED

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

22.9 Instruments of superior rating is allowed after seeking consent of the Employer.

22.10 Maintenance, calibration, up keeping, repair & replacement of these tools will be in the scope of the Contractor during 5 years of O&M.

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

23 Power evacuation system

23.1 The contractor has to do the power evacuation and integration to and with the designated substation via overhead transmission line and underground cables at specified grid voltage with all necessary infrastructure such as protection switchgears and metering systems as per the requirement of the Employer.

23.2 The power evacuation system for the plant shall be as per the local DISCOM requirement and appropriate approval. The contractor shall get the route approval from the Employer or concerned authorities prior to start of the construction. Any changes in the route or scheme introduced by DISCOM at any point of the time prior to commissioning shall be complied without any additional cost to the Employer.

23.3 The ROW for the TL/UG cable shall be obtained prior to the construction of the line from the concerned authorities. Total length for the power evacuation system is 4km (approx.) wherein it includes 3.2km (approx.) overhead line and 0.8km (approx.) of UG cable. UG cable shall also cross an existing railway siding of SPIC Chemical factory through GI pipe conduit(s) with due approvals from concerned authorities. Refer Annexure: Site details.

23.4 Overhead Transmission Line

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

23.5 Underground cable

23.5.1 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 DISCOM's requirement and the same shall be submitted to Employer for approval/ accord.

Civil, Mechanical & Plumbing Works

24 General Requirement

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

24.2 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.

24.3 Standards & Codes

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

24.3.2 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 Employer and the contractor shall submit proper justification for the same along with his request to the Employer review and approval, and the decision of the Employer shall be final and binding.

24.3.3 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 solar SPV plants.

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

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

24.4 The design calculations shall be supplemented with a neat sketch showing the structure geometry, node and member nos., lengths of various typical members, support points and type of supports, types of materials & type of sections with properties considered in analysis & design. The report shall also include back-up calculations for various loads adopted in design, brief write-up on primary load cases and design load combinations considered and conclusions on design results (with supporting sketches) for easy reference and clarity. Where a computer program (other than STAAD) is used for analysis and design, the contractor shall include a

write-up on the computer program used along with examples for validation check. Design Input (format suitable to the programme used and also in STAAD format) and output file shall also be given in the design report and in soft copy to facilitate its review and approval by the Employer.

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

25 Topographical Survey

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

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

25.3 The Contractor shall carry the Bench Mark from nearest GTS Bench mark or any other established source like Railway station, Permanent PWD/ WRD structure etc. as approved by the Employer, by fly-levelling and establish two permanent bench marks (PBM) at site. All subsequent transfer of levels shall be carried out with respect to these PBMs. The work shall also include constructing permanent reference pillars (RP) at suitable locations as directed by the Employer. These reference pillars shall be labelled permanently with their respective coordinates and reduced levels for future use. The Permanent Bench Marks (PBM) and reference pillars (RP) shall be shown on the survey drawings.

25.4 While carrying bench mark to the project site, levels shall also be established on the permanent objects like culverts etc. at least on one object in every 1 (one) km if available along with route with adequate description about the objects. These levels shall be maintained at site & also mentioned in the survey report to facilitate locating these objects later on.

25.5 The survey work shall be carried out in 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 Employer.

25.6 Positions, both in plan and elevation, of all natural and artificial features in the area like waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably symbols of survey of India Maps). All hills and valleys within the area/areas are to be surveyed and plotted on maps by contours. Any unusual

condition or formation on the ground, locations of rock outcrops (if visible on the surface) and springs/falls, sand heap/dune, possible aggregate deposits etc. shall also be noted and plotted on contour maps.

25.7 The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Employer'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.

26 Geotechnical Investigations

26.1 The contractor shall be responsible for detailed Geotechnical investigations at the proposed project site for the purpose of foundation design for various buildings, structures, HT lines, MMS etc. and other design/ planning requirements. The investigation work shall be carried out through any Govt. approved/ NABL accredited agency. The contractor shall submit the credentials of the proposed agency along with relevant certificates in support thereof for verification/ approval of the Investigation Agency by the Employer.

26.2 The scope of work 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, trial pits, electrical resistivity tests (ERT), field & laboratory CBR tests, conducting laboratory tests on collected samples of soil & ground water and preparation and submission of report. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20% met within a borehole. SPT test shall be conducted at every 1.5m interval or at change of strata. The starting depth of SPT shall be 0.5m from ground level. UDS shall be collected at every 1.5m interval or at change of strata.

26.3 The field investigations shall mainly include drilling of min. 5m deep boreholes (50% of total No. of boreholes shall be 10m deep), conducting SPT and collecting Disturbed (DS) and Undisturbed samples (UDS), conducting in-situ CBR test for approach road to the plant, internal roads & peripheral road; Trial pits and ERT s. Number and location of bore holes, CBR tests and Trial pits shall be decided as per the project layout, site topography and soil conditions in consultation with the Employer. There shall be minimum 1 nos. of Borehole per 5 acres of the area (However, total number of boreholes shall not be less than 5), 3 nos. of

Trial pits, 5 nos. of CBR test & ERT, 5 nos. of Ground water samples for laboratory investigations. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient nos. (Note- In case the project plot is divided in to number of discrete blocks separated from each other, min. 3 nos. of bore holes, 2 trial pits, 2 ERT and 2 CBR tests shall be taken per such block).

26.4 The proposed Geotechnical investigation plan indicating proposed locations of Trial pits, Bore holes, CBR test & ERT shall be submitted to the Employer for review and approval before start of work.

26.5 Laboratory tests shall be conducted on DS & UDS samples and ground water samples 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. Laboratory CBR test on soaked samples shall also be conducted on min. 5 no. of soil samples to ascertain the suitability of soil for sub-grade and requirement of any treatment of subgrade soil in case of CBR <2% as per IRC requirements.

26.6 After completion of field and laboratory work, the contractor shall submit a Geotechnical 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 and safe bearing capacity (SBC) for various Plant buildings (ICR, MCR etc.) and Open installations, Switch Yard structures & Sub-Station (as applicable), Transformer foundation, HT lines (as applicable), MMS foundation etc. corresponding to settlement of 25mm.

26.7 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 M25 (M30 in coastal areas/ marshy soil) for all RCC works except liquid retaining structures like underground water tank etc. where minimum grade of concrete shall be M30 (M35 in coastal areas/ marshy soil). Cement higher than 43 Grade, shall not be used in construction.

26.8 In case the contractor wishes to adopt concrete pile foundation for MMS supports the Geo-tech. report shall also include the calculations for safe pile capacity under direct compression, lateral load and pull out. The report shall include recommendations about type of pile, its depth and dia. to be used.

26.8.1 In coastal areas and in marshy or swelling type soil, under reamed or driven precast concrete pile shall be used. In case contractor wishes to use helical piles the design, fabrication and installation shall conform to IBC (International building code).

26.8.2 The contractor shall carry out field trials for initial load test on pile to verify the pile design to confirm the safe load carrying capacity under direct compression, Lateral load and Pull out.

26.8.3 The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area etc. However, minimum 5 nos. of piles shall be tested (min. 3 nos. in each block if the plant site is divided in discrete blocks separated from each other) under each category of load.

26.8.4 The locations of test piles shall be distributed over the plant site and to be finalized in consultation with Employer. In case of MMS column being anchored with base plate-anchor bolt assembly, the adequacy of provided pile reinforcement in job (working) pile corresponding to the set of test loads shall be reviewed by the contractor for any additional requirement of reinforcement and the same shall be provided in the pile to be cast for initial load test.

