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DISCLAMIER:

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

Place:

(Signature)

Date: Name and Designation of bidder

SECTION - VII

SUB-SECTION A

SCOPE OF WORKS

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1 Project Particulars

Particulars	Description
Design and Engineering	
Project AC Capacity	25 MW
Cumulative Power Transformer Capacity	50 MVA (2 X 25 MVA)
Cumulative Inverter Duty Transformer Capacity	40 MVA
Cumulative Inverter AC Capacity	40 MVA Note: Inverter shall be capable of delivering 25 MW AC Power with PF range -0.95 to +0.95 at POI
DC Capacity	50 MWp
BESS Power Rating	20 MW
BESS Power Rating	Nameplate rating: 50 MWh with minimum 40 MWh Dispatchable capacity at the Beginning of Life
Module Technology	Mono-Crystalline PERC / TOPCon
Origin of Supply Items	As per MNRE Order on Public Procurement (Preference to Make in India) to provide for Purchase Preference (linked with local content) in respect of RE Sector dated 9th February, 2021 and subsequent amendments
Module Mounting Structure Type	South Facing, Fixed Tilt
Design life of power plant	25 Years
O&M period	10 Years
Site Location and Land Details	
Location	Taru
District	Leh
State/UT	Ladakh
Latitude & Longitude	Refer Specific Annexure-SA-A: Tentative Land Layout
Altitude	
Available Land Area	
Type of Land	Revenue land (Owned by Ladakh Autonomous Hill Development Council (LAHDC))
Project Ownership	Solar Energy Corporation of India Limited
Access	

Nearest Urban Area	Leh
Nearest Highway	Srinagar-Leh (NH1)
Nearest Railway Station	Udhampur
Nearest Airport	Kushok Bakula Rimpochee Airport, Leh
Power Evacuation	
Plant End Substation Power Transformer Capacity	50 MVA (2 X 25 MVA)
Plant End Substation Switching Scheme (66 kV)	Double Bus Scheme (Main Bus-I & Main Bus-II)
Point of Interconnection	66 kV Loop-in-Loop-out (LILO) in 66 kV I/C line from Phyang S/s to 66 kV O/G line to Leh S/s Tower No: From 326 to 325
Metering Point	ABT Meter at the 66 kV Plant End Substation
Design Parameters	
Design Ambient Temperature	Min: -28.3ºC, Max: 25ºC
Basic Wind Speed (IS 875-3)	55 m/s
Seismic Zone (IS 1893-1)	Zone IV
Average Annual Rainfall	105 mm
Performance Ratio (at 11 kV HT Voltage Bus)	
For Operational Acceptance	87% **Note**: PR shall be estimated as per the procedure mentioned in General Annexure-J: FG Test Procedure.
Minimum Guaranteed Generation	
During O&M period	36.1%
BESS Availability	95%
Other Details	
Water and Power for Construction	To be arranged by the Contractor

2 Brief Scope of Work

Scope of Supply & Work includes design & engineering, procurement & supply of equipment and materials, testing at manufacturers works, multi – level inspections, packing and forwarding, supply, receipt, unloading and storage at site, associated civil works, services, permits, licences, installation and incidentals, insurance at all stages, erection, testing and commissioning for **“25 MW (AC) Grid Interactive Solar PV Power Plant with 20 MW / 50 MWh Battery Energy Storage System (BESS)”,** and performance demonstration with associated equipment and materials on turnkey basis along with 10 (Ten) years comprehensive operation and maintenance from the date of commissioning.

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

3 Design and Engineering

3.1 The Contractor shall prepare the detailed design basis report (DBR), and Master Drawing List (MDL). The Contractor shall submit a copy to Employer for review and approval prior to detail engineering.

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

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

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

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

Note: Tender Drawings and/or Indicative Schematic drawings provided with Section VII shall supplement the requirements specified in the technical specifications. These drawings are preliminary drawings for bidding purpose only and subject to necessary changes during the detailed engineering. Parameters specified in the tender drawing are the minimum required & any increase in these parameters, if required, to meet the system requirement shall be made by the Contractor without any additional cost implication to Employer.

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

- Detailed technical specifications (GTP) of all the equipment
- General arrangement and assembly drawings of all major equipment
- Schematic diagram for entire electrical system (DC, AC and auxiliary systems)
- GTP & G.A. drawings for all types of components 132 kV, 66 kV or 33 kV, 11 kV switchgears (as applicable) & other interfacing panels
- Test reports (for type, routine and acceptance tests)
- Relay setting charts
- Design calculations and sheets (civil, mechanical, structural and electrical designs)
- Geo technical investigation data and Topographical survey report including topographical survey data in digital format (Excel file) and Contour plan of the area.
- GA drawings of the entire project including equipment rooms/ inverter control rooms, office cum control room, roads, storm water drainage, sewage networks, security gate, fire protection system, perimeter fencing, transformer yard fencing etc.
- Transmission line drawings and erection plans as per Electricity Department/DISCOM / STU / CTU guidelines
- Quality assurance plans for manufacturing (MQP), Standard Operating procedure (SOP) and field activities (FQP)
- Detailed site EHS plan, fire safety & evacuation plan and disaster management plan.
- Detailed risk assessment and mitigation plan.

- O&M Instruction's and maintenance manuals for major equipment
- As-built drawings / documents and deviation list from good for construction (GFC)

3.5 Design of associated civil, structural, electrical & mechanical auxiliary systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for Earth- mat, Bus Bar & Spacers indoor and outdoor lighting/ illumination etc., GTP and GA drawings for the major equipment including transmission line, design basis & calculation sheets, and other relevant drawings and documents required for engineering of all facilities within the periphery to be provided under this contract.

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

3.7 The Contractor shall submit technical connection data, inter alia, generator data for fault studies, dynamic simulation data, details of data & voice communication (as applicable) , not later than six (6) months from award of work.

3.8 The Contractor shall submit the detailed and plant level Equivalent PSS/E Model of the SPV Plant to demonstrate performance under steady-state and dynamic state at the Point of Interconnection.

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

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

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

4 Procurement & Supply

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

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

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

4.3 String Combiner Box (SCB), along with mounting structure in case of central inverter configuration.

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

4.5 Power Conditioning Units of appropriate rating.

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

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

4.8 Inverter duty transformers of appropriate rating and in accordance with inverter manufacturer requirements, including fire protection system.

4.9 11 kV HT Switchgear Panels including Vacuum or SF6 Circuit Breakers, Current Transformers, Voltage Transformers, Relays and other accessories at the inverter stations.

Note: Electrical ratings of switchgear shall be in accordance with altitude correction factors above their standard designs, applicable as per IS/IEC 62271-1.

4.10 Battery Energy Storage System (BESS)

- Containerised Battery packs/modules/racks with Battery Management System (BMS), associated Fire Protection System, HVAC etc. (as required by the OEM design)
- BESS Power Conditioning System (PCS) of appropriate rating to deliver power at the Point of Common Coupling (with Solar PV array) as per Clause 1.
- Step-up transformers, LT & HT switchgear panels (two nos. of outgoing feeders), Auxiliary supply system, DC & AC power cables.
- Control and communication cables, along with RTU and related accessories for communication with the Plant SCADA
- BESS Energy Management System (EMS) for data acquisition and control of BESS parameters

4.11 11 kV Internal Transmission Line along with towers, conductors, insulators as per relevant standards.

4.12 66/11 kV Plant Pooling Substation with required number of 11 kV bays, required no. of 66/11kV transformers, four nos. of 66 kV Bays (Two Transformer Bays, One Line Bay & One Bus Coupler Bay), Bus PTs. Busbars, Equipment of Line Bay and Bus Coupler Bay shall be suitable for evacuation of 25 MW.

Note: Electrical ratings of switchgear shall be in accordance with altitude correction factors above their standard designs, applicable as per IS/IEC 62271-1.

4.13 ABT meters with all necessary metering rated CTs and PTs at the Metering Point as per CEA Metering Regulations 2006 as amended time to time and state metering code. Metering provision shall be made for the BESS feeders (at the Point of Common Coupling with the Solar PV array) and any auxiliary supply feeder to the BESS from the Plant Auxiliary Supply system.

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

4.15 Design & Construction of 66 kV LILO Over Head Transmission Line including Towers, Conductors, OPGW cable, Insulators, Cable Termination Kits and associated accessories from Plant end Substation to the interconnection point as per CTU/Leh PDD drawings/specifications including Right of Way, permits and approvals, CTU/Leh PDD supervision and maintenance charges.

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

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

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

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

4.20 Communication cables including end terminations and other required accessories.

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

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

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

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

4.24 Lightning Protection System for entire plant area.

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

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

- Pyranometers – Two in Horizontal Plane for GHI and two in inclined plane – Minimum 4 (Four) Nos.
- Ultrasonic Anemometer (wind speed and direction) – 1 (one) no.
- Temperature Sensor (ambient and module surface) – 5 (five) nos (2 for ambient and 3 for Module Surface)
- Sensors required for measurement of following parameters
  - (i) Sun rise and sun set timings
  - (ii) Cloud cover (Okta)
  - (iii) Rainfall (mm)
  - (iv) Relative humidity (%)
- Power source from UPS to the all sensors wherever required
- Data Logger

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

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

4.29 Testing instruments as specified.

4.30 Mandatory spares as specified.

4.31 Supply of site office with washroom (Portable Cabin type) for Owner during construction.

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

5 Installation

5.1 Installation, testing and commissioning of equipment procured and supplied under Clause 4 above, as per detailed specifications provided under Section VII (Sub-Sections B to E).

5.2 Ownership of packing materials (except of mandatory spares) shall be of the Contractor. Responsibility of removal and disposal of the packing material shall be in the scope of the Contractor.

6 Plant Testing and Commissioning

6.1 Pre-commissioning checks and tests for all equipment.

6.2 Synchronization and Commissioning of plant.

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

6.4 All costs associated with the Plant Testing and Commissioning shall be borne by the Contractor.

7 Civil Works

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

7.1 Topographical survey of the plant area.

7.2 Geotechnical investigation of the plant area. For reference of bidder, general information regarding Geo-technical aspects of the site has been provided as Specific Annexure – SA-B. The Employer shall not be responsible for any variations in soil characteristics and other conditions, between those stated in SA-B, observed during preliminary site visit and detailed investigations to be carried out by the Contractor during contract execution and there shall be no compensation what so ever in the contract price on this account.

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

7.4 Earthwork for site grading, cutting, filling, levelling and compaction of land as per detailed Technical specifications (Sub-Section C).

7.5 Construction of chain link fence along the Plant boundary. (Refer Sub Section E: SA-A: Tentative Land Layout)

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

7.7 Construction of foundation and / or mounting structure for String Combiner Box, AC Combiner Box / LT Switchgear panel, Power Conditioning Unit, Inverter Transformer, BESS Transformer, Auxiliary Transformer, 11 kV Switchgear panel, Power Transformer, Switchyard Equipment, BESS yard Equipment, lighting mast, lightening arrestor and other electrical equipment. Mounting structure of 66 kV switchyard equipment and gantry shall be as per PDD approved drawings.

7.8 Construction of ICRs/LCRs and Main Control Room.

7.9 Construction of Storage Cabin of area sufficient enough to store spares.

7.10 Construction of security room(s) at suitable strategic locations. (Refer Special

Annexure SA-A: Tentative Land Layout)

7.11 Construction of fence for transformer yards, 66/11 kV Plant end substation and BESS yard.

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

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

7.14 Construction of foundation for 66 kV Overhead Transmission Line from 66/11 kV plant end substation to Interconnection Point and associated civil works.

7.15 Construction of access roads, internal roads, switchyard roads, BESS yard roads and compacted corridor along the periphery as per specifications.

Note: Approach road to the Project site has been identified in Sub Section E (Specific Annexures: SA-A: Tentative Land Layout). The scope of works for Approach Road shall include re-compaction/re-rolling, filling of WBM (if required), provision of culvert and drain and bituminous topping as per detailed specifications.

7.16 Construction of cable trenches/over ground cable support structures

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

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

7.19 Erection of site office with washrooms (portable cabin type) for Owner during construction.

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

8 Statutory Approvals

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

- Pollution control board clearance, if required
- Mining Department, if required
- Forest Department, if required
- Ministry of Defence, if required
- All other approval as and when, as necessary for setting up of the solar power plant including CEIG/ CEA, power evacuation, etc. as per the suggested guidelines.

8.2 All statutory approvals / permissions and/or No Objection Certificates (NoC) etc. from

PDD, Ladakh for interconnection of solar power plant at the Point of Interconnection.

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

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

(i) CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 and subsequent amendments.

(ii) CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022

(iii) CEA (Grid Standard) Regulations, 2010

(iv) CEA (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations, 2011

(v) CEA (Measures relating to Safety and Electric Supply) Regulations, 2010

(vi) CEA (Installation and Operation of Meters) Regulations, 2006

(vii) CEA (Technical Standards for Communication System in Power System Operations) Regulations, 2020

(viii) CERC (Communication System for inter-State transmission of electricity) Regulations, 2017

(ix) CERC (Indian Electricity Grid Code) Regulations, 2023

(x) CEA (Cyber Security in Power Sector) Guidelines, 2021

(xi) CEA (Manual of communication planning in Power System Operation), 2022

(xii) Any other applicable Standards/Regulations/Procedures/Guidelines etc.

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

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

8.7 All other statutory approvals and permissions and their respective compliances, not mentioned specifically but are required to carry out hassle free Construction and O&M of the plant.

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

8.9 The Contractor shall comply with the provision of all relevant acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Mines Act 1952, Employees State Insurance Act 1948, Contract Labour (Regulations & Abolishment) Act 1970, Electricity Act 2003, Grid Code, Metering Code, MNRE guidelines or any modification thereof or any other law relating whereto and rules made there under or amended from time to time.

9 Security Services

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

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

9.3 Any other activities required for completion of project, but not specified in the above shall be in the scope of contractor. The Contractor must provide the BOM of the plant as per the design during the time of submission of design basis report. The detailed technical specifications of major equipment to be followed strictly and are described in the technical specification section.

10 Operation and Maintenance

10.1 The Scope of Works for Plant Operation shall include deputing necessary manpower necessary to operate the Solar Photovoltaic Power Plant. Operation procedures such as preparation to starting, running, routine operations with safety precautions, monitoring etc., shall be carried out as per the manufacturer's instructions to have trouble free operation of the complete system. The Contractor shall ensure continuous, un-uninterrupted Plant Operation and Monitoring, including Plant Operation and Maintenance activities, Scheduling of Power etc. for the interim period i.e. period commencing from Plant Commissioning to the signing of the O&M Agreement.

10.2 Total Operation & Maintenance of the SPV Plant shall be with the Contractor under an O&M Contract as per the terms and conditions of O&M Agreement (Section – VII Sub-Section-F: Operation & Maintenance Agreement), after Operational Acceptance and

Completion of the Plant Facilities, till currency of the O&M period.