26.8.5 In case the Contractor proposes to embed the Column leg in the pile for fixing, the test pile shall be provided with embedded column leg as per approved design and any dowels as required for application of test load. The drawing for the Test pile shall be submitted to Employer for his approval before casting the test pile. The load test on pile shall be conducted after min. of 28 days from the date of casting. In case the contractor desires to conduct the test earlier than 28 days, he may use suitable higher grade of concrete or if there is substantial evidence from earlier cube test results on design grade concrete to demonstrate the early gain of required compressive strength prior to application of the test load.

26.8.6 However, under no circumstances the test shall be conducted before 15 days of the date of casting the pile. All the dial gauges and hydraulic jack assembly shall be properly calibrated as per the requirements of relevant BIS standards and valid calibration certificate to this effect from Govt. / NABL accredited Test agency shall be submitted to the Employer before use.

26.8.7 The contractor shall submit detailed methodology for conducting the tests in line with IS: 2911 (Part 4) for Employer's approval before commencement of any test. After completion of these tests the contractor shall compile the test results and submit the report in a proper format as specified in the BIS standard with recommendations/ conclusions for Employer's approval. The pile work shall start only after approval of the final pile design duly verified/ confirmed with initial load test results.

26.9 All buildings/ Open installations (MCR, ICR etc.), Switchyard and Sub-station area shall have levelled ground. No foundation for MMS, 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.

27 Other Investigations

27.1 The contractor shall also obtain and study other input data at proposed project site for design of the project from metrological department/ local govt. authorities. This shall include data related to Rainfall, Maximum & Minimum ambient Temperature, Humidity, HFL etc.

27.2 The contractor shall carry out Shadow Analysis at proposed site and accordingly design strings and array layout with optimum use of space, material and man power. In case of large variations in topography (5^o to the horizontal) the study shall also include the effect of topographical variations on array layout and MMS structure design adequacy and stability. The contractor shall submit all the details/ design to the Employer for review/ approval.

27.3 The contractor shall also identify potential quarry areas for coarse and fine aggregates to be used for concrete and shall carry out the concrete mix design for different grades of concrete to be used before start of concrete 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 Employer. 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 Employer. (Reports for periodic cube tests from the supply batch shall also be submitted for review and record)

28 Area Grading and Land Development

28.1 The Finished Grade Level (FGL) of the proposed plant shall be fixed with reference to the highest flood level (HFL) and surrounding ground profile at proposed site to avoid flooding of plant site. The data regarding HFL at proposed site shall be obtained from the metrological department by the contractor. In case of absence of this data, the contractor shall assess the required information through local site reconnaissance. The area at and around all buildings/ open installations (ICR, MCR etc.), transformer yard and switch-yard shall be uniformly levelled at suitable RL to be finalized considering topography and HFL at site. The minimum plinth level of all buildings/ open installations shall be 450mm above FGL. Module mounting structure foundation/ Pile cap or any other pedestal shall be min. 200mm above FGL.

28.2 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 blocks shall be clearly marked on the Plant Layout/

Module Layout drawing.

28.3 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.

28.4 It shall be ensured that the land is graded or levelled properly for free flow of surface run-off and the grade levels shall be fixed with respect to high flood level at site, drainage pattern and system requirements. It shall be ensured that the land is used optimally to have maximum solar power generation considering full utilization of the plot areas. It is advisable to follow the natural flow of water at the ground as far as possible for drainage design.

28.5 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.

29 Roads

29.1 Suitable approach road (as applicable) from nearest public road up to plant Main gate, Access road from Main gate to Main control cum office room (MCR), Internal access roads connecting MCR and other facilities/ buildings/ open installations like Local control room(s) (LCR)/ Inverter control room(s) (ICR), Sub-station & Switch yard (as applicable) etc. and Internal peripheral road along the boundary fence/ wall shall be provided for safe and easy transportation of men, material and equipment during construction and maintenance.

29.2 The Approach road connecting nearest public road and the Main gate shall be of 5m wide carriage way with 0.5m wide shoulders on either side. The access road connecting Main gate and MCR and internal access road(s) connecting MCR to various facilities/ buildings shall be

of 3.5m wide carriage way with 0.5m wide shoulders on either side while the peripheral road shall be of 2.5m wide carriage way with 0.5m shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL to avoid flooding of roads during rains. The roads shall be provided with alongside drains as per design requirements of drainage system to avoid flow of storm water over the road. The roads shall be designed as per IRC SP-20 corresponding to design vehicular traffic of minimum - 150 Commercial vehicles per day and critical field CBR value. Shoulder shall be of min. 150mm thickness.

29.3 However, following minimum road section details shall be followed:

1) Topping: wearing course of 20 mm thick pre-mix carpet or surface dressing, compacted 75mm thick with murrum blended with WBM Grade-III, as applicable.
2) WBM (CBR>100%): compacted 75mm thick, Grade III
3) WBM (CBR>100%): compacted 100 mm thick, Grade II
4) Granular sub-base (CBR>15%): compacted 225 mm thick,
5) Compacted subgrade: 300mm thick, compacted up to 98% of standard proctor density
6) Shoulders: compacted 150mm thick, murrum blended with WBM Grade-III

29.4 Soaked CBR value of sub-grade shall not be less than 2%. Where the CBR of the subgrade is less than 2 per cent a capping layer of 100 mm thickness of material with a minimum CBR of 10 per cent is to be provided in addition to the sub-base required for CBR of 2 per cent. 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.

29.5 The construction of road shall conform to relevant IRC/ MORST standards.

29.6 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. Except for module cleaning system 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 suitable concrete (M20) bedding/ encasement shall be provided. Water supply pipe for module cleaning and service/ drinking water shall be taken through Medium class GI steel pipe conforming to IS: 1161.

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

29.8 Maintenance pathways of min. 1.0m width shall be provided between SPV arrays for easy movement of maintenance staff, tools, equipment and machinery, washing of modules etc. The pathway area shall be generally levelled and well compacted manually/ mechanically. Areas of depression, valley zones or wherever there is noticeable change in topography, shall

be levelled by laying min. 100mm thick PCC M10 (nominal mix 1:3:6)/ precast concrete paver blocks (min. 60mm thick, Grade M50) matching top surface with ground topography/ grade to avoid accumulation of water in the region and allowing its free flow to keep the area devoid of mud/ sludge. All pathways shall be laid with 50mm thick well compacted murrum layer at top for ensuring easy movement of motor bike and to minimise ground erosion.

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

30 Surface/ Area drainage

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

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

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

30.4 The design shall conform to the provisions of IRC SP 42 and best Industry practices. (The design rainfall shall be taken as max. hourly rainfall at 25 years return period at project site as provided in the Isopluvial map of the relevant subzone annexed with Flood Estimation Reports of Central Water Commission (CWC).

30.5 The coefficient of run-off for estimation of design discharge shall be considered as per catchment characteristics, however it shall not be less than 0.6.

30.6 The drainage scheme shall be designed considering the plant plot area and the surrounding catchment area contributing to the plant area drainage as per the topography.

30.7 The storm water drainage system shall be a network of open surface drains (with rectangular or trapezoidal cross section) and shall generally be designed to follow the natural flow of water and ground contours.

30.8 Suitable size plant peripheral drain as per design (min. 500mm wide x 500mm deep) along inside of plant boundary wall/ fence shall be provided for smooth channelization of outside storm water and flooding in the plant.

30.9 The trapezoidal drains shall be lined with either brick or RR masonry/ concrete or stone slabs as suitable to the site conditions. The min. Thickness of the lining shall be 115mm for brick masonry, 75mm for concrete slabs, 150mm for RR masonry and 100mm for stone slabs. The lining shall be in CM (1:4) and the joints shall be raked and pointed with CM (1:3), however, the joints in lining of plant peripheral drain may be left without pointing.

30.10 In case of rectangular drain, the thickness of the wall shall be checked against structural stability. Min. thickness shall be 230mm for brick wall, 300mm for RR masonry and 125mm for RCC wall, except for garland drain around buildings where the min. wall thickness can be

115mm, 200mm and 100mm respectively for brick masonry, RR masonry and RCC wall.

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

30.12 The drain outfall shall be connected to the nearest existing natural drain(s)/ water body outside plant premises and it shall be ensured that the drainage water shall not encroach/ flood in the adjacent property/ plot.

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

30.14 The contractor shall also explore for providing rain water harvesting system for water conservation by constructing suitable collection wells along the drains or through provision of detention ponds etc. The scheme for rain water harvesting along with design calculations shall be submitted for approval.

31 Peripheral boundary Wall/Fence

31.1 The plant peripheral boundary shall be provided with either Chan link or barbed wire fencing or masonry boundary wall as specified.

31.2 The boundary fence/ wall shall be provided along the Solar PV plant boundary to demarcate the plant boundary and to keep away the unauthorised access to the plant. The fence/ wall shall be provided with Main entry gate. The fencing/ wall shall be with 2.5m height above grade level including 400mm dia. GI concertina wire at the top to be supported on Y shape angle brackets. The main gate shall be min. 5.5m wide (clear) (4 m carriage way + 1.5m wicket gate).

31.3 Chain link fencing

31.3.1 The fencing shall be of Chain link (GI or poly coat GI as applicable) mesh fabric with internal, corner and stay posts of RCC (min 200mm x 200mm size, M30 grade) or MS angle (min. ISA 65x65x6 mm), as applicable, along with230 thick brick/ 300 thick RR masonry toe wall, with suitable foundation & 150mm height above GL.

31.3.2 The brick masonry toe wall shall be plastered with 15thick CM (1:4) plaster on both faces and shall have min. 50 thick PCC (1:2:4) coping finished smooth and projecting 40mm on either side of the wall with top sloping inwards.

31.3.3 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.

31.3.4 Joints in RR masonry shall be properly raked and pointed with CM (1:3). In case of pond/ drain area suitable grid of MS angles of min. Size 505 x 50 x 6 mm shall be provided in place of toe wall for smooth flow of water.

31.3.5 The GI chain link mesh fabric (40x40 mm with min. wire gauge 3.15mm, both ends twisted) shall conform to IS: 2721. Poly coat GI chain link mesh (50x50mm) shall conform to ASTM 668.

31.4 Boundary wall

The boundary wall structure shall be a RCC beam-column structure with brick/ concrete block wall or Pre-cast RCC wall panels.

31.5 Barbed wire fencing:

The details of barbed wire fencing shall be same as those for chain link fencing except providing barbed wires in place of chain-link mesh

31.6 Main Gate:

31.6.1 The Main entry gate (2.5m height) shall of rugged design with solid MS steel sections (25x25mm). The spacing of vertical members shall not be more than 150 mm.

31.6.2 The gate shall be complete with MS flat guide track, castor wheel(s), GI fittings & fixtures like hinges, aldrop, locking arrangement, posts etc.

31.6.3 The main gate shall have 4.5m wide Gate for vehicular movement and adjacent 1.5m wide wicket gate for pedestrian movement.

31.6.4 The gate shall be provided with the Project name plate (2.5mx 1m, 3mm thick MS plate).The gate shall be painted with 2 coats of epoxy paint over 2 coats of suitable primer.

31.7 All design and drawings for peripheral boundary fence/ Wall and Main gate shall be submitted for Employer's approval before execution.

32 Plant Layout

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

32.2 The Plant and SPV module layout shall be a comprehensive drawing showing various requirements of the project like, Reference coordinate grid, Geographical and Plant North, Layout of boundary fence including coordinates of all corner points, Location of main entrance gate and any other access gates as per project needs, Block wise FGL, Layout of main approach road to the plant, Internal and peripheral roads, Security Room/ cabin (s), all Buildings and Open installations with coordinates, Temporary Storage yard/ facility to be used by the contractor during construction, proposed Array layout, Lightening arrester, UG/Over ground water Tank(s), Storm water drains, Corridor for buried cables etc.

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

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

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

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

33 Design Loads

33.1 Unless otherwise specified elsewhere, Dead load, Live load, Wind load and Seismic load for

buildings and structures shall be considered as per provisions of relevant BIS standards.

33.2 The following minimum imposed load as indicated for some of the important areas shall, however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

S. No.	Area	Imposed (Live) Load
a	Roof	1.50kN/ Sqm
b	Building floors (GF) & Grade Slab	10.00 kN/ Sqm
c	RCC Floors (General)	5.00 kN/ Sqm
d	Outdoor platforms, Stairs, Landing and Balconies, Walkway, Chequred plate & Grating (except cable trench cover)	5.00 kN/ Sqm
f	Road culverts & allied structures over drain & pipe crossings subjected to vehicular traffic	Design for Class – 'AA' loading (Wheeled & Tracked both) and check for Class – 'A' loading as per IRC Standard
g	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
h	Pre-cast and chequred plate cover over cable trench	4.00 kN/ Sqm
i	Main access & Internal Roads	As per IRC SP 20 corresponding to vehicular traffic of 150 commercial vehicles per day and critical in-field CBR

33.3 Primary Loads

1) Dead Load (DL)
2) Live Load (LL)
3) Wind Load (WL) – Both along X & Z horizontal direction
4) Seismic Load (EL) – Both along X & Z horizontal direction

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

specified elsewhere. (VoCPT site – basic wind speed V_b shall be 39 m/sec)

33.5 To calculate the design wind speed (V_z), the factors K_1 (probability factor or risk coefficient), K_2 (terrain roughness and height factor) and K3 (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)

33.6 In case of plant site within 60 km of sea coast, the importance factor for cyclonic region, 'k_4' shall be taken as 1.30. Provisions of IS: 15498 shall also be followed to ensure general safety of the structure.

33.7 To calculate the design wind pressure, 'p_d', factors 'k_a' and 'k_c' shall be taken as 1.0. (The factor 'k_d' shall be taken as 1.0 in case of plat site within 60km of sea coast)

33.8 The Seismic Load shall be considered corresponding to Earth quake zone at site as per IS: 1893 (Part- 4) with Importance factor 1.5. Ductile detailing as per IS 13920 shall be followed in concrete structures.

Notes for MMS design:

1) WL shall be considered as detailed below for estimation of WL (±X, ±Z direction) under primary loads
2) Load due to fair (positive pressure) wind direction on design tilt angles of MMS members for wind acting in X, Z direction
3) Load due to adverse (negative pressure) wind direction on design tilt angles of MMS members for wind acting in X, Z direction
4) Load due to wind on side (exposed) face of respective MMS members (Drag force) for wind acting in X & Z direction to be considered along with (i) & (ii) above.