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

SECTION - VII

SUB-SECTION B

TECHNICAL SPECIFICATIONS (TS) – ELECTRICAL SYSTEM

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A Electrical System

1 Photovoltaic Modules

1.1 General

1.1.1 PV Modules shall be registered with Bureau of India Standards (BIS) and bear the Standard Mark as per Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017 and subsequent amendments.

1.1.2 The PV Module shall be enlisted in ALMM – List I in accordance with extant provisions of Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration, Order, 2019) and subsequent amendments.

1.2 Standards and Codes

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

Standard	Description
IS 14286: Part 1: 2019	Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval, Part 1: Test Requirements (Second Revision)
IS 14286: Part 1: Sec 1: 2019	Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval, Part 1: Test Requirements, Section 1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules (Second Revision)
IS/IEC 61730-1: 2016	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
IS/IEC 61730-2: 2016	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
IS 17210: Part 1: 2019	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon (under conditions of 85°C/85% RH for minimum 192 hours)

1.3 Technical Requirements

Parameter	Specification
Cell type	Mono-crystalline PERC / TOPCon

Module Efficiency	≥ 20.9 %
Rated power at STC	≥ 540 Wp, No negative tolerance is allowed
Temperature co-efficient of power	Not less than -0.4%/°C
Maximum System Voltage	1500 V
Application Class as per IS/IEC 61730	Class II

1.4 Component Specifications

1.4.1 Glass Panel:

(i) Glass/Backsheet Modules: The PV Modules glass panel shall have transmittance of above 90%. The minimum thickness of glass shall be 3.2 mm.

(ii) Glass/Glass Modules: Glass shall have minimum 2 mm thickness on each side. Glass shall have transmittance above 90%.

1.4.2 The back sheet used in the PV modules (applicable in case of Glass/Backsheet) shall be of three-layered structure with properties of moisture barrier, elongation retention and UV resistance. The back sheet shall have the following properties:

Parameter	**Value**
Material Thickness	≥ 300 microns
Water Vapor Transmission Rate	≤ 2 g/m^2/day
Partial Discharge Test Voltage	≥ 1500V
Elongation at break	≥ 100%
Adhesion strength with encapsulant	≥ 40 N/cm
Interlayer adhesion strength	≥ 4 N/cm

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

Parameter	**Value**
Gel content	≥ 75% for EVA (applicable for glass/polymer modules) ≥ 70% for POE or EPE i.e. EVA co-extruded with POE (applicable for glass/glass modules and glass/polymer

	modules)
Volume resistivity	≥ 1×10^{14} Ω.cm
Peeling strength with glass	≥ 40 N/cm

1.4.4 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.

1.4.5 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 shall have provision for earthing to connect it to the earthing grid. The anodization thickness shall be 15 micron (12 micron in case of 6005 Grade Aluminium).

1.4.6 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 IP 67. Minimum three number of bypass diodes and two number of IS 16781 / IEC 62852 certified MC4 compatible connectors with IS 17293 / IEC 62930 certified 4 sq.mm. copper cable shall be provided.

1.4.7 The following information must be mentioned in the RFID used on each module (This can be inside or outside the laminate, but must be able to withstand harsh environmental conditions).

i) Name of the manufacturer of PV Module
ii) Name of the Manufacturer of Solar cells
iii) Month and year of the manufacture (separately for solar cells and module)
iv) Country of origin (separately for solar cells and module)
v) I-V curve for the module at Standard Test Condition (1000 W/m 2, AM 1.5, 250 C)
vi) Wattage, Im, Vm and FF for the module
vii) Unique Serial No. and Model No. of the module
viii) Date and year of obtaining IEC PV module qualification certificate
ix) Name of the test lab issuing IEC certificate
x) Other relevant information on traceability of solar cells and module as per ISO 9000

Note: RFID scanner and database of all the modules supplied, containing the above information shall also be provided.

1.5 Warranty

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

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

1.5.3 Warranty Insurance: The above warranties shall be backed by third party insurance. The insurance should be valid for a minimum period of 25 years from the date of energization or 6 months (180 days) beyond last delivery at site, whichever is earlier and the claim period should extend for a minimum of 1 year beyond the validity period. Warranty Insurance certificate shall clearly identify the Beneficiary (i.e. SECI) along with project details viz. Location, Total Sum Insured and relevant contract reference details.

1.6 Approval

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

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

1.6.3 The BOM proposed shall be the subset of IEC 61215/61730 Constructional Data Form (CDF)s, subject to suitability of the proposed BOM for other type tests applicable as per Clause 1.2. The BOM extensions for PV Module BOM components shall be in accordance with IEC 62915 retest guidelines.

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

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

1.7 Manufacturing and Inspection

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

1.7.2 The EMPLOYER shall perform material inspection at the Manufacturer's factory during manufacturing of Modules or during pre-dispatch Inspection. Proof of procurement of components as per the approved BOM mentioning manufacturer name, manufacturing date and relevant test certificate shall be submitted during material inspection for verification.

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

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

1.7.5 Current binning of modules shall be employed (max. 3 no. of bins) so that current mismatch of modules in a bin does not exceed 150 mA. Different colour codes shall be provided on the modules as well as pallet for identification of different bins.

1.7.6 Pre-dispatch inspection of modules shall be performed as per the inspection protocol attached in General Annexure – B.

1.8 Transportation, Handling, Storage and Installation

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

1.8.2 The module shall be kept in common storage area with proper arrangement.

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

i. Modules shall be covered with tarpaulin sheet. Alternatively, the Modules, properly stacked as per OEM recommendations.

2 String Combiner Box

2.1 Standards and Codes

Standard/Code	**Description**
IS/IEC 60529	Enclosure Ingress Protection

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

2.2 Construction

2.2.1 SCB enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP 65 and mechanical impact resistance shall be at least IK 08.

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

2.2.3 Every SCB input shall be provided with fuses on both positive and negative side. In case of negative grounded system, fuse at positive side only is acceptable. The rating of the fuses shall be selected such that it protects the modules from reverse current overload. The fuses shall be 'gPV' type conforming to IEC 60269-6.

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

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

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

2.2.7 UV resistant printed cable ferrules for solar cables & communication cables and punched/ embossed aluminium tags for DC cables shall be provided at cable termination points for identification.

2.3 Warranty

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

2.4 Tests

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

3 Solar and DC Cables

3.1 Standards and Codes

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

3.2 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.

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

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

(i) Cable size and voltage grade

(ii) Word ‘HALOGEN FREE LOW SMOKE’

(iii) Sequential marking of length of the cable

3.5 Cables shall be sized based on the following considerations:

(i) Rated current of module

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

(iii) Short circuit withstand capability

(iv) De-rating factors according to laying pattern

3.6 Warranty

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

3.7 Tests

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

3.8 Installation

3.8.1 Cable installation shall be as per IS 1255.

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

3.8.3 Solar cables shall be provided with UV resistant printed ferrules and DC cables shall be provided with punched/ embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

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

3.8.5 Solar cables shall be aesthetically tied to Module Mounting Structure using GI/SS cable-ties.

3.8.6 DC cables from SCB to PCU shall be laid directly buried underground as per IS 1255. DC cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

4 Power Conditioning Unit

4.1 Standards and Codes

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

Standard	Description
IEC 61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 62109-1 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
IEC 62109-2 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
IEC 61000-6-2 Ed.3	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments

IEC 61000-6-4 Ed.3	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 62116 Ed.2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1 Ed.6	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2 Ed.5	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14 Ed.6	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30 Ed.3	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 and 2019 Amendment	
As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, Inverters used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards.	

4.2 Supplier Qualification Criteria

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

4.3 Technical Requirements

Parameter	**Specification**
Type	Central
Rated AC power	As per design
Maximum input voltage	1500 V
Rated AC output voltage	As per design
Tolerance on rated AC output voltage	+/-10%
Rated frequency	50 Hz
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.8 lag to 0.8 lead
European efficiency	Minimum 98%
Maximum loss in Sleep Mode	0.05% of rated AC power
Total Harmonic Distortion	Less than 3% at 100% load

Degree of protection	Central Inverter – IP 20 (Indoor) / IP 54 (Outdoor)

4.3.1 The rated/ name plate AC capacity of the PCU shall be AC power output of the PCU at 25°C.

Note: The equipment shall be suitably derated for the Altitude.

4.3.2 Maximum power point tracker (MPPT) shall be integrated in the PCU to maximize energy drawn from the Solar PV array. The MPPT voltage window shall be sufficient enough to accommodate the output voltage of the PV array at the site.

4.3.3 The PCU output shall always follow the grid in terms of voltage and frequency. The operating voltage and frequency range of the PCU shall be sufficient enough to accommodate the allowable grid voltage and frequency variations.

4.4 Construction

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

4.4.2 Every DC input terminal of PCU shall be provided with fuse / MCB / MCCB of appropriate rating. The combined DC feeder shall have suitably rated isolators for safe start up and shut down of the system. One spare DC input terminal shall be provided for each PCU.

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

4.4.4 Type-I+II surge protective device (SPD) conforming to IEC 61643-31 shall be connected between positive/ negative bus and earth on the DC side. Type-II SPD conforming to IEC 61643-11 shall be provided on the AC side.

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

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

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

4.4.8 All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through protective conductor of appropriate size. Grounding on DC side of the PCU shall be as per the requirements of PV Module Manufacturer.

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

4.4.10 PCU front panel shall be provided with LCD/ LED to display all the relevant parameters related to PCU operation and fault conditions. It shall include, but not limited to, the following parameters.

(i) DC input power
(ii) DC input voltage
(iii) DC input current (for each terminal)
(iv) AC output power
(v) AC output voltage (all the 3 phases and line)
(vi) AC output current (all the 3 phases and line)
(vii) Frequency
(viii) Power Factor

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

4.5 Operating Modes

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

4.5.1 Standby Mode

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

4.5.2 MPPT Mode

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

4.5.3 Sleep Mode

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

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

4.6 Protection Features

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

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

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

4.7 Grid Support Functions

4.7.1 Active power regulation

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

4.7.2 Reactive power control

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

4.7.3 Voltage Ride Through

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

4.8 Warranty

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

4.9 Tests

4.9.1 Type Tests

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

4.9.2 Routine Tests

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

5 Inverter Transformer and Auxiliary Transformer

5.1 Standards and Codes

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

Standard	Description
IS 2026, IEC 60076	Specification of Power Transformers
IS 11171, IEC 60076	Dry-Type Power Transformers
IS 2099, IEC 60137	Bushings for alternate voltage above 1000 V
IS 335, IEC 60296	Insulating oil
IS 3639	Fittings and Accessories for Power Transformers
IS 12063	Degree of protection provided by enclosures
CBIP publication no. 317	

CEA regulations and other statutory regulations

5.2 Technical Requirements

Parameters	**Inverter Transformer**	**Auxiliary Transformer**
VA Rating	As per system design requirement	
Voltage Ratio	11 kV / Inverter output voltage	As per system design
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)	Continuous application (Outdoor/Indoor)
Winding	As per system design requirement	2
Frequency	50 Hz	50Hz
Nos. of Phase	3	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement	Dyn11
Cooling	ONAN	ONAN / AN
Tap Changer	OCTC, No. of steps shall be as per system requirement	
Impedance at 75°C	As per Inverter Manufacturer requirement	As per system requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)		
Top Oil	50°C	As per IS/IEC
Winding	55°C	As per IS/IEC
SC withstand time (thermal)	2 second	2 second
Short Circuit Apparent power	As per system requirement	
Termination	As per system requirement	
Bushing rating, Insulation class (Winding & bushing)	12 kV – porcelain bushings 1.1 kV – epoxy bushings	As per the system requirement
Noise level	As per NEMA TR-1	
Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7	

Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds. Bidder shall furnish over fluxing characteristic up to 150%
Air Clearance	As per IS/IEC

5.3 <u>Construction</u>

5.3.1 The transformer shall be provided with conventional single compartment conservator with prismatic toughened glass oil gauge. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. Inverter transformers shall be provided with Magnetic Oil Gauge (MOG) with low oil level alarm contact.

5.3.2 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.

5.3.3 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.

5.3.4 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.

5.3.5 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.

5.3.6 Neutral earthing of inverter transformer shall be as per the recommendations of inverter manufacturer. Even if neutral earthing is not required, neutral bushing shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker “For testing purpose only. Do not earth”. Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.

5.3.7 Transformer shall have 150 mm dial type Oil Temperature Indicator (OTI) and

Winding Temperature Indicator (WTI) with alarm and trip contacts. All indicators shall have accuracy of 1.5%. For inverter transformers, WTI shall be provided for all the windings.

5.3.8 The radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/ valve at the bottom and air release plug at the top.

5.3.9 Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

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

5.3.11 Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.

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

5.3.13 All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.

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

5.3.15 Air release plug, bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.

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

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

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

5.4 Dry Type Auxiliary Transformer

5.4.1 Transformer shall be cast resin encapsulated dry type transformer, made of cold rolled grain-oriented silicon steel laminations of M4 grade or better. Winding conductor shall be electrolytic grade Copper/Aluminium and insulation shall be Class F or better.

5.4.2 The transformers shall be housed in a metal protective housing, having a degree of protection of IP 23 suitable for indoor installation. The enclosure shall be provided with suitable hardware and accessories required for satisfactory operation of the transformer per the relevant standard.

5.5 Warranty

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

5.6 Testing and Inspection

5.6.1 Type Tests and Special Tests

The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar transformer by NABL accredited laboratory within last five years from the last date of bid submission.

5.6.1.1 Type Tests

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

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

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

5.6.1.2 Special Tests

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

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

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

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

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

5.6.1.3 Type tests mentioned in Clause 5.6.1.1(ii) & (iii) shall be performed for auxiliary transformers. Special tests are not required.

5.6.2 Routine Tests

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

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

5.6.3 Tests at Site

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

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

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

6 11 kV HT Switchgear Panel

6.1 Standards and Codes

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

Standard/Code	Description
IS/IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IS/IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 62271-206	High-voltage Switchgear and Control gear - Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 15086-4	Surge Arresters, Part 4: Metal-Oxide Surge Arresters Without Gaps for A.C. systems
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

6.2 Technical Parameters

Parameter	Specification
System Parameters **Note:** Electrical ratings of switchgear shall be in accordance with altitude correction	

factors above their standard designs, applicable as per IS/IEC 62271-1	
Highest system voltage	12 kV
Rated system voltage	11 kV
Rated frequency	50 Hz
Number of phases	3
Power frequency withstand voltage	28 kV (r.m.s.)
Lightning impulse withstand voltage	75 kV (peak)
System fault current	25 kA / 1s
Internal Arc Classification	IAC-A, FLR, 25 kA for 1s
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 3min – CO – 3min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C1
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2S for metering at outgoing feeder), 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class E or better
Voltage Transformer	
Accuracy class	0.2 for metering, 3P for protection
Rated VA burden	As per requirement
Insulation class	Class E or better

6.3 Switchgear Panel

6.3.1 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.