33.9 Design Load combinations

33.9.1 Appropriate Load factors in LSM design for concrete structures and appropriate Factor of safety in WSM design (ASD) for all steel structures including MMS shall be considered as per relevant BIS standard. No increase in permissible stress is permitted in design of MMS

33.9.2 Following load combinations shall be considered in design:

1) DL+LL
2) DL+LL ± WLx
3) DL +LL± WLz
4) DL+LL ± ELx
5) DL+LL ± ELz

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

34 Foundations (General)

34.1 Contractor shall design all foundations for buildings, equipment, HT line Towers, Switch yard structures, Transformer, MMS & other structures as per relevant BIS standards and recommendations of Geotechnical investigation report.

34.2 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

34.3 All design & drawings shall be submitted to the Employer for approval before execution.

35 MMS Foundation:

35.1 Module mounting structure (MMS) may be supported on isolated/ strip footing or pile foundation.

35.2 Bored cast-in situ, Driven precast or under reamed Concrete pile

35.2.1 In case the contractor proposes to provide pile; the type, dia. and length of pile shall be as per recommendations of Geotechnical investigation report corresponding to prevalent soil characteristics at site. However the min. dia. and depth of the pile shall be 300mm and 1800mm respectively except when very hard strata/ rock (N>100) is encountered at a higher level, the pile shall be extended in to the hard strata minimum 1.5 times the diameter of the pile with total depth of the pile not less than 1200mm.

35.2.2 As specified above, the MMS support shall project minimum 200mm above FGL (Finished grade level) to avoid any damage to the MMS column/sub support due to direct contact of rain water/ surface run-off. This shall be ensured through either single stage construction of entire pile length including portion above FGL or by providing a collar (to be cast in second stage) which shall project min. 75mm in plan beyond the pile face and shall extend min. 250mm below GL.

35.2.3 The surface of first stage concrete shall be made rough by trowelling and cleaning out laitance and cement slurry by using wire brush on the surface of joint immediately after initial setting of concrete and to clean out the same immediately thereafter. The prepared surface should be in a clean saturated surface dry condition when fresh concrete is placed against it. The prepared surface shall be applied with a suitable bonding agent before construction of pile cap/ collar as required.

35.2.4 In case the column post/stub is supported through base plate-anchor bolt assembly, the same shall only be provided through RCC pile cap to be designed as per provisions of relevant BIS standard.

35.2.5 In case of collapse of foundation strata during drilling of the pile bore, removable steel liner shall be used to maintain design depth and diameter of the pile for proper concreting. The design &

installation of piles shall conform to IS: 2911. The bore shall be free from water before poring of pile concrete. For under water concreting tremie shall be used.

35.3 Helical/ Screw Pile:

35.3.1 The design, manufacture, testing and installation of Helical/ Screw pile shall conform to ICB-2009 and Practice Note 28- **Screw Piles: Guidelines for Design, Construction & Installation,** ISSN 1176-0907 October 2015 (IPENZ Engineers New Zealand)

35.3.2 The design of pile shall be undertaken and verified by a suitably qualified geotechnical or structural Chartered Engineer with experience in the design of helical/screw piles.

35.3.3 The pile shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by installation into the ground and service loads.

35.3.4 The steel grade for pile shaft, helix plates and other accessories shall be with min. Fy 350 MPa. Min. thickness (BMT) of shaft and helix plate shall be 6 and 8mm respectively in case of coastal installations and soils containing aggressive chemicals and at other project sites it shall be respectively 5 and 6mm. Cap plate and col base plate shall be min. 12mm thick and of min. grade E-250 conforming to IS:2062

35.3.5 All materials shall be hot dip galvanized conforming to relevant BIS with min. thickness of galvanization 80 microns.

35.3.6 Wherever the pile shaft is required to be infilled with concrete, the same shall be min. grade M30

35.3.6.1 The allowable axial design load (Direct compression & Pull out), *Pa ,* of helical piles shall be the **least of the following** values:

1) Sum of the areas of the helical bearing plates times the bearing capacity of the soil or rock comprising the bearing stratum.
2) Capacity determined from well-documented correlations with installation torque.
3) Load capacity determined from initial load tests.
4) Axial capacity of pile shaft.
5) Axial capacity of pile shaft couplings.
6) Sum of the axial capacity of helical bearing plates affixed to pile.

35.3.6.2 The lateral allowable load capacity of the pile shall be calculated using P-Y analysis and shall be verified with field trials. The allowable design lateral load shall be equal to the min. of (i) the total lateral load producing max. lateral deflection of 5mm and (ii) 50% of the total lateral load at which the lateral displacement increases to 12mm.

1) Dimensions of the central shaft and the number, size and thickness of helical bearing plates shall be sufficient to support the design loads.
2) The Design Report shall include following details:
   - Design loads

- Geotechnical Strength Reduction Factors and supporting methodology
- List of design standards
- Design methodology and how specific loads such as seismic, lateral and settlement are addressed
- Founding stratum
- Estimated length
- Connection design and details between pile shaft & pile cap plate and Col base plate
- Pre-production and production load testing to support design including acceptance criteria.

35.3.6.3 Helical piles shall be installed to specified embedment depth and torsional resistance criteria as per design. The torque applied during installation shall not exceed the maximum allowable installation torque of the helical pile

35.3.6.4 Special inspections shall be performed continuously during installation of helical pile foundations. The information recorded shall include installation equipment used, pile dimensions, tip elevations, final depth, final installation torque and other pertinent installation data as required.

35.3.6.5 The installation of piles shall be done by an agency having adequate experience in helical pile construction.

35.3.6.6 The method statement for pre-production load testing (initial test) and construction for Helical Pile shall be submitted for review and approval. The method statement shall comply following requirements:

35.3.6.6.1 Helical pile pre-production load testing**:**

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

- Programme of the testing, detailing the timing and sequence of each load test including any additional investigations proposed
- The general arrangement of the equipment
- A method for measuring the displacement at the head and toe of each test pile
- Template for the Pile load test report
- Confirming the criteria for determining the acceptability of the compression, tension and lateral load tests
- A contingency plan in the event that a load test is deemed not acceptable
- A procedure for verifying the capacity for each individual pile, this may include correlating the installation torque for each pre-production pile with the load test results

- All pile load tests shall be supervised by suitably experienced personnel, who are competent to operate, monitor and record each test throughout its duration. Each pile load test shall be continuously monitored throughout its duration.

35.3.6.6.2 Helical Pile Construction:

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

- Programme of the works, detailing the timing and sequence of individual portions of the works
- Full details of the installation plant to be used, including manufacturer's information and proof of servicing/recent upkeep and calibration
- Proposed phasing of excavation/filling operations such that the design stresses in the piles (and any supporting frames) are not exceeded
- The contingency plan to be adopted, to minimize disruption and delay, in the event of encountering obstructions
- Anticipated noise levels (measured in dB) and vibration levels (measured in mm/sec) arising from piling operations (if applicable)

35.3.6.6.3 The Piling Contractor shall nominate a suitably experienced, professionally qualified engineer, as the "Piling Supervisor".

35.3.6.7 Unless specified else were, the field trials for initial load tests on concrete and helical/ screw pile shall conform to IS: 2911 (Part 4) & Practice Note-28 (IPENZ Engineers New Zealand) as applicable. The no. and location of such tests shall be as per the provisions stipulated under Cl. No. 4 above.

35.3.7 Contractor shall also carry out routine tests on 0.5 % of the total no. of working/ job piles as per provisions of IS: 2911 (Part 4). In case of unsatisfactory results, min. no. of routine tests may be increased up to 2% of the total no. of working/ job piles as per the directions of the Engineer-in-charge

36 Module Mounting Structure (MMS)

36.1 The ground mounting structure design shall generally follow the existing land profile. The top of the table shall be in one plane and shall not have inclination more than 5° to the horizontal.