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

6.3.3 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.

6.3.4 All surfaces shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. The minimum dry film thickness (DFT) shall be 100 micron.

6.3.5 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.

6.3.6 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.

6.3.7 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.

6.3.8 Degree of protection shall not be less than IP 5X for auxiliary circuit compartment. However, for remaining compartments it shall not be less than IP 4X. For outdoor panels, degree of protection shall not be less than IP 55.

6.3.9 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.

6.3.10 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.

6.3.11 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.

6.3.12 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.

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

6.3.14 Suitable lifting hooks shall be provided for each panel.

6.4 Circuit Breakers

6.4.1 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.

6.4.2 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.

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

6.4.4 Each circuit breaker shall be provided with two tripping coils. Each trip coil shall have its own actuating contacts.

6.4.5 The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating mechanism.

6.4.6 The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.

6.4.7 Mechanical indicators shall be provided to indicate OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided. These indicators and counter shall be visible from the panel front door without opening it.

6.5 Relays

6.5.1 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.

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

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

6.5.4 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.

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

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

6.5.7 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

6.5.8 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

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

6.5.10 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.

6.5.11 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.

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

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

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

6.6 Instrument Transformers

6.6.1 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.

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

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

6.6.4 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.

6.7 Earthing

6.7.1 An earth bus made of copper shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar.

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

6.7.3 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.

6.7.4 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.

6.7.5 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.

6.7.6 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.

6.7.7 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.

6.7.8 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.

6.8 Bus bar

6.8.1 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.

6.8.2 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.

6.8.3 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.

6.8.4 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.

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

6.9 Measuring Instruments

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

6.9.2 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.

6.9.3 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)

6.10 Wiring and Terminal blocks

6.10.1 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.

6.10.2 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.

6.10.3 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.

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

6.10.5 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.

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

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

6.11 Warranty

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

6.12 Testing and Inspection

6.12.1 Type Tests

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

Test	**Standard**	**Relevant IEC Clause**
Switchgear Panel		
Dielectric tests		
Power frequency voltage test	IEC 62271-200	6.2.6.1
Lightning impulse voltage test	IEC 62271-200	6.2.6.2
Dielectric tests on auxiliary and control circuits	IEC 62271-200	6.2.10
Measurement of the resistance of the main circuit	IEC 62271-200	6.4.1
Temperature-rise tests	IEC 62271-200	6.5
Short-time withstand current and peak withstand current tests	IEC 62271-200	6.6
Verification of the IP coding	IEC 62271-200	6.7.1
Verification of making and breaking capacities	IEC 62271-200	6.101
Mechanical operation test	IEC 62271-200	6.102
Internal arc test	IEC 62271-200	6.106
Circuit Breaker		
Mechanical operation test at ambient air temperature (M2 Class)	IEC 62271-100	6.101.2

Basic short-circuit test-duties	IEC 62271-100	6.106
Relays		
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional Requirements	Relevant standards of IEC 60255-1xx series	
Communication requirements	IEC 61850	
Current Transformers		
Temperature-rise test	IEC 61869-2	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-2	7.2.3
Tests for accuracy	IEC 61869-2	7.2.6
Short-time current tests	IEC 61869-2	7.2.201
Voltage Transformer		
Temperature-rise test	IEC 61869-3	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-3	7.2.3
Test for accuracy	IEC 61869-3	7.2.6
Short-circuit withstand capability test	IEC 61869-3	7.2.301

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

6.12.2 Routine Tests

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

7 AC Cables

7.1 Standards and Codes

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

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

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

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

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

(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

7.5 Cables shall be sized based on the following considerations:

(i) Rated current the equipment

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

(iii) Short circuit withstand capability as per design

(iv) De-rating factors according to laying pattern

7.6 Warranty

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

7.7 Testing

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

7.8 Installation

7.8.1 Cable installation shall be as per IS 1255.

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

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

7.8.4 AC Cables from Inverter Transformer to 11 kV Switchgear Panel in Local Control Room may be laid overground on GI cable trays / directly buried underground. AC cables from 11 kV Switchgear Panel in Local Control Room to 11 kV Switchgear Panel in Plant Pooling Substation may be laid overground on GI cable trays / directly buried underground / on overground transmission lines.

7.8.5 Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

7.8.6 All AC cables shall be provided with punched/embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

8 Auxiliary Supply System

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

8.2 It shall mainly comprise of auxiliary transformer, AC distribution board(s) (ACDB), Battery & battery charger system, emergency lighting network, Uninterrupted power supply (UPS), distribution cables and metering & protective devices.

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

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

(i) 20% future load margin

(ii) Total connected load at 0.8 power factor

9 LT Switchgear

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

9.1 Standards and Codes

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

Standard/Code	Description
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers
IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60947-5-1	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 62052-11	Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 11: Metering equipment
IS 694	Polyvinyl chloride insulated unsheathed-and sheathed cables/ cords with rigid and flexible conductor for rated voltages - up to and including 450/750V
IEC 61869	Instrument Transformers
IS 3043	Code of practice for earthing
IEC 60255	Measuring relays and protection equipment - Part 1: Common requirements

9.2 Technical Parameters

System Details	
Rated system voltage	415 V ± 10%, 3 Phase, 50Hz, 4 wire, Neutral Solidly Earthed
Rated frequency	50 Hz ± 5%
System fault current	As per system requirement
Moulded case circuit breaker (MCCB)	
Rated voltage	415 V
Rated current	As per system requirement

Rated insulation level	690 V
Rated ultimate short-circuit breaking capacity and Rated service short-circuit breaking capacity	As per system fault current
Rated short-circuit making capacity	2.1 × Rated ultimate short-circuit breaking capacity
Rated short-time withstand current duration	1 s
Utilization category	A
Current transformer (CT)	
Type	Cast Resin Bar Primary
Voltage class and frequency	650 V, 50 Hz
CT Secondary Current	1 A
Class of insulation	Class E or better
Accuracy class & burden	
a) For Protection	5P20, 5VA
b) For Metering	Class 0.5, 5VA (min)
Instrument Security Factor for metering CT	5
Voltage transformer (VT)	
Type	Cast Resin
Accuracy class	0.5
Rated Voltage factor	1.1 continuous, 1.5 for 30 seconds
Class of insulation	E or better
Digital Multifunctional Meter (MFM)	
Accuracy class	0.5
Communication with SCADA	RS485 communication with Modbus RTU

9.3 Constructional Details

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

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

9.3.3 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.

9.3.4 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.

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

9.3.6 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.

9.3.7 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.

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

9.3.9 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.

9.3.10 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.

9.3.11 Suitable lifting hooks shall be provided for each panel.

9.3.12 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.

9.3.13 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.

9.4 <u>Warranty</u>

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

9.5 <u>Testing</u>

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

10 Uninterrupted Power Supply

10.1 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

10.2 General Requirements

10.2.1 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

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

10.2.3 Sizing of UPS shall be done considering the above-mentioned load at power factor of 0.8 lagging inclusive of 10% design margin at 25 ˚C.

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

10.3 System Description

10.3.1 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

10.3.2 The UPS shall meet the following minimum specifications.

Parameter	**Specification**
Topology	Online double conversion UPS
Overall efficiency	> 90%
Input	
Voltage	230 V ± 10% AC for UPS rating of less than 5 kVA 415 V ± 10% AC for UPS rating of 5 kVA and above
Frequency	50 ± 5%
Power factor	0.95
Output	
Voltage	230V ± 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Sealed, Maintenance-Free (AGM) battery
Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED Indication	Yes
Local Display	LCD / LED
SCADA communication	RS-485 Interface Port

10.3.3 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.

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

10.4 Warranty

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

10.5 Tests

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

10.5.2 On completion of installation and commissioning of the equipment on site tests shall be carried out with the max. available load, which does not exceed the rated continuous load. An on-site test procedure shall be submitted by contractor include a check of controls and indicators after installation of the equipment.

11 Battery and Battery Charger

11.1 Standards and Codes

Standard/Code	Description
IEC 60896-21:2004	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IEC 60896-22:2004	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements
IS 15549	Stationary Regulated Lead Acid Batteries

11.2 General

11.2.1 110 V / 220 V DC system (Battery, Battery Charger & DCDB) in accordance with this specification and standards stated herein, shall comprise of the following.

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

(ii) Float cum Boost Charger (FCBC)

(iii) DC Distribution Board (DCDB)

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

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

(i) Trip and closing coil of HT circuit breaker

(ii) Spring charging motors for HT circuit breaker

(iii) Annunciator and Indication circuit of HT switchgear panel

(iv) Auxiliary supply to protection relays

(v) Pooling Substation protection and control supply

(vi) PLCC equipment

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

11.2.5 The design of the battery bank and sizing calculation along with the data sheet for the battery and battery charger shall be submitted for approval.

11.3 Battery

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

11.4 Battery Charger

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

11.4.2 The battery charger shall regulate the float/boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback control.

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

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

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

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

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

11.4.8 Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1%, irrespective of DC load level, even when they are not connected to battery.

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

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

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

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

11.4.13 The charging equipment shall be housed in a free standing, floor mounted compartmentalized panels. Panel shall have provision for bottom cable entry with removable undrilled cable gland plate of 3.0 mm thickness.

11.4.14 The panel shall be of CRCA sheet steel construction having thickness of at least 2.0 mm. Degree of protection provided by the enclosure to the internals of charger shall be IP 42 (Indoor) / IP 55 (Outdoor).

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

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

11.5 Warranty

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

11.6 Tests

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

12 Earthing

12.1 Standards and Codes

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

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

12.2 General Requirements

12.2.1 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.

12.2.2 The earth electrode shall be made of high tensile low carbon steel rod, molecularly bonded by high conductivity copper on outer surface with coating thickness not less than 250 micron as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS 3043. For Plant Pooling Substation earthing, mild steel rod may be used as earth electrode.

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

12.2.4 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.

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

12.2.6 Transformer yard and switchyard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.

12.2.7 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.

12.3 Earthing of PV array field

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

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

12.3.3 VOID.

12.3.4 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.

12.3.5 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.

12.3.6 SCB 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.

12.4 PCU Earthing

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

12.5 Transformer Earthing

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

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

12.5.3 Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.

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

12.6 Inverter Room and Main Control Room Earthing

12.6.1 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.

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

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

12.7 Switchyard Earthing

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

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

12.8 Tests

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

On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.

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

13 Lightning Protection System

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

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

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

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

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

13.6 <u>Lightning Protection System for Plant Pooling Substation</u>

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

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

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

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

14 Communication Cables

14.1 <u>Optical Fibre Cables</u>

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

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

14.1.3 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.

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

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

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

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

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

14.2 RS-485 Cable

RS-485 Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 sq.mm. Cable shall be flame retardant according to IEC 60332-1-2.

15 SCADA

15.1 General Requirements

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

15.1.2 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.

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

(i) Web enabled Operator Dashboards: Showing key information on Generation, Performance and Current Status of various equipment in Single Line Diagram (SLD) format with capability to monitor PV array Zone level (i.e. SCB level) parameters.

(ii) Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.

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

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

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

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

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

15.2 Architecture

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

15.2.2 Data acquisition shall be distributed across MCR and LCRs while plant level data aggregation shall be done in plant servers. Indicative SCADA Schematic Diagram along with Indicative I/O List has been attached in General Annexure - H.

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

15.2.4 Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.

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

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

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

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

15.2.8 Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. In case no broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided.

15.2.9 GPS based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with antenna, receiver, cabinet and internal interconnection cables. All SCADA controllers, servers, OWS and communicating equipment shall be synchronized to the GPS clock.

15.3 Industrial IoT Controllers & Data Acquisition

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

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

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

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

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

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

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

15.3.7 Data Communication with Servers: Shall send the data collected, from all the equipment at Inverter Control Room and/or Main Control Room, to the Monitoring & Control Server.

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

15.4 System Spare Capacity

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

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

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

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

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

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

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

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

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

15.5 Functionalities

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

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

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

15.5.4 The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on status change of hardwired DI shall also be provided.

15.5.5 The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds. The list of such parameters shall be finalised in consultation with the Owner.

15.5.6 The SCADA system shall have user-friendly browser-based User Interface for secure access from anywhere, for minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of total plant generation, day's export, irradiance, Inverter Control Room level generation and performance indicators like PR and CUF.

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

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

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

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

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

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

15.6 Earthing

15.6.1 Two isolated electronic earth pits near to SCADA panel at every Inverter and Control Room with < 1 Ohm resistance shall be provided. One earth pit shall be used for protective/body earth and the other to be used for Signal Earth.

15.6.2 Apart from providing separate earth pits, manufacturer specified earthing recommendations shall be followed for all communicating equipment connected to SCADA. This includes but is not limited to SCBs, Inverters, WMS and Switchgear panels.

15.7 Communication Cable Laying

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

15.7.2 Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure minimum 1.5 ft separation between power and communication cables all along the trench.

15.7.3 IO Cables between switch gear panels and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

15.7.4 RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

15.8 Control Cabinets / Panels / Desks at Main Control Room

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

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

15.9 Software Licences

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

15.10 Hardware at Main Control Room

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

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

Plant Server (2 Nos. - Main & Redundant)	
Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 × 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (RedHat Linux or equivalent Linux OS, Oracle/MySQL or Windows or equivalent DB), with required AMC for 5 years.
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3. Pointing Device: Mouse 4. Intelligent UPS (on line): Minimum 2 hour battery backup.
Operator Workstation (OWS) – 2 Nos.	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 2TB SSD hard disk, 28" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. UPS of required capacity with 2 hour battery backup. Common for the Operator Workstations: 1. Screen Display Unit: Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer.
PPC Workstation – 1 No.	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 2 TB SSD hard disk, 28" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. UPS of required capacity with 2 hour battery backup.

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

15.11 Factory Acceptance Test (FAT)

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

16 Power Plant Controller

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

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

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

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

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

17 Power Transformer

17.1 Standards and Codes

Power 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 8468	On-load tap changers
IS 335, IEC 60296	Insulating oil
IS 3639	Fittings and Accessories for Power Transformers

17.2 Technical Requirements

Parameter	Specification
Rated Capacity	As mentioned in Scope of Works
Rated Voltage	11 kV / 66 kV
Duty & Service	Continuous duty & Outdoor
Number of phases	3
Frequency	50 Hz
Vector group	As per system requirement
Impedance at principal tap and 75°C	10%
Tap changer	On Load Tap Changer (OLTC) on HV side +5% to -15% with steps of 1.25%
Power frequency withstand voltage (winding & bushing)	LV – 28 kV (rms) HV – 140 kV (rms)
Lightning impulse withstand voltage (winding & bushing)	LV – 75 kVp HV – 325 kVp
Permissible temperature rise over an ambient of 50°C (irrespective of tap)	
Top oil	50°C
Winding	55°C
Fault level & duration	As per system requirement
Short-circuit withstand time (Thermal)	2 second
Bushing	HV –72.5 kV oil filled condenser bushing LV – 12 kV porcelain bushing
Termination	As per system requirement
Noise level	As per NEMA TR-1
Loading capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance

	with IEC 60076-7
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds The Contractor shall furnish over fluxing characteristic up to 150%
Air clearance	As per CBIP

17.3 Tank

17.3.1 The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of adequate thickness. The tank and the tank cover shall be of welded construction. All seams and joints shall be welded and where practicable, they shall be double welded. The tank so welded shall be reinforced by stiffener of structural steel for general rigidity.

17.3.2 The transformer top shall be provided with a detachable tank cover with bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

17.3.3 The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760mm of Hg.

17.3.4 Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

17.3.5 Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

17.3.6 All bolted connections to tank shall be fitted with suitable oil-tight gasket, which shall give satisfactory service under the operating conditions. All gaskets shall be closed design (without open ends) and shall be of one piece only. Gasket of nitrile rubber or equivalent shall be used. Gaskets of neoprene and / or any kind of impregnated / bonded core or cork only which can easily be damaged by over-pressing are not acceptable. Use of hemp as gasket material is also not acceptable.

17.3.7 Lifting lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantling. In addition, the transformer tank shall be provided with lifting lugs and bosses properly secured to the sides of the tank for lifting the complete transformer assembly with oil either by crane or by jacks.

17.3.8 The transformer tank shall be supported on a structural steel base equipped with forged steel single flanged wheels suitable for moving the transformer completely with oil. The wheels shall be bi-directional and mounted on swivels which may be turned through 90° when the tank is jacked up and capable of being locked in position parallel to and at right angles to the longitudinal axis.

17.4 <u>Core</u>

17.4.1 The transformer core shall be built up with high-grade non-ageing cold rolled grain oriented (CRGO) silicon steel laminations having high permeability and low hysteresis loss. The thickness of lamination shall be 0.27 mm or less.

17.4.2 The transformer shall be so designed that the flux density in the core shall not exceed 1.7 tesla at rated voltage and rated frequency. The maximum flux density in any part of core or yoke at 10% continuous over voltage condition shall not exceed 1.9 tesla.

17.4.3 The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.

17.4.4 The core shall be rigidly clamped to ensure adequate mechanical strength and to prevent vibration during operation and transportation. The clamping structure shall be designed to minimize eddy current loss.

17.4.5 The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux components at right angles to the plane of the laminations which may cause local heating.

17.4.6 The core shall be provided with lugs suitable for lifting the complete CCA of the transformer. The CCA shall be fixed with the tank so that it does not shift when transformer is moved or during short circuit.

17.4.7 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV RMS for one minute.

17.4.8 The core shall not be earthed at multiple locations. Terminal shall be brought on top of tank and earthed through link. Core and Frame terminals should be brought out on transformer top so as to enable megger.

17.5 Winding

17.5.1 The conductor for winding shall be made of electrolytic grade copper. The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs can be readily done without special equipment.

17.5.2 The coils shall be supported between adjacent sections by insulating spacers and barriers. Bracings and other insulation used in the assembly of the windings shall be arranged to ensure a free circulation of the oil and to reduce hot spots in the windings.

17.5.3 The insulation paper shall be of high quality and the value of degree of polymerization shall not be less than 1200 Pv.

17.5.4 Materials used for insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise get affected under the operating conditions.

17.5.5 All threaded connections shall be provided with locking facilities. All leads from the winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

17.5.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperature along the windings.

17.5.7 Windings shall be subjected to a shrinkage treatment before final assembly, so that no further shrinkage occurs during service. Adjustable device shall be provided for taking up any possible shrinkage of coils in service if required.

17.5.8 The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and windings shall be vacuum dried and suitably impregnated before removal from the treating tank. The copper conductors used in the coil structure shall be best suited to the requirements and all permanent current carrying joints in the windings and the locks shall be welded or brazed.

17.6 Insulating Oil

The oil for first filling together with 10% extra shall be supplied with the transformer. The oil shall comply in all respects with the provisions of the latest edition of IS 335 (as amended up to date). Particular attention shall be paid to deliver the oil free from moisture having uniform quality throughout in non-returnable steel drums.

17.7 On-Load Tap Changer

17.7.1 On-Load Tap Changer (OLTC) shall be designed for remote control operation from Remote Tap Change Control (RTCC) Panel in the control room in addition to being capable of local manual as well as local electrical operation. The OLTC shall include the following.

(vi) An oil immersed tap selector and arcing switch or arc suppressing tap selector, provided with reactor or resistor for reduction of make and break arcing voltages and short circuits.

(vii) Motor driven mechanism

(viii) Control and protection devices

(ix) Local /Remote tap changer position indicator

(x) Manual/Electrical operating device

(xi) Pressure relief device

17.7.2 The OLTC shall be so designed that the contacts do not interrupt arc within the main tank of the transformer. The tap selector and arcing switch or arc suppressing selector switch shall be located in oil filled compartment. The compartment shall be provided with Oil Surge Relay. It shall be designed so as to prevent oil in the tap selector compartment from mixing with the oil in the transformer tank.

17.7.3 The contactors and associated gear for the driving motor shall be housed in a local kiosk mounted adjacent to or on the transformer. The degree of protection of the complete arrangement shall be IP 55 or better. The motor shall be suitable for operation with three phase, 415 V, 50 Hz external power supply.

17.7.4 RTCC Panel

Remote Tap Change Control (RTCC) Panel shall include, but not limited to, the following.

(xii) Automatic Voltage Regulator with SCADA compatibility

(xiii) Under voltage relay to monitor the taper changer control voltage

(xiv) Raise and lower push button

(xv) Tap position indicator

(xvi) Indication lamp showing tap changing in progress

(xvii) Alarms and Annunciation

(xviii) Any other accessory required for satisfactory operation or required during detail engineering

17.8 <u>Bushing</u>

17.8.1 The bushings shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushings and grounded parts. Bushings of identical voltage rating shall be interchangeable.

17.8.2 All bushings shall be equipped with terminals suitable for bimetallic connection. Each bushing shall be so coordinated with the transformer insulation that all flash over will occur outside the tank.

17.8.3 HV bushings shall be 72.5 kV voltage class, oil filled condenser type and hermetically sealed. The bushings shall have provision for measurement of capacitance and loss factor without dismantling of the bushing. The bushings shall be removable without disturbing the Bushing Current Transformers if any. LV bushings shall be 12 kV voltage class, porcelain type. The oil used for the oil filled type bushings shall be the same as that used in the transformer.

17.9 Radiators

17.9.1 Radiators provided shall have sufficient cooling surface to limit the temperature rise to the values as specified in the 'Technical Requirements'. The radiators shall be seamless and made of mild steel/CRCA with minimum thickness not less than 1.2 mm. It shall be suitably braced to protect them from mechanical shocks.

17.9.2 The radiators shall be connected to the tank by machined steel flanges with adequate gaskets to avoid oil leakage. Each radiator unit shall be provided with butterfly type or positive operated gate type oil leak proof shut-off valve which can be fastened in either closed or open position and separate oil tight flange for each tank connection for use when the radiator unit is detached. Each radiator unit shall have a lifting arrangement and oil drain at the bottom and a vent at the top.

17.9.3 It shall be possible to take out any of the radiator unit without disturbing the transformer. The radiators shall be so designed as to prevent any accumulation of water on the outer surface or formation of gas pockets when the tank is being filled.

17.10 Accessories

17.10.1 Conservator

The conservator shall have air cell type constant oil preservation system to prevent oxidation and contamination of oil due to contact with moisture. The conservator shall be provided with separate compartment for OLTC. No separate conservator tank shall be provided for OLTC. The conservator shall be fitted with oil filling hole, cap and drain valve. Prismatic toughened glass oil level gauge and 150 mm Magnetic Oil Gauge (MOG) with low oil level alarm contact shall also be provided.

17.10.2 Silica gel breather

The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel dehydrating breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. The capacity of breather should be such that it can contain minimum 5 kg silica gel for main conservator compartment and minimum 1 kg silica gel for OLTC conservator compartment. The GI pipe connecting breather with conservator should be seamless and no joint is permitted.

17.10.3 Buchholz relay

Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper or stainless-steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling when the transformer in service. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.

17.10.4 Pressure Relief Device

Pressure Relief Device shall be provided on main tank and OLTC for rapid release of any pressure in transformer which may endanger the equipment. The device shall operate at a static pressure of less than hydraulic test pressure of transformer tank/OLTC chamber. The terminal box of the PRD shall be water tight with protection class IP 56 or better as per IEC 60529. Electrically insulated contact shall be provided for trip signal.

17.10.5 Temperature Indicators

17.10.5.1 Oil Temperature Indicator (OTI)

150 mm dial type temperature indicator with ‘Maximum’ reading pointer and resetting device shall be provided. The indicator shall have adjustable, electrically independent, potential free alarm and trip contacts. A temperature sensing element suitably located in a pocket on top oil shall be provided. Accuracy class of OTI shall be 1.5% or better.

17.10.5.2 Winding Temperature Indicator (WTI)

A device for measuring the hot spot temperature of each of the winding shall be provided. It shall comprise the following.

(i) Temperature sensing elements, one each on HV and LV winding.

(ii) Image coil.

(iii) Auxiliary CTs, if required to match the image coil.

(iv) 150 mm dial type temperature indicator with 'Maximum' reading pointer and resetting device with adjustable, electrically independent, potential free alarm and trip contacts.

(v) Calibration device.

The winding temperature indicator shall be responsive to the combination of top oil temperature and winding current, calibrated to follow the hottest spot temperature of the transformer winding. Accuracy class of WTI shall be 1.5% or better.

17.10.6 Marshalling Box

Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. One dummy terminal block in between each trip wire terminal shall be provided. At least 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene or synthetic 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.

17.10.7 Valves

The transformer shall be provided with the following (but not limited to) valves.

(xix) Two nos. of filter valves, one at top and another at bottom on diagonally opposite corners

(xx) Two nos. of sampling valves at top and bottom of the tank

(xxi) Drain valve on main tank

(xxii) Drain valves on main and OLTC compartment of conservator

(xxiii) Valves (for nitrogen injection and oil drain) as required by firefighting system

All valves shall be constructed of stainless steel, brass or gun metal except of shutoff valve for radiator and cooler. For radiator and cooler, valve shall be made up of gun metal or cast iron.

17.11 Painting

17.11.1 Before painting or filling with oil, un-galvanized parts shall be completely cleaned and free from rust, scale and grease. All external rough surfaces on casting shall be filled by metal deposition. The interior of transformer tank and other filled chambers and internal structural steel work shall be cleaned of all scale and rust by send blasting or other approved method. These surfaces shall be painted with an oil resisting varnish or paint.

17.11.2 Except for nuts, bolts and washers, all external surfaces shall receive a minimum of three coats of paint. The primary coat shall be applied immediately after cleaning. The second coat shall be of oil paint of weather resisting nature. The final coat shall be of a glossy, oil and weather resisting non-fading paint. The paint shade shall be as provided by the Employer during detailed engineering.

17.11.3 All internal surfaces of mechanism chambers and kiosk except those which have received anticorrosion treatment, shall receive three coats of paint applied to the thoroughly cleaned metal surface. The final coat shall be of light coloured anti-condensation mixture.

17.11.4 Any damage to paint work incurred during transport and erection shall be made good by thoroughly cleaning the damaged portion and by applying full number of coats of paints.

17.12 Transportation

17.12.1 Transformer tank is filled with oil or pure dry nitrogen/ air depending upon the transport weight limitations. Necessary arrangement shall be ensured to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

17.12.2 Bushings shall be crated, packed and transported as per standard guide lines of the Bushing Manufacturer. All care should be taken to avoid any damage of the porcelain due to vibration during transport.

17.12.3 Special attention shall be paid in packing the accessories & spares to avoid moisture ingress. All parts shall be adequately marked to facilitate field erection.

17.13 Warranty

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

17.14 Testing and Inspection

17.14.1 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.

17.14.1.1 Type Tests

(i) Lightning impulse (Full & Chopped Wave) test on windings as per IS 2026-3/IEC 60076-3

(ii) Temperature Rise test at a tap corresponding to maximum losses as per IS 2026-2/IEC 60076-2. Dissolved Gas Analysis (DGA) shall be conducted on oil sample taken before and immediately after temperature rise test. Gas analysis shall be as per IS 9434/IEC 60567 and results will be interpreted as per IS 10593/IEC 60599.

17.14.1.2 Special Tests

(i) Short circuit withstand test as per IS 2026-5/IEC 60076-5

(ii) Measurement of zero-sequence impedance as per IS 2026-1/IEC 60076-1

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

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

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.

17.14.2 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 at 90%, 100% & 110% of rated voltage

(v) Measurement of short-circuit impedance and load loss at principal and extreme taps

(vi) Magnetic balance test & magnetizing current 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 and polarization index

(x) Measurement of tan delta and capacitance of winding

(xi) Core isolation test

(xii) Marshalling box functional test

(xiii) IR Measurement on wiring of marshalling box

(xiv) Test on on-load tap changer

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

(xvi) Jacking test followed by D.P. test

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

18 Nitrogen Injection Fire Protection System

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

18.1 Standards and Codes

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

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

18.2 Technical Requirements

Parameter	Specification
Fire extinction period from commencement of nitrogen injection	30 second (maximum)
Total time duration to bring oil temperature below flash point	30 minute (maximum)

Fire detector heat sensing temperature	141°C
TCIV setting for normal operation to ensure no obstacle for transformer breathing	40 litre per minute
TCIV setting for operation during abnormal flow of oil	60 litre per minute
Capacity of nitrogen gas cylinder	10 m^3 gas at pressure of 150 kg/cm^2 for up to 60,000 litre of oil 20 m^3 gas at pressure of 150 kg/cm^2 for above 60,000 litre of oil

18.3 System Components

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

18.3.1 Fire Extinguishing Cubicle

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

(i) Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer. The nitrogen gas cylinder should have been certified by Bureau of Indian Standards and approved by Chief Controller of Explosives, Government of India.