36.2 In case of topographical variations more than 5°, the contractor shall carry out detailed study of its effect on array layout and structural stability of MMS.

36.3 The structure shall be designed to allow easy replacement of any module and shall be in line with site requirements.

36.4 The MMS stub/ column, rafter, purlin, ties and bracing members shall conform to following Indian standards

- IS: 2062 – Hot rolled Medium and High tensile structural steel
- IS: 811 – Cold formed light gauge structural steel sections
- IS: 1161 – Steel tubes for structural purposes
- IS: 4923 – Hollow steel sections for structural use
- Minimum grade of steel for sections conforming to IS: 811 & IS: 4923 shall be E350 conforming to IS: 2062 and Y_{St} 310 conforming to IS: 1608 respectively.

36.5 The contractor can also propose new light gauge structural steel or structural aluminum sections other than specified in IS: 811 subject to approval of the Employer. In this case the contractor shall submit his proposal stating the technical advantages of the proposed sections for Employer's review along with supporting literature and sample design calculations conforming to present specifications at the time of bidding.

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

- Stub/ column – 3.15mm,
- Rafter – 2.5mm &
- Purlin & other members – 2.0mm

36.7 The primary loads and load combinations for design of MMS structure shall be as specified under Cl. No. 9. The design shall be done by Working stress method and no increase in allowable stress shall be permitted.

36.8 The maximum permissible deflection/ side sway limits for various elements of MMS under serviceability conditions shall be as following:

- Lateral deflection/ side sway for Column – Span/ 240
- Vertical deflection for Rafter and Purlin – Span/ 180
- Lateral deflection for Purlin – Span/240

36.9 For fundamental time period T_0 >1.0 Sec, the design of the MMS structure shall be checked against dynamic effects of wind as per provisions of IS – 875 (Part-3) using gust factor method.

36.10 The purlins shall be provided with min. following 10mm dia. GI sag/ tie rods:

- 1 no. in each middle span
- 1 no. diagonal tie rod at each corner in end spans

36.11 Lateral restraint to compression flange if any due to PV panels is not permitted in purlin design.

36.12 The vertical diagonal bracing shall be provided in end spans of each unit (table) of MMS.

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

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

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

36.16 It is to ensure that before application of this coating, the steel surface shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or any foreign material likely to interfere with the coating process.

36.17 The bidder shall ensure that inner side is also provided with galvanization coating.

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

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

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

36.21 All fasteners and washers (2 round + 1 spring) for MMS connections and fixing of PV Module shall be adequately protected from atmosphere and weather prevailing in the area.

36.22 Fasteners and washers to be used for erection of mounting structures and those for fixing Module over MMS shall be of stainless steel grade SS 304 & SS 316 with property class A2-50 and A2-70 respectively conforming to relevant ISO standard and must sustain the adverse climatic conditions to ensure the life of the structure for 25 years.

36.23 Min. diameter of bolt for MMS connections shall be 10mm except for column-rafter connection where it shall not be less than 12mm (not less than 16mm in case of single bolt connection)

36.24 Modules shall be clamped & bolted with the structure properly. The material of clamps shall be Al / SS having weather resistant properties. Clamp – bolt shall use EPDM rubber and shall be designed in such a way so as not to cast any shadow on the active part of a module.

36.25 MMS column post shall generally be supported with base plate secured to foundation using anchor bolts for easy maintenance/ repair/ replacement during operation stage. The anchor bolts shall be galvanized high strength “J” bolts conforming to specifications of IS: 4000/ IS: 1367 and relevant IS code Installation of foundation bolts and embedment of column leg in foundation concrete shall be done by using template to ensure proper alignment. The underside of base plate shall be provided with anti- shrink grout.

36.26 In case the contractor proposes to embed the column leg in the pile/ pedestal as an alternate fixing arrangement, the column member shall be extended for full depth of the pile/ pedestal (100mm bottom cover) with an end plate of min. 4mm thickness to be fixed at the bottom of column leg. (However, for plants in coastal area or in case of marshy soil the column post shall be supported only with based secured to foundation through base plate and anchor bolts and

no embedment of column leg in foundation is permitted)

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

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

36.29 The Bidder should design the structure height considering highest flood level at the site and the finished grade level. The minimum clearance between the lower edge of the module and the finished grade shall be the higher of (i) Highest flood level + 100mm and (ii) 500 mm, as applicable

36.30 The length of single table shall not be more than 20m.

36.31 The contractor shall submit the foundation & structural design basis for MMS along with the list of reference standards in his Bid duly certified by a Chartered Engineer having adequate successful experience in similar works which shall be finalized with the prospective bidder during pre-award.

36.32 The contractor shall submit the detailed design calculations and drawings for MMS structure, bill of materials and their specifications/ standards to the Employer for approval before start of fabrication work as per the engineering work program (L2 schedule) as finalized during kick-off meeting

37 Concrete Works

37.1 All RCC works shall be using 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.

37.2 The contractor shall carry out concrete mix design well in advance prior to construction through NABL accredited laboratory/ Govt. Institutes.

37.3 The minimum grade of RCC shall be as specified above. Unless otherwise specified elsewhere in this specifications, 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).

37.4 Reinforcement steel shall be of high strength TMT bars of grade Fe500 D conforming to IS: 1786. Ductile detailing in accordance with IS: 13920 shall be adopted for superstructure and sub-structure of all RCC buildings and structures.

37.5 Unless specified otherwise for grouting works anti shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound shall be used. The grout shall be high strength grout having min. characteristic strength of 35 N/ mm2 at 28 days.

38 Miscellaneous Steel Works

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

38.2 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.

39 Buildings

39.1 General Requirement

39.1.1 Plant buildings/ open installations are required to be constructed for housing the electrical equipment/ panel (Local Control Room Building - LCR) and Control room cum office cum store (Main Control Room Building - MCR) for operation and maintenance of Photovoltaic Solar Power Plant. Security room at main gate & Security cabin(s) (at strategic locations) shall also be provided to secure the plant from any theft/ burglary/unauthorized entry.

39.1.2 Unless otherwise specified elsewhere, all buildings except Security room/ cabin shall have RCC framed structure. Brick partition walls shall be provided for Kitchen, Pantry, Battery room and Toilet units. For other rooms AL Glass partitions shall be provided. The equipment area shall be designed with OEM requirements to ensure all satisfactory operations. The security room/ cabin(s) shall be of prefabricated structure.

39.1.3 All buildings shall have provision of adequate windows for natural light & ventilation, Fire safety provisions and shall be designed as per provisions of National building code (NBC)

39.1.4 The contractor shall submit the proposed layout drawings to the Employer for approval before development of Architectural drawings. The building layout, exterior elevations shall be aesthetically designed following good architectural practices to get a pleasant look. Horizontal/ vertical bands through projections/ groves in external plaster may be provided to break the monotony. Roof slab shall have projection of 500mm beyond external walls with RCC parapet wall of 450 mm clear height all-around which shall form a projected band at roof level. For weather protection all doors and windows shall be provided with 450mm wide RCC chajja. However, chajja for rolling shutter shall be 750mm wide.