(ii) Oil drain pipe with mechanical quick drain valve

(iii) Control equipment for draining of oil and injecting nitrogen gas

(iv) Pressure monitoring switch for backup protection for nitrogen release

(v) Limit switches for monitoring of the system

(vi) Valve with flanges on top of the cubicle for connecting oil drain pipe and nitrogen injection pipe

(vii) Panel lighting

(viii) Oil drain pipe extension of suitable sizes for connecting pipes to oil pit

18.3.2 Control Box

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

18.3.3 Transformer Conservator Isolation Valve

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

18.3.4 Fire Detector

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

18.3.5 Signal Box

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

18.3.6 Cables

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

18.3.7 Pipes

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

18.3.8 Other Items

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

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

18.4 Operation

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

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

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

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

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

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

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

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

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

19 Control and Relay Panel

19.1 <u>Standards and Codes</u>

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

Standard/Code	Description
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment

IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 15086-4	Surge Arresters, Part 4: Metal-Oxide Surge Arresters Without Gaps for A.C. systems
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

19.2 Construction

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

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

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

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

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

19.3 Relays

19.3.1 All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

19.4 Protection Scheme

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

(i) Biased Differential Protection with Second Harmonic Restraint

(ii) Non-directional Over Current and Earth Fault Protection

(iii) Restricted Earth Fault Protection

(iv) Under Voltage and Over Voltage Protection

(iii) Buchholz Alarm and Trip

(iv) OTI Alarm and Trip

(v) WTI Alarm and Trip

(vi) PRV Trip

(vii) MOG Alarm

(viii) OSR Trip

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

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

19.5 Measuring Instruments

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

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

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

19.6 Control Switches

All control switches shall be rotary operated type with adequate making, carrying and breaking current ratings. The control switches shall be pistol grip type, lockable with spring return to normal position. They shall be flush mounted on the panel with shrouded terminals.

19.7 Indications

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

19.8 Annunciation

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

19.9 Earthing

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

19.9.2 All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with earth grid.

19.9.3 All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

19.9.4 Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

19.10 Mimic Diagram

Coloured mimic diagram made of metal or plastic with symbols to facilitate exact representation of the system shall be fixed on the front of control panel. Semaphore indicators shall be incorporated in the mimic diagram for indicating position of circuit breakers, isolators and earthing switches. The rated control voltage of semaphore indicator shall be 110 / 220 VDC.

19.11 Wiring and Terminal Blocks

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

19.11.2 Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

19.11.3 Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.

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

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

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

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

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

19.12 Accessories

(i) Thermostatically controlled space heater with switch for isolation

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

(iii) LED lamp controlled by door switch

19.13 Warranty

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

19.14 Testing and Inspection

19.14.1 Type Tests

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

19.14.2 Routine Tests

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

20 11/66 kV Plant Pooling Sub-Station Equipment

20.1 Standards and Codes

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

Standard/Code	Description
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IEC 60376, IS 13072	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IEC 61869	Instrument Transformers
IS 2099	Bushings for alternating voltages above 1000 Volts
IS 2544	Porcelain post insulators for systems with nominal voltage greater than 1000 Volts
IS 335, IEC 60296	Insulating oil
IS/IEC 60034	Rotating electrical machines
IS 996	Single-phase AC industrial motors for general purpose
IS 3070, IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
Indian Electricity Act, CBIP manual, CEA rules and guidelines	

20.2 General Technical Parameters

Note: Electrical ratings of switchgear shall be in accordance with altitude correction factors above their standard designs, applicable as per IS/IEC 62271-1

System Parameters	Specification
Highest system voltage	72.5 kV
Rated system voltage	66 kV
Rated frequency	50 Hz
Number of phases	3

Power frequency withstand voltage I. To earth II. Across Isolating distance	 140 kV (rms) 160 kV (rms)
Lightning impulse withstand voltage I. To earth II. Across Isolating distance	 325 kV (peak) 375 kV (peak)
System fault current	As per system requirement
Minimum Creepage distance	25 mm/kV of highest system voltage
System neutral earthing	Effectively earthed

20.3 Circuit breaker

20.3.1 Technical parameters

Parameters	**Specification**
Type	Outdoor SF6
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times of Short circuit breaking current
Rated break time	100ms
Re-strike performance class	C2
Mechanical endurance class	M1
First pole to clear factor	1.5 (As per IEC 62271 – 100)
Reclosing	Three phase high speed auto reclosing
Auxiliary contacts	As required plus 4NO and 4NC contacts per pole as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 milliseconds at 220V DC

20.3.2 Circuit breakers shall be of SF6 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.

20.3.3 The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.

20.3.4 Circuit breaker shall be provided with two independent set of trip circuit connected to separate fuse or MCB controlled DC supplies for greater reliability.

20.3.5 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.

20.3.6 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.

20.3.7 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.

20.3.8 Temperature compensated SF6 gas density monitor and pressure switches along with pressure indicator shall be provided to monitor and regulate the density of SF6 gas in breaker respectively in each pole. It shall be possible to dismantle the monitor without any seepage of SF6 gas.

20.3.9 Interrupter assembly shall be provided with an absorbing product box to eliminate moisture and SF6 decomposition products.

20.3.10 10% of total SF6 gas requirement shall be supplied in separate container as spare in addition to the required SF6 gas to fill the breaker installed at site.

20.3.11 Mechanical indicators shall be provided to indicate OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation analyzer shall be provided to record contact travel against time and measure opening time. These indicators and counter shall be visible from the panel front door without opening it.

20.3.12 Control cabinet shall be free standing, floor mounted, single front, metal enclosed construction. It 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. All external surface shall be painted with two coats of epoxy-based paint of color shade RAL 7032. Internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns. Degree of protection shall not be less than IP5X.

20.3.13 Control cabinet shall be provided with thermostatically controlled space heaters 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. It shall also be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch and a 240 V, 15 A, SPN industrial socket-outlet with ON/OFF switch.

20.3.14 The bidder shall furnish complete literature regarding assembly, maintenance and charging procedures as applicable to SF6 breakers.

20.4 Isolator

20.4.1 Technical parameters

System Parameters	Specification
Service	Outdoor
Type of Isolator	Mechanically gang operated, Double break or centre break with earthing switch
Operating Mechanism a) Isolator b) Earth switch	 Motor Manual
Auxiliary contacts	As required plus 4NO and 4NC contacts per pole as spare for isolator and earth switch each.
Short time current	As per system requirement
Safe duration of over load a) 150% of rated current b) 120% of rated current	 5 minutes 30 minutes

20.4.2 Isolators shall be outdoor type with blades rotating in horizontal plane, suitable for electrical as well as manual operation and local/remote operation.

20.4.3 Isolator and earth switch shall be capable of withstanding dynamic and thermal effects of system fault current in closed position and should not open under influence of fault current and wind pressure together.

20.4.4 Isolator shall be provided with heavy duty, self-aligning, high pressure current carrying contacts and moving blades made up of highly conductive, corrosion resistant, hard drawing electrolytic copper alloy. Copper contacts shall be silver-plated with minimum 25-micron thickness.

20.4.5 Arcing horns on the fixed and moving contacts, if required shall be of ‘make before and break after’ type.

20.4.6 Each single pole of isolator shall be provided with suitable galvanized steel base channels with holes and designed for mounting on a lattice supporting structure.

The bas shall be rigid and self-supporting.

20.4.7 Operating mechanism for isolator and earth switch shall provide quick, simple and effective operation and shall be provide on opposite ends.

20.4.8 Control cabinet/operating mechanism box shall be constructed with CRCA steel/Aluzinc sheet of minimum 3 mm thickness. 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 microns. Degree of protection shall not be less than IP5X. It shall be provided with thermostatically controlled space heaters to prevent condensation within the compartment, LED lamp for interior illumination controlled by door switch and an industrial socket-outlet with ON/OFF switch.

20.4.9 Support insulators for Isolator and earth switch shall be solid core type made up of homogenous and vitreous porcelain.

20.4.10 Mechanical indicators shall be provided to indicate OPEN/CLOSED position of the isolator.

20.4.11 Following fail safe type electrical and mechanical interlocks are required between Isolator & earthing switch and Isolator & circuit breaker:

(iii) Prevention of opening of isolators on load.
(iv) Prevention of closing of earth switch, when line isolator is closed.
(v) Prevention of closing of line isolator, when earth-switch is closed.
(vi) Prevention of opening of isolator, when circuit breaker is closed and vice versa.
(vii) Provision shall be made for pad locking the mechanism of isolator and earthing switches in both, the ‘close’ and ‘open’ position.

20.5 <u>Instrument transformer</u>

20.5.1 Technical parameters

Parameter	**Specification**
Current Transformer	
Accuracy class	0.2S for metering 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class E
Rated Short time thermal rating	As per system requirement
Rated short time dynamic rating	As per IEC 16277
Partial discharge level	10 Pico Coulomb maximum

No. of terminals in Terminal box	As required plus 10 terminals as spare
Voltage Transformer	
Accuracy class	0.2 for metering 3P for protection
Rated VA burden	As per requirement
Insulation class	Class E
Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
Partial discharge level	10 Pico Coulomb maximum
Rated voltage factor	1.2 continuous and 1.5 for 30 sec.
No. of terminals in Terminal box	As required plus 10 terminals as spare

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

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

20.5.4 The insulators shall have cantilever strength of more than 600 kgf.

20.5.5 Secondary terminals of instrument transformer shall be brought outside in a terminal box constructed with CRCA steel/Aluzinc sheet of minimum 3 mm thickness. 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 microns. Degree of protection shall not be less than IP5X. It shall be provided with thermostatically controlled space heaters to prevent condensation within the compartment, LED lamp for interior illumination controlled by door switch and an industrial socket-outlet with ON/OFF switch.

20.5.6 CTs shall be suitable for high speed auto reclosing.

20.5.7 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.

20.5.8 Wiring and Terminal blocks of instrument transformers

20.5.8.1 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.

20.5.8.2 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.

20.5.8.3 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.

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

20.5.8.5 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.

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

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

20.6 Warranty

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

20.7 Testing and Inspection

20.7.1 Type Tests

All switchyard equipment shall be of type tested design. Type test reports as per the relevant IEC/IS standards shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory. 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.

20.7.2 Routine Tests

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

21 Illumination

21.1 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 Colour Maintenance of LED Packages, Arrays and Modules

21.2 General Specification

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

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

21.2.3 Lighting system shall work on the auxiliary supply and same shall be incorporated in auxiliary loads. The Contractor shall provide minimum 20% of total lighting points as emergency lighting points, fed from UPS DB or DCDB as per scheme adopted by the Contractor.

21.3 Lighting Levels

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

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

21.3.2 The lighting level shall take into account appropriate light output ratio of luminaires, coefficient of utilization maintenance factor (of 0.7 or less) to take into account deterioration with time and dust deposition and illuminance uniformity [Uo] shall be min 0.3.

21.4 LED Luminaire for Outdoor Applications

21.4.1 LED luminaires shall meet the following parameters.

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

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

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

21.4.4 The LED luminaire (outdoor) housing should be made of non-corrosive, high-pressure, die-cast aluminium and the housing should be power coated grey, so as to ensure good weatherability. Each individual LED source should be provided with an asymmetrical distribution high reflectance aluminized reflector, which should ensure that the light distribution of the luminaire is suitable for road lighting applications (wide beam distribution) and should ensure high pole to pole spacing.

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

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

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

21.4.8 All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.

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

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

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

21.5 LED Luminaire/Lamps for Indoor Applications

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

21.6 Warranty

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

22 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.

22.1 Pyranometer

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

22.1.2 Specification of the pyranometer shall be as follows.

Parameter	Specification
Spectral Response (50% points)	0.31 to 2.8 micron
Operating temperature range	0°C to +80°C
Ingress Protection	IP 67
Resolution	Minimum +/- 1W/m^2

Output	Analog output: 4 – 20 mA Serial output: RS485

22.1.3 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.

22.2 Temperature Sensor

The temperature sensor shall be Resistance Temperature Detector (RTD)/ Semiconductor type with measurement range of 0°C to 80°C. The instrument shall have valid calibration certificate. The temperature sensor for ambient temperature measurement shall have shielding case.

22.3 Anemometer

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

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

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

(i) Sun rise and sun set timings

(ii) Cloud cover (Okta)

(iii) Rainfall (mm)

(iv) Relative humidity (%)

22.5 Data logger and Data Acquisition System

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

22.5.1 Provision for analog, digital and counter type inputs for interfacing with various type of sensors

(i) Analog Input
- Adequate nos. for all analog sensors with redundancy
- Provision for operation in different current and voltage ranges as per connected sensors
- Accuracy of +/-0.1% of FS

(ii) Digital Inputs
- Adequate no. of Digital inputs and outputs for the application

(iii) Provision for RS232 and RS485 serial outputs
(iv) Built-in battery backup
(v) Connectivity and Data transmission:
- RS485 MODBUS interface for data collection and storage on SCADA
- Communication protocol should support fast data transmission rates, enable operation in different Frequency bands and have an encryption-based data security layer for secure data transmission

(vi) Display Settings: Graphic LCD screen which should be easily accessible and should display relevant details like all sensor values, battery strength, network strength etc.
(vii) Provision of Time synchronization from telecom time or server time
(viii) Data Storage: Provision for at least 2 MB internal Flash Memory and at least 8 GB Micro SD card (expandable)
(ix) Protection level: IP 65

23 CCTV Camera

23.1 CCTV Cameras along with monitoring stations (sufficient numbers) and all other accessories required for its proper operation must be installed to have complete coverage of following areas for 24 hours.
(i) Each entry/exit gate.
(ii) Along the Plant Perimeter: Covering complete perimeter of Plant Area to capture all possible intrusion
(iii) Main Control Room: Covering Entry/Exit and Equipment Rooms
(iv) Inverter Station & Inverter Transformer Yard
(v) Plant Pooling Substation
(vi) Weather Monitoring station
(vii) BESS Switchyard

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

23.3 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.

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

23.5 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 (minimum 32") for live video.

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

(i) Video motion detection

(ii) Object tracking

(iii) Object classification

(iv) Camera server shall be provided with sufficient storage space to storage recordings of all cameras at HD mode for a period of 15 days. All recordings shall have camera ID, location, date and time of recording.

24 Fire Alarm System

24.1 <u>Standards and Codes</u>

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

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

24.3 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.

24.4 Minimum two numbers of fire extinguishers (CO_2 and Foam type each, of capacity 9 kg having BIS certification marking as per IS 15683) shall be provided at every building/ enclosure, transformer yard and switchyard. However, contractor must comply with existing building code for fire protection and relevant IS codes.

24.5 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.