39.2 Functional requirements

39.2.1 MCR Building

For operation & maintenance of SPV Plant, unless otherwise specified elsewhere, Control room cum office area of MCR building shall provide following facilities:

- Air conditioned area (with provision of split A/C unit of adequate capacity) for SCADA room (approx. carpet area 12m^2) & Conference room (approx. carpet area 20 m^2)
- Inverter/ Switchgear, equipment room(s) as per requirements
- Supervisor cabin and office area (approx. carpet area 20 m^2)
- Store cum record room (approx. carpet area 15 m^2)
- Battery room as per requirement

- Toilet block with separate gents and ladies wash room facilities (approx. total carpet area 12 m^2)
- Pantry with service platform and utensil washing facilities (approx. carpet area 5 m^2)
- Suitable provision for passage (for smooth movement of O & M personnel), cable trenches, operating area etc. (min. clear width 1500mm)

39.2.2 LCR/ Inverter Building

- Unless otherwise specified elsewhere, Inverter room/ LCR consists of data loggers, battery, Inverter, Electrical panels etc. as per requirement. There shall be suitable provision for easy/ smooth passage for O & M personnel, cable trench, operating area etc.
- The size of LCR/ Inverter room shall be provided as per system requirements
- In case ICR and MCR building facilities are clubbed in one single building, the Equipment area (Invertor room) and Office cum Control room area shall be separated by a brick wall with provision of internal entry door
- MCR building shall have separate main entry to office area plus a provision of fire exit door
- The size of Inverter/ HT panel room shall be provided as per system requirements.

39.2.3 Security Room/ Cabin

39.2.3.1 Contractor shall provide required number of prefabricated security cabins at strategic locations & at corners of the plot and 1 nos. security room per Main entry gate.

39.2.3.2 The Main security room shall be of min. size 3m x 3m and height 2.75m. The security cabin shall be of min. size 1.2 x 1.8m and height 2.5m.

39.2.3.3 Security room/ cabin shall be a pre-engineered & pre-fabricated structure. The walls and roof of the building shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.5mm, 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 10^0 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 Employer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS; 15965.

39.2.3.4 The Main security room shall be provided with one Aluminum (AL) glazed door (0.75m wide x 2.1m height) on one face and AL glazed sliding windows (1.2m width x 1.0 m height) with AL grill on remaining three sides. Security cabin shall have 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.

39.2.3.5 The door and windows shall be provided with all necessary fitting and fixtures like handles,

tower bolts, mortise lock for door, stays, door stopper etc. All AL sections for doors and windows shall be anodized (min. average thickness 25 microns) or polyester powder coated (min. DFT 50 microns) with approved color shade for protection against weather.

39.2.3.6 Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used. Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

39.2.3.7 The Security Cabin may be installed on concrete M15 skid platform, 250 thick with shrinkage reinforcement near top surface. The concrete platform shall project 200mm beyond the walls. The Security Room shall be supported on RCC pedestal & foundations.

39.2.3.8 The Design and drawings shall be submitted for approval prior to fabrication and installation

40 Flooring, Skirting and Dado

40.1 Store area, Equipment Room:

40 mm thick Cement concrete (IPS) flooring (1:2:4), aggregate size 10 mm down, conforming to IS 2571 with 2mm thick Heavy duty epoxy coating (Industrial grade) of approved make on top as per manufacturer specifications and 10mm thick matching skirting of 100mm height.

40.2 SCADA Room, Control cum Office Room, Supervisor Room and Lobby:

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

40.3 Battery Room:

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

40.4 Toilet:

40 mm thick Ceramic tile (8mm thick) flooring and glazed tile (6mm thick) 2100 height dado.

40.5 Pantry:

40 mm thick heavy duty vitrified tile (8 mm thick) flooring and glazed tile (6mm thick) 2100 mm height dado, 20mm thick Granite stone finish over service platform

40.6 Passage/ Corridor:

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

40.7 Steps

Kota stone – 20 thick/ 50 thick cement concrete (IPS) flooring conforming to IS 2571

40.8 All items shall be of reputed make. Only Items with approved samples by the employer shall be used.

41 Doors and Windows

41.1 Doors, windows and ventilators shall be made of AL sections (minimum average thickness 2.5mm), industrial grade, anodized (grade AC25, min. thickness 25 micron conforming to IS: 1868) or with polyester powder coating (Total DFT 50 microns conforming to IS: 13871) and shall be approved make & colour shade. All sections, fittings and fixtures shall be anodized (min. thickness of coating 20 micron). The window and door shutters shall be of clear float/ wired glass as per design/ functional requirements. However, the doors in toile area shall be of steel frame with solid core (MDF) flush shutter, 35mm thick, with laminated finish conforming to IS: 2202.

41.2 The area of the openings shall be designed to have adequate ventilation and natural light and to meet functional requirements. AL Louvers, duct/ ventilation openings shall be provided as per functional requirement.

41.3 All doors, windows and ventilators shall be provided with all necessary fittings and fixtures like handles, tower bolts, wind stays, hinges etc. of heavy duty anodized AL. All doors shall be provided with hydraulic door closure of required capacity.

41.4 All windows shall be provided with suitable AL grill of anodized sections with adequate thickness for security purposes.

41.5 Clear float glass for window and door shutter shall be of min 4mm and 6mm thickness respectively. Wired glass where provided shall be of min thickness 6mm.

41.6 Entrance door and door in passage shall be min. 1.5m wide (double leaf) x 2.1 m height while door for Conference room and Store room shall be min. 1.2m wide x 2.1m height. All other doors shall be min. 1.0m widex2.1m height except for WC which may be of 0.8m width.

41.7 Rolling shutters shall be of required size and shall be made of cold rolled steel strips with adequate gauge thickness and shall conform to IS 6248. Rolling shutter shall be provided with all fixture, accessories, paintings etc. all complete and shall be mechanically operated type.

42 Roofing

42.1 The roof of all buildings shall be provided with min. slope of 1:100 for effective drainage of rain water. The slope shall be achieved either by application of screed concrete of grade 1:2:4 (with 12.5mm down coarse aggregate) with min. 25mm thick CM 1:4 layer on top to achieve smooth surface to facilitate application of water proofing treatment.

42.2 The water proofing treatment shall be in situ five course water proofing treatment with APP (Atactic Polypropylene) modified Polymeric membrane over roof consisting of first coat of bitumen primer @ 0.40Kg per sqm, 2nd & 4th courses of bonding material @ 1.20 kg/sqm, which shall consist of blown type bitumen of grade 85/25 conforming to IS : 702, 3rd layer of roofing membrane APP modified Polymeric membrane 2.0 mm thick of 3.00 Kg/sqm weight consisting of five layers prefabricated with centre core as 100 micron HMHDPE film

sandwiched on both sides with polymeric mix and the polymeric mix is protected on both sides with 20 micron HMHDPE film. The top most layer (5th layer) shall be finished with brick tiles of class designation 10 grouted with cement mortar 1:3 (1 cement: 3 fine sand) mixed with 2% integral water proofing compound by weight of cement over a 12 mm layer of cement mortar 1:3 (1 cement: 3 fine sand) and finished neat. The water proofing treatment shall be extended over golla/ fillet and inner face of the parapet up to 450mm height.

42.3 The corners at parapet wall and slab shall be provided with 50 thick fillet/ golla in CM 1:3 with neat finish.

42.4 Required no. of rain water down take pipes min. 100mm dia. PVC pipes (UV resistant), with 450x450mmx15mm deep khurra and MS grill at inlet shall be provided for rain water disposal.

43 Plinth protection and drain

43.1 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.

43.2 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 shall be provided along the periphery of the plinth protection for collection and disposal of rain water from building roof including 12mm thick plaster in CM 1:5 and 25thk PCC (1:3:6) coping at top

44 Plinth filling for buildings

44.1 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) Minimum of.235 thick or above, well compacted bounder soling with interstices filled with sand.

(iii) 75mm thick PCC 1:3:6 over (ii)

(iv) 100mm thick PCC 1:2:4 over (iii)

(v) 40mm thick floor finish over (iv)

45 Anti- termite Treatment:

In case presence of termites at the project site, an anti-termite treatment shall be provided for all foundation pits and building plinth in MCR building conforming to IS: 6313 to control entry of termites

46 Plumbing & Sanitary Works

46.1 Toilet block (with separate wash room facilities for both Genders) in MCR building

46.2 Wash rooms shall have following min. fittings:

- Wall mounted WC (Western type) 390 mm high with toilet paper roll holder, low height flushing tank and all fittings

- A set of 2 wall mounted Urinals (430 x 260 x 350 mm size) with flushing tank and all fittings (Gent's wash room only)
- Wash basin (550 x 400 mm) above platform with all fittings including 2-pillar cocks
- Bathroom mirror (600 x 450 x 6 mm thick clear float glass) with hard board backing
- CP brass towel rail (600 x 20 mm) with C.P. brass brackets
- Soap holder and liquid soap dispenser
- Ventilators – Mechanical exhaust facility
- Overhead PVC water storage tank – Capacity 1000 litres (common for both wash rooms)

46.3 Pantry room shall be provided with kitchen sink cum drain board and provision for installation of Water Cooler.

46.4 One toilet room with provision of WC and Wash basin shall be provided at Security Room near main gate. Necessary plumbing lines shall be provided for MCR building and Security room near main gate.

46.5 All sanitary ware, fittings and fixtures shall be of reputed Make and Type and approved by the Employer. All fittings, fastener, grating shall be of CP brass conforming to relevant BIS standards.

47 Painting & Other Finishes

47.1 Painting

Painting and white wash/ colour wash for the buildings shall conform to relevant BIS standards. The make and colour shade of the finish shall be as advised and approved by the Employer.

Internal Walls except toilets & battery room	Acrylic emulsion (for MCR) & Oil Bound distemper (for LCR/ Security Room)
Battery room	Acid/ Alkali resistant tiled dado of 2100 mm height & Chlorinated rubber paint above dado (Vitrified tile flooring dado in case of maintenance free batteries)
Toilet	Oil bound distemper
External Walls	All weather proof cement based acrylic emulsion paint, exterior grade
MMS foundations/ Earth pit Enclosure	Cement paint
Underside of roof slab	White wash
Air conditioned areas	Underside of roof slab- Under deck insulation with 50mm thick mineral wool, min. density 45 kg/ m3 and Gypsum board false ceiling with GI grid/ Gypsum tile (600x600mmx 12 thick) false ceiling with AL grid as per manufacturer's

	details
Battery room	Acid resistant resin based epoxy Paint Paint above dado bound distemper in case of maintenance free batteries)

48 Air conditioning & Ventilation for MCR and Other Buildings

48.1 All buildings shall be equipped with appropriate numbers of fans for effective heat dissipation.

48.2 In MCR building, the supervisor room, Conference room and SCADA room shall have split type air conditioning units.

49 Fire Extinguishers

49.1 All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. LiquefiedCO_2/ foam/ ABC type fire extinguisher shall be upright type of capacity 10kg conforming to IS: 2171, IS: 10658.

49.2 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.

50 Sand buckets

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

50.2 All buildings shall be provided with required no. of sand buckets as per relevant BIS standard and NBC. 4 No. of Bucket stands with four buckets on each stand shall be provided in the Transformer Yard.

51 Sign Boards and Danger Boards

51.1 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 Employer.

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

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

51.4 The Contractor shall provide to the Employer, detailed specifications of the sign boards.

52 Masonry Work

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

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

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

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

52.5 Unless otherwise specified elsewhere, Bricks shall be of class designation 7.5 conforming to IS: 1077, IS: 2212 & IS: 3495.

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

52.7 The laterite blocks shall conform to IS: 3620.

52.8 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.

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

53 Plastering, Pointing & Coping Works.

53.1 All brick masonry work shall be provided with plaster.

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

53.3 Thickness of plaster shall be 18mm and 12mm for rough and smooth surface of the brick wall respectively. The ceiling plaster shall be 6mm thick.

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

53.5 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.

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

54 Building Water Supply & Plumbing Works

54.1 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.

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

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

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

54.5 Sewage Treatment facility:

54.5.1 The Contractor shall design & provide soak pit and RCC Septic tank for treatment of sewage and waste water from MCR building and Security room. However, in case of ground water within 1.5m of finished grade level or the soil strata being of low permeability (permeability ≤ 10^{-6} m/s) where septic tank and soak pit arrangement is not effective suitable packaged sewage

treatment plant of reputed make/manufacture shall be provided. The sewage treatment facility shall be of required capacity and of proven design.

54.5.2 The sewage treatment facility shall be designed for total of 15 people.

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

55 Pipe & Cable Trenches

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

55.2 The trench shall be designed for lateral load due to external soil fill, ground water table at FGL and 50 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.

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

55.4 Min. thickness of precast cover shall be 50mm. Both bearing edges of the cable trench and all edges of pre-cast covers shall be provided with min. 50x50x6 mm edge protection angle with lugs.

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

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

55.7 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.

55.8 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.

56 Transformer Yard Civil Works

56.1 Transformer and equipment foundations shall be founded on piles/isolated spread footings or block foundation depending on the final geotechnical investigation report and functional requirements.

56.2 Transformer foundations shall have its own 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 transformer pit shall be min. 1/3 volume of the transformer oil and it shall be filled with granite stone gravel of size 40mm uniformly graded with 250 mm free space above gravel fill.

56.3 In case of transformer oil tank capacity more ≥ 2000 litres or as the relevant code suggests, the transformer pit shall be connected to separate oil collection pit through discharge pipe and shall be suitably sized to accommodate full oil volume of the transformer connected to it,

without backflow. The oil collection 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.

56.4 Both, the transformer pit including side walls and the oil collection pit shall be of RCC. 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.

56.5 The area around the transformer and equipment shall be covered with gravel.

56.6 The area shall be provided with galvanized chain link fence of height min 1.8m with 3.5m wide gate. The specifications for fencing shall be similar to those specified above except fence post which shall be of 65X65X6 MS angles spaced at 2.5m c/c.

56.7 The Gate of size 3.5m shall be of MS pipe (of class MB 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. In addition to main gate a wicket gate of MS pipe frame with 1.2 m width shall be provided for man entry for maintenance purpose.

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

56.9 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.

57 Water Supply & Cleaning of Modules

57.1 The contractor shall design and install the effective module cleaning system.

57.2 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.

57.3 The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at least once in two week or at closer frequency as per the soiling conditions prevailing at site, in order to operate the plant at its guaranteed plant performance. Also, the contractor is required to plan the water storage accordingly with provision of a tank of suitable capacity for this purpose. However, min. consumption of 2 Ltr / Sqm of surface area of SPV module shall be considered in estimation of required quantity of water storage.

57.4 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.

57.5 If required, for settlement of any grit/ unacceptable suspended particles in the water a settling tank shall be installed before the inlet of the storage tank. Suitable arrangement for discharge/ disposal of sediment/ slush shall be provided in silting chamber by gravity disposal in surface drain or with provision of sludge sump and pump of adequate capacity.