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

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

25 Testing Instruments

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

25.1 <u>Earth resistance tester</u>

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

25.2 <u>Array tester</u>

Parameter	**Specification**
Display	Backlit LCD or LED display

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

25.3 Insulation tester

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

25.4 Digital Multimeter

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

25.5 Clamp meter

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

25.6 Infra-red thermal imaging camera

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

25.7 Digital lux meter

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

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

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

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

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

26 Power Evacuation System

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

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

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

26.4 <u>Overhead Transmission Line</u>

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

B Battery Energy Storage System

1 Scope of Works:

The Scope of Work covered under this specification shall be but not limited to the following:

1.1 Initial Design and Fabrication

For the initial design and fabrication of the equipment, the Contractor shall

- Design, fabricate, and assemble a fully functional, transportable BESS that meets the requirements delineated herein. This shall include a control system that provides standard input/output channels and appropriate control actions for all required operational and protective features.
- Fully document the design and expected performance of the BESS by means of documents, drawings, reports, data, and other submittals, as required herein.
- Perform factory acceptance testing of the BESS.
- Account for the geographical/climatic conditions of the Project site in the design.
- Obtain site-specific data in preparation for developing installation implementation plans.
- Develop site installation/construction drawings, specifications, and calculations.
- Supply any special equipment and tools required for maintenance of the BESS.
- Supply an initial complement of spare parts (as per OEM recommendations and to meet the BESS Availability Guarantee).
- Provide warranty for the entire BESS and its constituent equipment.

1.2 Definitions

- **PCC** – Point of common coupling, the electrical boundary between the Solar PV field of the Plant Facilities and the BESS at the common bus where the Energy injected from the BESS is metered.
- **Unit battery** – A unit battery is the minimum field-replaceable stored energy component or assembly. It may consist of one or more electrochemical cells, electrically interconnected in any series and/or series–parallel configuration. A unit battery has one (and not more than one) set of positive and negative terminals, by which it is interconnected with the rest of the storage system.
- **FAT –** Factory Acceptance Test
- **BESS** – AC Coupled energy storage system with electrochemical type accumulator subsystem, capable of receiving, storing and delivering electrical

energy at specified rate(s) suitable for the application laid out in the specifications herein. For the purpose of common reference in these specifications, BESS shall comprise of following subsystems/components:

1. Accumulation System, comprising unit batteries/battery packs/racks with battery management system (BMS)
2. Conversion Subsystem - Bi-directional PCU
3. Auxiliary sub-systems such as HVAC and fire suppression systems
4. Data Acquisition and Communication sub-systems
5. BESS Transformer.
6. BESS Energy Management System (EMS)/ BESS Data Acquisition System (DAS)

Note: The Accumulation system i.e. battery packs/modules/racks along with associated systems (BMS, HVAC, auxiliary subsystems etc.) deemed necessary to enable system operation shall be containerised.

- **BMS** - or Battery Management System, is any electronic system that manages a rechargeable battery (cell or battery pack), including protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.
- **Available or Dispatchable or throughput energy** is the sum total of energy (kWh) delivered from the BESS at the PCC.
- **Nameplate Energy** is the sum total of the rated energy capacity of the energy storage units i.e. battery packs/modules/racks

2 Site-Specific Implementation Requirements

2.1 Procurement-Specific Location and Site Characteristics for Design: Table-1 below lists supply-specific location and site characteristics.

Table 1: Procurement-Specific Location and Site Characteristics

Item	**Characteristic**
Location	Taru, Leh District, Ladakh
Site characteristics:	
Precipitation	The driest month is October, with 3 mm of rainfall. In August, the precipitation reaches its peak, with an average of 15 mm.
Seismic Zone (Geological Survey of India, 2014)	Zone – IV

Design elevation	3,400 m above sea level
Electrical infrastructure: AC system interconnection requirement at Point of Common Coupling (PCC)	11 kV / 415 V, 50 Hz, 3 phase The BESS will be coupled with the PV System at the AC Bus on the MV (11 kV) side of the Inverter Transformers.

2.2 Codes and Standards

IEC 62485-2	Safety requirements for secondary batteries and battery installations - to meet requirements on safety aspects associated with the erection, use, inspection, maintenance and disposal	Applicable only for Lead Acid and NiCd / NiMH batteries
UL 1642 or UL 1973, Appendix E (cell) or IEC 62619 (cell) + IEC 63056 (cell)	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Required for Cell
UL 1973 (battery) or (IEC 62619 (battery) + IEC 63056 (battery))	Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications / Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Required for Battery
IEC 62281 / UN 38.3	Safety of primary and secondary lithium cells and batteries during transport: Applicable for storage systems using Lithium Ion chemistries	Required for the unit transported
UL 9540 or (IEC TS 62933-5-1 + IEC	Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid integrated EES systems – General	Either UL9540 or (IEC 62933-5-1 + IEC 62933-5-2) is required for BESS system level

62933-5-2)	specification / Standard for Energy Storage Systems and Equipment	
UL 9540A	Standard for Thermal runaway	At cell/module/rack /system level, as required by standard

3 **Technical Specification of Battery Energy Storage System**

3.1 Procurement-Specific Ratings and Requirements: Table-2 below specifies project-specific BESS capabilities and ratings for this Project.

Table 2: Supply-Specific Ratings and Requirements

Item Description	**Requirement**
Battery Technology	Any battery technology with totally Maintenance Free suitable for operation in site-specific climatic conditions can be used.
Rated No of Cycles (Minimum)	4000 cycles at rated energy capacity at minimum 80% Depth of Discharge (DoD) at 25°C and 0.5 C Rate of Discharge
Power rating* (A)	20 MW, continuous
Energy rating*, (B)	Minimum 50 MWh Nameplate capacity with at least 40 MWh dispatchable at the beginning of life and not less than 80% of this capacity i.e. 32 MWh at any point of time up to End of Battery Life.
BESS Availability	98%
System ac-dc-ac efficiency*:	>80%
Use case requirements	Peak Management
Charge-discharge cycles	One discharge cycle per day is envisaged
Ventilation System inside the Container	Should be such as to maintain minimum and maximum Temperature as recommended by the manufacturer for optimum performance of the batteries.
Grid Charging	No
***To be verified as per the procedure described in General Annexure-I to this Section for Plant Commissioning and Test Procedure and to be verified on annual basis as per Schedule. All measurement instruments for conducting the tests shall be maintained by the Contractor.**	

3.1.1 The BESS Supplier/Sub-Contractor must have experience of having successfully completed ‘Design, Engineering, Procurement, Construction, Installation, Testing and

Commissioning of Grid Connected Battery Energy Storage System (BESS)' of at least 02 (Two) Grid connected BESS Plants, each having an individual capacity of 2 MWh (Five Mega Watt Hour) or above in last five years. However, such BESS Plant capacity must have been in satisfactory operation for at least 12 (Twelve) months from the date of commissioning.

3.2 System Ratings

3.2.1 Overall System Real Power and Energy Ratings

During discharge, the BESS shall be rated to supply at the PCC, continuous net ac real power and ac energy output specified in *Table 2: Supply-Specific Ratings and Requirements* above. The Power and energy ratings shall be achievable during discharge for the full range of stated environmental conditions, provided that the battery is fully charged and the HVAC system has stabilized. In any case, the BESS shall be capable of being discharged at reduced power levels from that specified above. The Contractor shall account for efficiencies of the BESS components up to the PCC as well as the expected losses from auxiliaries for system sizing

Note: The real power level during charging shall be at the Contractor's discretion, so long as the other charging/discharging requirements in this specification are met.

3.3 The BESS shall be capable of operating over its entire life in one or more of the use cases described in this section to meet the system requirements specified in Table-2, and further detailed in the NIT.

3.4 The use cases supported by this technical specification include the following:

3.4.1 Peak management (PM)

In the PM use case, the BESS is charged from the Solar PV bus at the PCC during solar hours and discharged at any power level up to the maximum power level specified in this document. In this Use case, each daily operation is expected to consist of one discharge and charge cycle, in either a variable or a constant power output.

Note: For the purpose of system nameplate sizing subject to the minimum specified in *Table 2: Supply-Specific Ratings and Requirements* above, the Contractor shall consider 4 hours of discharge during the post-solar hours.

4 Design, Fabrication, and Construction Requirements of BESS

4.1 General

The methods and materials specified in this technical specification are intended to represent minimum requirements. Reliance thereon shall not diminish the responsibility for meeting performance and other requirements stated herein. The design of the BESS shall incorporate the principle of modularity, with a view to reducing life-cycle costs and ease of replenishment of storage capacity while facilitating ease of maintenance, space requirements, and reliability. The design should also facilitate rapid and easy replacement of the unit batteries/battery packs/modules without significant downtime.

4.2 **System-Level Design and Performance Requirements**

The major equipment items shall include battery packs/modules, battery management system (BMS), PCS, output/isolation transformer, and BESS EMS which is to be integrated with the solar plant SCADA system defined elsewhere in this document. Additional equipment shall include HVAC, wiring, connectors, protective devices, grounding, junction boxes and enclosures, instrumentation, enclosures, and all other items needed for a fully functional, grid-interactive BESS to meet the requirements set forth in this specification.

4.3 **Containerization and Transportability**

4.3.1 Containers for the accumulation subsystem shall comply with International Organization for Standardization (ISO) 668 shipping containers or custom-designed power equipment centres. The container or containers shall be designed to be drop-shipped onto a properly prepared pad or foundation (such as compacted soil, concrete pad or platform).

4.3.2 Containers shall be designed and constructed to meet IP54/NEMA 3R requirements.

4.3.3 All containers and packaging of separately shipped components shall be suitable for land or sea transport, including offering suitable protection of the equipment inside against damage from weather and vibration or shock from transportation.

4.3.4 The containers and their contents shall be designed to be easily prepared for transport, shipped, connected and operated at site. Containers shall be transported along with all requisite bracing and shipping stabilization equipment.

4.4 **Design Life and Life-Cycle Costs**

4.4.1 End of battery life – End of battery life is that point in time when the BESS can no longer meet the power and/or energy discharge requirements of this Specification due to age or non-repairable malfunction of the accumulation subsystem, and/or non-replaceable components. When the system is no longer able to provide these requirements, the system has reached its end of life. Battery End of life shall not be less than the total period from the date of Commissioning to the expiry of the O&M

Contract.

4.4.2 It shall be the responsibility of the Contractor to make periodic replacements/replenishments of unit batteries, if and when required, up to the End of Battery Life as described above. Outage time as a result of replacement will also be counted as an "Accountable BESS Outage" for the purpose of computing BESS Availability.

4.5 **BESS Availability**

Availability is the percentage of hours that the BESS is available during the year. The availability guarantee shall begin upon facility commissioning. Annual availability shall be calculated as follows:

$$[1 - \left(\frac{\sum Accountable\ \mathrm{BESS}\ Outage\ duration\ in\ hours\ \times We}{8760}\right)\ ]\times 100$$

Where:

- *We, Weightage* is the $\frac{\text{Outage Capacity}}{\text{Rated Cpacity}}$, where Outage and Rated Capacity shall be in Energy terms, i.e MWh. Rated Capacity in a given year shall correspond to the daily throughput capacity guarantee for the beginning of the year.
- *Accountable BESS outages* are outages caused or necessitated by the BESS equipment that result in reduced capacity or loss of essential function of the BESS. These outages may be initiated by failure of components, loss of battery capacity (to the extent that End of Battery Life is not reached), operation of protective devices, alarms, or manual action. Such outages include both forced outages due to equipment problems and scheduled outages for BESS maintenance.
- *Accountable BESS outage duration* is the elapsed time of accountable BESS outages from the instant the BESS experiences reduced capacity or is out of service to the instant it is returned to service or full capacity. If the BESS experiences reduced capacity but is determined by the Employer to be available for service, even if the Employer elects not to immediately return the equipment to full capacity, such time will be discounted from the outage duration.
- The BESS shall be under an accountable outage if any of Procurement Specific ratings (Table 2) cannot be met. The BESS shall also be under an accountable outage if a scheduled (or required) charge cycle cannot be completed.
- The data required for assessment of the availability of the BESS shall be collected through the BESS EMS/ Plant's integrated SCADA system.
- Grid Outage hours shall be subtracted from the total no. of hours in a year

- If the Plane of Array solar irradiation/insolation is less than 2 kWh/m2 on a day, the day (i.e. 24 hours) shall be excluded.

The BESS shall be capable of unattended operation, with provision of remote monitoring and control.

4.6 **Battery Subsystem Design Requirements**

4.6.1 Electrochemical Cells

Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the Employer and approved prior to dispatch.

Labelling of the unit batteries/battery packs shall include manufacturer's name, cell type, nameplate rating, and date of manufacture, in fully legible characters and traceable to the point of origin for purpose of addressing safety issues.

4.7 **Electrochemical Storage System**

4.7.1 The storage system may consist of one or more unit batteries/battery packs/racks. If the storage system consists of more than one unit battery, these may be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements.

4.7.2 Each electrically series-connected string of unit batteries shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). The means of disconnect shall provide for a physical interruption of the string electrical circuit, which shall be visible and accessible to maintenance personnel and shall be capable of being locked or secured in an open position.

4.7.3 If the disconnect means consists of removal of a unit battery, the storage system shall be designed to allow maintenance personnel to determine that there is no current flowing in the string and provisions to ensure that the PCS is off before the unit battery is removed. Procedures for maintenance and/or field replacement of unit batteries shall neither require nor recommend removal of the unit battery without first ensuring that no current is flowing in the string circuit.

4.7.4 Over-current protection, whether on the ac or dc side, in paralleled unit battery strings shall be sized and coordinated so that currents from other strings do not contribute to a fault in any unit battery string.

4.7.5 Protection shall include a dc breaker, fuse, or other current-limiting device on the battery bus. This protection shall be coordinated with the PCS capabilities and battery string protection. The Contractor shall produce a fault analysis and protection coordination study for the battery dc subsystem during final design.

4.7.6 Cells, wiring, switch gear, and all dc electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety.

4.7.7 The BESS shall include appropriate self-protective and self-diagnostic features to protect itself and the battery from damage in the event of BESS component failure or from parameters beyond the BESS's safe operating range due to internal or external causes.

4.7.8 Temperature sensors shall be incorporated in critical components within the BESS. The BESS shall alarm and go to standby/fault mode when an over-temperature condition is detected.

4.7.9 Door interlock switches shall be provided for all BESS container doors. The BESS shall alarm and go to shutdown mode when a BESS Container door is opened. Doors shall be fitted with provisions for external locks.

4.7.10 The battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for the container or, if more than one electrical series string is installed in the container, for each series string.

4.7.11 The battery system shall include a monitoring/alarm system and/or prescribed maintenance procedures to detect abnormal unit battery conditions and notify proper personnel of their occurrence.

4.7.12 The Battery Management System (BMS) shall have at least the following protection mechanisms for battery:

- Reverse Polarity
- Over/Under Voltage
- Over Temperature
- Over Charge

4.7.13 Unit battery monitoring, whether automatic or manual, should be specified to alert the proper personnel in a timely manner that an abnormal unit battery condition exists or may exist. All alarms shall be part of the control system and shall include remote display or annunciation capability.

4.7.14 The unit batteries shall be racked or shall be housed in stackable modules. The unit batteries or cells shall be arranged and installed to permit easy access for equipment and personnel. The moveable units shall be arranged and installed to permit easy access for equipment and personnel to carry out unit removal and replacement activities. For all systems, it shall be possible to remove and replace a prematurely failed unit battery or cell (as appropriate), when system performance specifications cannot be met. The lengths and widths of all aisles and spaces into which personnel may enter in the field for operations and/or routine or unscheduled maintenance purposes, as well as egress routes from these aisles and spaces, shall conform to applicable codes and standards.

4.7.15 All racks and metallic conductive members of stackable modules shall be grounded to earth. Racks shall meet the seismic load requirements and shall include means to restrain cell movement during seismic events. The Contractor shall furnish analyses and/or other data that show that the rack and cell designs are designed to meet all potential seismic vibration requirements.

4.7.16 The cells and battery system shall be supplied with all required and/or recommended accessories. This includes inter-cell connectors and monitoring devices for cell temperature and cell voltage, if required.

4.8 **Power Conditioning System Design Requirements**

4.8.1 Standards and Codes

Power Conditioning Units (PCUs) shall comply with the following standards and codes:

Standard	Description
IEC 62447-1	Safety requirements for power electronic converter systems and equipment - Part 1: General
IEC 61000-6-2 Ed. 2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed. 2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 62116 Ed. 2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat

IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations with the latest amendments	

4.8.2 Power Conditioning System Rating

The PCS shall be bi-directional type, capable of delivering Real power as specified in Table-2. This rating shall be referred to in all project documentation, including this specification, as the nameplate VA rating. To account for losses in the PCS, the DC input power to the PCS will be higher than the rated PCS output power. The available DC input power will be the BESS nameplate watt rating divided by the PCS full load efficiency (as specified in the datasheet) during discharge.

4.8.3 The PCS shall include provisions for disconnect on both its AC and DC terminals for maintenance work. The detailed maintenance procedure shall be addressed in the O&M manual.

4.9 BESS Transformer

BESS Transformer may be dry type or Oil type as per specifications provided elsewhere in this document.

4.10 AC System

The BESS AC system shall include all switch gear, cable, connectors, transformers, and protective relaying. Metering arrangement required for connecting the BESS at the PCC shall be in line with codes and standards specified elsewhere in this document.

4.10.1 Protection and Control - The protection system shall be capable of monitoring significant operating parameters and sensing all abnormal operations or fault conditions. It shall isolate the faulted circuits or components without causing damage to other circuits and components of the system. The protection system shall also provide adequate indications and/or alarms for identification of the faulted circuits, components, and abnormal conditions, allowing preventive action and rapid restoration of service.

4.10.2 Other protections shall not be interlocked with the position of any isolating/interrupting devices.

4.10.3 The BESS shall include provisions to protect against transient voltage surges from switching, lightning, and similar causes, in accordance with applicable standards.

4.11 Auxiliary Power

4.11.1 The BESS shall include an auxiliary power system (separate or same as the Solar Plant auxiliary system). comprising of step-down transformers, breakers, fuses, relaying, panels, enclosures, junction boxes, conduits, raceways, wiring, etc., as required for the BESS operation.

4.11.2 The auxiliary supply to the BESS shall be metered separately. Meters shall be TVM of 0.2 accuracy.

4.11.3 Auxiliary System shall provide for whatever emergency power backup is necessary for orderly shutdown during abnormal conditions such as loss of grid power.

5 Control and Communication

5.1 Control System General Requirements

The control system shall be designed to provide for automatic, unattended operation. The control system design shall provide for local manual operation and remote operation or dispatch from a remotely located computer. The control system shall be programmable for establishing or adjusting all parameters, set points, algorithms, limits, and so on that are required for effective operation as described in this specification.

5.2 Control Functions and Protocols

5.2.1 All BESS control communications shall be built over MODBUS TCP/IP communication (Fast Ethernet or 802.11a/b/g/n).

5.2.2 There shall be provision of redundant communication channels.

Additional Control System Functions

5.3 Shutdown/Startup/Standby

The control system shall ensure orderly and safe shutdown, even in the absence of grid power; an orderly startup sequence, which shall provide for a safe system reset from any standby or operating condition so that the unit goes through a normal startup sequence in the same way it would when being powered up after loss of power or being in a shutdown state, and for a standby state (that is, BESS but not charging or discharging), which shall be the end result of a normal startup sequence.

5.4 Initiation of Shutdown

The control system shall initiate shutdown under the following conditions and shall remain in the shutdown state until a reset signal, either local or remote, is initiated. An appropriate alarm shall be set.

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

5.5 Reset Alarms

For all system-generated alarms, the control system shall provide for the resetting of those alarms. This function is intended for alarms that, after they are set (for example, by a fault condition, as listed above and elsewhere in this specification), must be cleared by operator intervention to allow normal operation to be restored.

5.6 Modify Storage Settings

The control system shall provide for modification of various set points and fixed operation/control settings associated with the various control functions.

5.7 Event/History Logging

The control system shall provide for the automatic logging of the following information:

- All errors or failures
- All startup and shutdown actions

- All control actions
- All responses to control actions
- All limit violations, including returns within limits

5.8 Status Reporting

The control system shall provide for reading and reporting of various BESS- supplied status information in accordance with the data collection and reporting requirements specified in this technical specification.

5.9 Time Synchronization

The control system shall provide for synchronization of its real-time clock with a GPS synchronized time source.

5.10 Change Operational Mode

The control functions are expected to be executed by command from a remote host, but may also be scheduled.

5.11 Perform Self Diagnostics

The control system shall provide for self-diagnostic functions.

5.12 Control System Hardware

All local control and monitoring system components shall be housed in appropriate controlled environment enclosures either as separate arrangement or in conjunction with Solar Plant SCADA system.

5.13 The BESS shall include, as a minimum, the following operator controls shall be provided in a local Control Panel or built into BESS EMS:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.
- Selector to select remote or local operation.
- Selector to manually set the operating state or have the control system set the operating state automatically.
- Meter readings, indicators, and displays.

Performance Monitoring and Data Acquisition

5.14 The BESS shall include a (Data Acquisition System) DAS to provide continuous monitoring and display of key operational parameters, as well as permanent archival of all measured parameters. The DAS shall include sensors, transducers, wiring, signal isolation and conditioning circuitry, and data acquisition and analysis hardware and software as required to perform the functions described in this section. The DAS shall be suitable for operation in the climatic conditions prevailing at site.

5.15 The DAS shall measure operational data, as described in this Clause, and shall record all data points to fixed and removable non-volatile memory. The DAS shall be capable of making all monitored data and events available through the DNP3 / IEC 61850 communication interface and shall permit display of current values and recent historical trends on a local screen for all recorded points. In addition, the DAS shall provide panel meter displays of certain operational parameters, as prescribed below.

5.16 Provision of monitoring and event data via the communication to capture at least the following data points:

- Frequency at the AC bus
- AC real power
- Power factor
- Real energy delivered
- Real energy received
- Auxiliary power
- Auxiliary energy
- DC power
- DC voltage
- DC current
- Phase A voltage
- Phase A angle
- Phase B voltage
- Phase B angle
- Phase C voltage
- Phase C angle
- Battery state of charge
- Battery string currents
- Battery temperature

5.17 Digital displays of the above shall update at least once per second. The DAS shall be integrated with the Solar PV SCADA described elsewhere in this Technical Specification either as addendum or within an overall Energy Management System Interface.

5.18 The DAS shall continuously measure or calculate the data points and make them available via the communication network as specified. All measured parameters shall also be permanently archived in all modes of operation. For continuously varying quantities, the Contractor shall propose for Employer's review and approval an approach to data archiving that is suitable for each quantity measured. The final approach will be decided during detailed engineering design.

5.19 The DAS shall provide unsolicited message capability for reporting critical alarms. The Contractor and the Employer will agree on a list of alarms that are reported the instant they are detected. However, a minimum of following parameters shall be displayed on BESS local control panel, console, or SCADA:

- Main temperature Alarm (on system temperature exceeding a predetermined threshold)
- Smoke/fire Alarm (on system detection of smoke/fire)
- DC leakage current (battery leakage current to ground exceeding a predetermined threshold)
- Breaker status (connect/disconnect switch)
- AC voltage OK (system ac voltage exceeding a predetermined threshold)
- Battery temperature alarm (battery temperature exceeding a predetermined threshold)
- Synchronization error shutdown
- PCS fault
- AC system fault
- DC fuse blown
- Container door open (BESS container door opening)

5.20 The BESS shall include provisions for determining and storing in non-volatile memory the sequence of abnormal events, trips, and/or alarms that cause the BESS to go the disconnect or shutdown state. It is preferable that this function be implemented separately from the normal operations data acquisition function of the DAS so that failures in the latter (hardware/software failures or power interruptions) will not prevent the permanent logging of abnormal event sequences. The BESS shall include provisions to transmit, at a minimum, the data displayed on the panel meters and the alarm/status indicators to the remote computer.

6 Grounding

All exposed non-current-carrying metal parts of the BESS shall be solidly grounded. This system shall be designed to be tied to an existing site grounding system. The system also shall be adequate for the detection and clearing of ground faults. Measures to mitigate galvanic corrosion shall be proposed, as required.

7 Wiring

7.1 All wiring shall be continuous for each wiring run; splices are not acceptable.

7.2 Wiring that may be exposed to mechanical damage shall be placed in conduit or armoured.

7.3 Wires shall have identifying labels or markings on both ends. The labels or markings shall be permanent and durable. Stick-on labels will not be allowed. All field wiring between separate equipment items supplied by the Contractor shall be color-coded according to appropriate standards.

7.4 In general and where practicable, control and instrumentation wiring shall be separated from power and high-voltage wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips within a common enclosure.

7.5 BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner. Wires shall be of sufficient length to preclude mechanical stress on terminals. Wiring around hinged panels or doors shall be extra flexible and shall include loops to prevent mechanical stress or fatigue on the wires.

7.6 Insulation and jackets shall be flame retardant and self-extinguishing.

7.7 Wiring to terminal blocks shall be arranged as marked on wiring diagrams. Terminal groupings shall be in accordance with external circuit requirements.

7.8 Raceway and cable systems shall not block access to equipment by personnel. There shall be no exposed current-carrying or voltage-bearing parts.

8 Fire Protection

8.1 The Contractor shall design and install a fire protection system that conforms to good engineering practice, CEA guidelines and considering thermal runaway fire characteristics of the Battery Unit/Packs provided by the OEM.

8.2 The fire protection system design and associated alarms shall take into account that the BESS will be unattended. If required by the type of fire protection system provided, the Contractor shall calculate and consider the heat content of the battery cell materials in designing an appropriate fire protection system. Separate fire protection systems may be used in the battery, PCS, and control areas.

9 Toxic Materials

If any toxic substance can be emitted from the equipment during a failure, fire, or emergency or protective operation, description of the toxic nature of the substances as well as treatment for exposure to it shall be included in the O&M manual. Their treatment and disposal shall be in accordance with the New Hazardous Waste Management Rules 2016 notified by the Government of India and subsequent amendments.

10 Spare Parts and Equipment

The Contractor shall evaluate the design with regard to expected failure rates, modes, and effects; overall BESS reliability; and planned mode of servicing. Based on this evaluation, the Contractor shall recommend and furnish an initial complement of spare parts that are not readily available. For example, these spare parts may include spare unit batteries and a small rectifier to maintain the unit batteries, as well as fuses, printed circuit boards, and minimum field replaceable switching devices.

11 Maintenance and Repair

11.1 The Contractor shall supply all labour, equipment, and materials needed to maintain the BESS performance and safe operation, including all maintenance required to satisfy the warranty terms and conditions.

11.2 The Contractor shall list all maintenance activities to be carried out under the maintenance contract. For each maintenance item, the list shall include a description of the item, the expected frequency (maintenance interval), the time required to perform the maintenance, any anticipated parts replacement, and any potential problems in carrying out the maintenance.

12 Factory Acceptance Testing of BESS

12.1 The Contractor shall develop and submit to the Employer for its review and approval a comprehensive FAT plan that shall demonstrate that the BESS will meet the requirements of the specification. The Employer shall have the right to request reasonable changes to the test plan.

12.2 Where full-scale testing of larger systems at the factory may be difficult or impossible due to the large system, the FAT shall be carried out at a subsystem or module level and shall consist of tests of 100% of the subsystems or modules that comprise the complete BESS, to the extent possible. In the FAT plan, the Contractor shall clearly state what is being tested and shall fully explain any features or functions of the fully assembled BESS that would not be fully tested in the reduced-scale testing proposed.

In such a case, the SAT plan shall further describe how the tests that could not be carried out in the factory will instead be carried out at the site.

12.3 After the Contractor determines that the BESS is fully operational, the Contractor shall conduct a FAT, witnessed by the Employer and/or the Employer's representative. The FAT shall consist of the Contractor demonstrating to the Employer that the BESS is fully operational and performs as specified. This includes but is not limited to the following:

- Visual inspection of all provided equipment, including dimensions and overall design.
- Verification of proper mechanical construction such as electrical connection torques.
- Verification of sensors, metering, and alarms.
- Verification of all control functions, including remote control and monitoring, and communications interfaces.
- Verification of BESS performance at full and partial power and energy ratings.
- Verification of maintenance and replacement features for unit batteries and other key components.
- Verification of compliance with specifications.

12.4 During the FAT, the BESS shall meet the following:

- Be operated and function as specified and designed in all the operating states, use cases, and duty cycles specified herein
- Meet the power and energy requirements specified herein
- Be demonstrated to meet the safety and response to catastrophic failure requirements specified herein
- Have the efficiencies, response capabilities, and other features specified herein and/or proposed by the Contractor

Note: *The methodology for measurement of procurement specifications is provided in the General Annexure-I to this Section.*

12.5 Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local (control console), and remote operation of the controls shall be demonstrated.

12.6 The Contractor shall perform any and all system modifications required during start-up and testing. The testing may be suspended as a result of a BESS malfunction and resumed only on rectification of problem items. Such suspension and resumption will occur at the sole discretion of the Employer.

12.7 The BESS will not be accepted for shipment until all FATs have been successfully completed. In addition, the Employer will verify that all provisions of the contract have been met, including verification of all required submittals, any spare parts delivery, and any required system modifications.

13 Commissioning and Functional Guarantee test procedure

13.1 The Contractor shall develop and submit to the Employer for its review and approval a comprehensive SAT plan that shall demonstrate to the Employer that the BESS will perform as specified at the Employer's site. The Employer shall have the right to request reasonable changes to the test plan.