57.6 The module cleaning system shall include construction of RCC tank or supply and installation of Ground mounted PVC tank (s) of required storage capacity, pumps (including 1 No. standby pump), water supply mains and flexible hose pipes, taps, valves (NRV, Butterfly valve, Ball valve, Gate valve, PRV, scour valve etc.), Water hammer arrester(s), pressure gauge, flow meter etc. as per the planning & design.

57.7 In case of over ground water storage tank, the contractor shall check its effect on plant performance through shadow analysis. The PVC storage tank shall conform to IS: 12701. The valves shall conform to IS: 778. A suitable metal sheet canopy for protection from direct sunlight shall be provided over the tank area.

57.8 The water supply mains could be either of GI, uPVC or HDPE, however, the vertical pipe connecting supply main to the discharge point shall be of GI.

57.9 Masonry chamber shall be provided for Main gate valve at pump end. Whereas, as per requirement s, at other locations either a masonry or GI/ HDPE pipe chamber may be provided.

57.10 Module cleaning procedure and pressure requirement at discharge point shall be as per the recommendation of PV module manufacturer. However, discharge pressure at outlet shall not be less than 50kg/cm2 (5 MPa)

57.11 All the pipes thus laid shall be buried in ground at least 150mm below FGL or taken above ground clamping on suitable concrete support blocks. In case of above ground piping GI pipes shall be used. At road and drain crossings they shall be taken through a casing pipe as specified above.

58 Underground/ Overground Water Tank

58.1 The top of the UG tank shall be 250 mm above FGL.

58.2 The tank shall have clear free board of 300mm above MWL.

58.3 The tank bottom shall have a slope of 1:100 towards drainage sump (500x500x500 mm deep). The slope shall be provided either in structural slab or in screed concrete (1:2:4) trawl finished. 1000x1000 mm size Manhole in roof slab and 20 mm MS rung ladder shall be provided for easy access to the storage tank and silting chamber for periodic cleaning. The manhole shall be covered with RCC precast cover. 50x50x6 mm MS angles shall be provided around precast cover and tank slab opening for edge protection. Rungs shall be painted with 2 coats of epoxy paint over 2 coats of primer.

58.4 The underground RCC tank shall be designed for following load conditions:

- External earth pressure + hydrostatic pressure due to ground water table (to be considered at FGL for design purposes) + Surcharge of 2 T/ Sqm and Tank Empty.
- Tank full up to MWL and no external loads

58.5 The design shall conform to IS: 3370 with maximum crack width of 0.1mm for wall, bottom slab and roof slab. Min. grade of concrete shall be M30 (M35 in coastal areas, marshy and saturated soils) conforming to IS: 456. Suitable construction joints shall be provided as per provisions of IS: 3370 (Part 1). Water proofing admixture conforming to relevant BIS standard and of approved make shall be added to concrete as per manufacturer's recommendations.

58.6 The underground water tank shall be tested for water tightness as per the provisions of IS 3370 (Part-4). In case any leakage is noticed the same shall be repaired by injection of cement grout installing suitable nozzles around affected areas. Outside face of water tank in contact with water and soil and underside of roof slab shall be painted with 2 coats of epoxy paint

59 Miscellaneous structures:

59.1 Support structure for weather monitoring device:

59.1.1 Weather monitoring device shall be mounted on tubular steel pole of required height. The pole shall conform to IS: 2713.

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

59.1.3 200 long 20 dia. rods shall be welded to the pole at 300 mm C/c for access to the device for maintenance purpose.

59.1.4 The support structure shall be hot dip galvanized.

59.2 Support structures for SMU

59.2.1 SMU shall not be supported from MMS and shall have an independent structural steel supporting frame of ISMC 75, secured to an independent RCC foundation structure.

59.2.2 The support structure shall be of adequate height to ensure either min. ground clearance of 1.2m to SMU unit or HFL + 100mm, whichever is higher.

Quality Assurance and Inspection of Civil Works:

60 Introduction

60.1 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.

60.2 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.

60.3 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.

60.4 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 to the owner.

60.5 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 Employer.

60.6 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 Employer

61 QA and QC Manpower:

61.1 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.

61.2 All correspondence related to Quality Assurance shall be addressed by the contractor's QA coordinator to Employer/ Consultant.

61.3 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 Employer/ Consultant on the other hand.

61.4 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.

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

62 Laboratory and Field Testing:

62.1 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.

62.2 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.

62.3 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.

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

62.5 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.

62.6 In case contractor desires to hire the services of any established laboratory nearby 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.

62.7 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 Employer. 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 Employer.

62.8 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-in-charge. Test report along with the recommendations shall be obtained from the laboratories without delay and submitted to Employer.

62.9 Based on the schedule of work agreed with the Engineer-in-charge and the approved FQP, the contractor shall prepare a schedule of tests and submit them to the Engineer-in-charge

and organize to carry out the tests as scheduled/agreed.

63 Sampling and Testing of Construction Materials:

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

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

63.3 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-in-charge.

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

63.5 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.

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

64 Purchase and Service:

64.1 All structural steel shall be procured from main steel producers like SAIL, TISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel Industries, Jindal Steel & Power for rounds (15-105 mm), flats (45-120 mm width & 4.75-28 mm thick), hex rods (15.5-42 mm) and wire rods (5.5-38 mm)}. In case of non-availability of some of the sections with main steel producers listed above, 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 Employer 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.

64.2 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.

64.3 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.

64.4 Reinforcement steel shall be procured from main steel producers like SAIL, TISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel Industries, Jindal Steel& Power and Jai Balaji Industries Ltd, Durgapur (for 8-40mm reinforcement steel) and Mill test certificates (MTC) is to be obtained and submitted to the Employer for correlation.

65 Field Quality Plan

65.1 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.

65.2 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.

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

66 General QA Requirements

66.1 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.	8
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.	12

Mechanical weighing machine	nos.	1 (100kg capacity)
Drum type concrete mixer (for trial mixes)	nos.	1
Proctor testing equipment	Set	1

66.2 Notes:

66.2.1 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.

66.2.2 All test reports/ inspection reports shall be submitted in soft copy also and shall be available at site for easy access to the Engineer-in-charge/ Employer.

66.2.3 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 Employer for acceptance/approval.

Performance Measurement Procedure

67 Performance Ratio (PR)

Performance Ratio (PR) test for Operational Acceptance of the plant shall be performed as per the procedure attached in Annexure B (PG Test Procedure)

68 Capacity Utilization Factor (CUF)

68.1 Capacity Utilization Factor shall be calculated as per the following formula.

$$CUF = \frac{Eac}{8760 \times Pac \times [1 - DF \times (N-1)]}$$

where,

E_{ac} = is the number of units recorded in the ABT meter located at plant facilities after excluding auxiliary consumption, kWh

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

DF = is module degradation factor, 0.75% per year

N = is the number of years of operation after operational acceptance of the plant

68.2 CUF shall be calculated on annual basis from the date of operational acceptance of the plant. 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. 0.75% per year will be considered from second year of operation.

68.3 It is the responsibility of the Contractor to build-in the expected variation of irradiance in their design by installing additional DC capacity to meet the committed CUF. Irradiance variation will not be considered for the calculation of CUF.

68.4 Grid outage hours shall be subtracted from total number of hours in a year. The Contractor shall submit grid outage certification from component authority of STU/DISCOM.