13.2 The Contractor shall develop and perform SAT procedures to ensure that the BESS will perform as designed and that the system meets the performance criteria specified elsewhere in these specifications. The SAT plan shall include procedures to test operating scenarios described in the specification. These procedures may involve special requirements and/or witnessing by the local independent system operator. To the extent achievable, all use cases and operating modes described in the specification shall be tested.

13.3 After the Contractor has determined that the BESS is fully operational, the Contractor shall conduct the SAT, witnessed by the Employer and/or the Employer's representative. The tests shall include, as a minimum, the following:

- Verification of sensors, metering, and alarms
- Verification of all control functions, including automatic, local, and remote control
- Verification that the performance criteria in the specification can be met or exceeded
- Demonstration of all of the intended uses
- Demonstration of interface protection circuits and functions and control interfaces

13.4 Tests shall demonstrate that the BESS capabilities, efficiencies, response, and features are as proposed by the Contractor.

13.5 Testing shall include, as a minimum, measurement of harmonic content and power factor at full and partial power levels for both charge and discharge.

13.6 Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local, and remote operation shall be demonstrated.

13.7 The SAT shall also specifically address discovery of problems or failures that may have occurred during or as a result of shipment.

13.8 The Contractor shall perform any required modifications and repairs identified by the testing, before acceptance by the Employer.

13.9 The Employer will not accept the BESS for commissioning until all acceptance tests have been successfully completed and all provisions of the contract have been met.

13.10 Functional Guarantee - Actual Operating Experience

13.11 Since it may not be possible, due to system constraints, to test all facets of the BESS function as part of the performance verification tests specified in the preceding sections the actual operating experience of the BESS during the performance guarantee period after initial startup shall be deemed an extension of the performance verification tests. The performance guarantee period shall not be construed as a substitute for the warranty requirements, as specified in the subsequent Clause. Actual operating experience will be documented through Contractor-furnished records, and other system monitoring equipment and associated BESS performance. Documented failure or malfunctions of any BESS component during the performance guarantee period shall be deemed a failure of the system commissioning test. The Contractor shall, at no cost to the Employer, make the necessary repairs, replacements, modifications, or adjustments to prevent the same failure or malfunction from occurring again. The replacement of certain BESS components in response to a system failure may necessitate, at the discretion of the Employer, the duplication of certain performance verification tests, which shall be performed at the Contractor’s expense.

14 Warranty

14.1 The Contractor shall provide a warranty for the entire BESS and its constituent equipment.

14.2 At a minimum, the Contractor shall provide an unconditional, 5 (five) -year parts and labour warranty on all BESS equipment except battery (unit or racks). For the battery storage, the warranty shall cover parts warranty including battery nominal capacity ratings in order to meet the End of battery Life condition described in this specification.

14.3 Warranty replacement shall be required for individual unit batteries that degrade in performance to the point at which the BESS cannot meet the requirements specified in this specification up to the End of Battery Life and/or for unit batteries that materially degrade the availability, reliability, safety, or functionality of the BESS.

14.4 The warranty shall guarantee the availability of battery replacements delivered to the site within 2 weeks of notification during the battery warranty period. This period, shall, however, not be considered part of the Accountable Outage period for assessing BESS availability.

14.5 Additional warranty requirements are as follows:

- The warranty shall specify the terms and conditions of the warranty, including operating conditions requirements, procedures that must be followed, and all maintenance requirements.
- The warranty shall provide an explicit statement as to the warranted cycle life and the warranted calendar life of the battery.
- The warranty shall include a simple and easy to understand proration formula, if any, to be used in crediting the Employer for unused life or capacity of equipment replaced or repaired.
- The warranty shall specify the scope of service associated with software updates.
- The warranty shall specify the scope of service included in replacement or repair of the equipment.
- The warranty shall specify all labour, materials, shipping charges, and other Employer expenses not included in the warranty.

15 Documentation and Submittals

15.1 The Contractor shall furnish complete documentation that will be used for determination of contract compliance, as well as O&M of the BESS.

15.2 Review and acceptance of submittals shall not encumber the Employer or the Host Utility with responsibility for the adequacy or safety of the Contractor's design.

15.3 Titles shall clearly indicate the function of the document, the Employer and location of the facility.

15.4 At a minimum, Contractor's documentation shall consist of the following:

- Construction and installation drawings
- Equipment drawings and specifications
- Operation and maintenance manual
- Quality Assurance Plan
- Quality assurance manual
- Software documentation
- Test reports

C EMS (Energy Management System)

1 General Requirements

1.1 Energy Management System (EMS) system shall be a controller based system along with required accessories and communication links for integrated, real-time monitoring, efficient operation and control of active power, reactive power as well as voltage at the interconnection point of PV arrays and BESS.

1.2 EMS shall be integrated with the SCADA described under Part B: Electrical System to acquire/monitor real time data of various equipment of Plant facilities and have in built logic/programming to monitor, control, and optimize the performance of Plant facilities as per specification. Contractor shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire Plant facilities and its auxiliary systems. Contractor shall include in his proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in this specification.

2 EMS functionality for the BESS Control

The following operation modes of BESS can be set from the EMS system.

- Automatic mode: This means that a part of the power quantity of the BESS behaves according to the selected operation mode.
- HMI mode or manual mode: in this mode, the operator has the possibility to:
  - Select the operation point
  - Direct control of active and reactive set points of the PCS.
  - Command of the balance of plants
- OFF-mode: A BESS is not producing any power. The system is disconnected form the grid.
- STANDBY-mode: the BESS is connected to the grid, but the IGBT’s in the PCS system are in an off-state (i.e. open switching)

Also, the performance of every application mode will be controlled and adaptable by this system.

This energy management strategy will be operated by the SCADA in Main Control Room. Any failure in the process or the control system including instrumentation must be detected and logged. This means that the instrumentation, electronic and electrical equipment shall include those failure detections.

A communication with the SCADA system must be possible to receive set points and transmit set points for each application mode. The SCADA should be able to remotely control the BESS. The EMS should allow the SCADA at least the following:

- Change the operation mode of each BESS independently
- Start/Stop each application mode appointed to a BESS.
- Change the application mode of each BESS (multiple modes can be selected together)
- Select the amount of power dedicated to each selected application mode.
- Specifically, for following use cases:
    - Power ramp rate control
    - Power Curtailment
    - Change the set points for the SOC management
    - Direct control of active and reactive set point of a PCS
- Adapt the parameters needed for the operation of every application mode

The Communication protocol shall be MODBUS TCP. Other solutions can be proposed but are subjected to the approval of the client.

3 **EMS functionality for the Plant Control**

3.1 The EMS monitors grid and Plant facility variables and should be programmable for selecting the optimum-operating mode of the whole plant w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behaviour to the new settings.

The EMS shall perform following functionality to Control the Plant facilities.

- Communication with grid or SCADA
- Communications with PV Inverters, BESS and other power units
- Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)
- Control capability of PV Inverters, BESS and other power units

The EMS shall allow following operation modes for the Plant facilities.

- Reactive Control (Q Control, setting point of reactive power Q at EMS)
- Power Factor Control (PF Control, setting point of cos(L) at EMS)
- Voltage Control (V closed loop control, setting point of V at EMS)
- Voltage Droop (Reactive power vs Voltage programmable curve or droop)

- Apparent Power Control (S Lim, setting point of S Lim at EMS)
- Active Power Limitation (P Lim, setting point of P Lim at EMS)
- Power Ramp Rate Control (setting point of maximum %Pn/min)
- Frequency Regulation (Power vs Frequency programmable curve or droop)

3.2 In addition to these operating modes, the EMS shall be prepared to work under voltage dips, allowing the inverters to inject the corresponding reactive power to provide the corresponding voltage support at the EMS. The EMS can receive the target values specified by grid operators using a standard protocol (i.e. Modbus TCP/IP) and over different communication media

4 **Measurements**

The measurements at the PCC shall include, but not limited to:

- Voltage
- Current
- Output power (Active and Reactive)

4.1 Control & Power Supply Scheme

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

4.2 Software Documentation & Listings

All technical manuals, reference manuals, user's guide etc. in English required for modification/editing/addition/deletion of features in the software of the EMS System shall be furnished. The Contractor shall furnish a comprehensive list of all system/application software documentation after system organization for Employer's review and approval. All The software listings for application software, Project data files etc. shall be submitted by the Contractor. All the EMS Software with license Key shall be handed over to the Owner. All the hardware and software shall be licensed to SECI.

SECTION - VII

SUB-SECTION C

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

TABLE OF CONTENTS

1 General Requirement

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

1.2 This specification does not cover design of transmission line poles, towers, tower extensions and accessories. They shall be designed as per latest CTU/STU/DISCOM guidelines and relevant IS standards. Copies of released for construction (RFC) designs & drawings for transmission line poles, towers, tower extensions and accessories approved by CTU/STU/DISCOM shall be submitted to the employer for reference and record.

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

1.4 <u>Standards & Codes</u>

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

1.4.2 Design of steel structures shall conform to IS: 800, 801 or 802 as applicable. Ductile design and detailing as per IS 13920 shall be followed in concrete structures except in case of concrete support structure up to plinth level supporting open installations of inverter transformers, control panels at ICR/LCR etc. wherein the detailing shall conform to IS 456 and SP 34. For design of liquid retaining structure IS: 3370 shall be followed. Only in case of non-availability of Indian standard, equivalent American or British standard may be used for design with prior approval of the Engineer and the contractor shall submit proper justification for the same along with his request to the Engineer for review and approval, and the decision of the Engineer shall be final and binding.

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

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

1.4.5 As per project requirements, the Employer may ask for approval of all civil designs and drawings by IITs/NITs, the cost of which is included in the bid price.

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

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

2 Topographical Survey

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

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

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

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

2.5 The survey work shall be carried out in UTM grid system. The contractor shall also establish the latitudes and longitudes and UTM coordinates of all the corners of the project site. At least 50m width of the adjoining plots and surrounding areas shall also be covered in the survey for correlation with adjoining plots and facilities. The grids for the survey work shall be established in N-S & E-W direction (corresponding to Geographical North or Plant North) as directed by the Engineer.

2.6 Positions, both in plan and elevation, of all natural and artificial features in the area like waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably symbols of survey of India Maps). All hills and valleys within the area/areas are to be surveyed and plotted on maps by contours. Any unusual condition or formation on the ground, locations of rock outcrops (if visible on the surface) and springs/falls, sand heap/dune, possible aggregate deposits etc. shall also be noted and plotted on contour maps. The C/L coordinates of existing road & cross drainage (CD) works (culverts etc.) at intermediate points & at corners/ intersections and width of carriage way of the road shall be recorded with their position on the contour maps.

2.7 The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Engineer's review before submission of final contour map. The contour interval shall be as required for proper representation of the topography however it shall not be more than 0.5m. The Contractor shall submit survey maps of the site in 1:10,000 scale indicating grid lines and contour lines, demarcating all permanent features like roads, railways, waterways, buildings, power lines, natural streams, trees, sand dunes etc. Present use of the site i.e. mining, quarrying, agriculture etc., existing drainage pattern of the site, possibility of water logging and high flood level of the area shall also be captured in the document. The project plot boundary with coordinates of all corner points along with coordinate grid of 50m x 50m interval shall be marked on the contour map.

3 Geotechnical Investigations

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

3.2 The scope of work includes execution of complete soil exploration including boring and drilling with rotary drilling rig (DTH in case of rocky strata), standard penetration test (SPT), collecting disturbed (DS) and undisturbed samples (UDS), collecting ground water samples, trial pits, electrical resistivity tests (ERT), field & laboratory CBR tests, conducting laboratory tests on collected samples of soil & ground water and preparation and submission of report. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20% met within a borehole (BH). SPT test and UDS collection shall be alternately done at every 1.5m interval or at change of strata. The starting depth of SPT/UDS collection shall be 0.5m from ground level. For strata where UDS collection is not possible, SPT shall be done in place of UDS collection. The min. size of trial pit shall be 2.0m x 2.0m x 1.5m deep.

3.3 The field investigations shall mainly include drilling of min. 5 m deep BHs, conducting SPT and collecting Disturbed (DS) and Undisturbed samples (UDS), conducting in-situ CBR test for approach road to the plant, internal roads & peripheral road; Trial pits (TP) and Electrical resistivity tests (ERT). Number and location of BHs, California bearing ratio (CBR) tests, ERTs and TPs shall be decided as per the project layout, site topography and soil conditions in consultation with the Employer. The proposed locations shall fairly represent the total project site to get the complete required geotechnical information. There shall be minimum 1 no. of BH per 10 acres of the area, 1 no. (each) of Trial pit, CBR test, ERT & Ground water samples for laboratory investigations for every 25 acres of area. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient nos. (Note- In case the project plot is divided into number of discrete blocks (< 25 acres) separated from each other, there shall be min. 3 nos. of bore holes, 2 nos. of trial pits, 2 nos. of CBR test & ERT, 2 nos. of Ground water samples for laboratory investigations per such block.)

3.4 The proposed Geotechnical investigation plan indicating proposed locations of TPs, BHs, water sample collection points, CBR test & ERT shall be submitted to the Employer for review and approval before start of work.

3.5 Laboratory tests shall be conducted on DS & UDS samples and ground water samples in sufficient no. & shall include, Soil classification, Grain size analysis including Hydrometer analysis, determination of Bulk and dry density, Specific gravity, Natural moisture content, Atterberg limits, Tri-axial shear tests (Unconsolidated Undrained – UU) on UDS, Undrained shear test, Consolidation tests, Unconfined compression tests (UCS), Free swell index, chemical analysis of soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, Organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), permeability test (in-situ, to be conducted at a depth of 750 mm), Slake Durability etc. Laboratory CBR test on soaked samples shall also be conducted to ascertain the suitability of soil for sub-grade and requirement of any treatment of subgrade soil in case of CBR <2% as per IRC requirements.

3.6 After completion of field and laboratory work, the contractor shall submit a Geotechnical Investigation Report for Engineer's approval. All bore log details and lab test results shall be presented in the report as per provisions of relevant BIS standards indicating BH coordinates, Existing GL, Depth of water table, Method of drilling etc. The report shall include a Map showing the locations of various field tests including coordinates, calculations and recommendations for foundation type and safe bearing capacity (SBC) for various Plant buildings & Open installations (as applicable), Switch Yard structures & Sub-Station (as applicable), Transformer foundation, HT lines (as applicable), MMS foundation etc. corresponding to settlement of 25mm.

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

3.8 The report shall also include ground water analysis (water sample collected from bore well) to ascertain its suitability for construction purposes, recommendations for type of cement, grade of concrete & minimum cement content as per prevalent soil characteristics with respect to presence of aggressive chemicals and environment exposure conditions as per relevant BIS specifications. However, minimum grade of concrete shall be as specified under Clause No. 14 'Concrete Works'.

3.9 In case the contractor wishes to adopt concrete pile foundation for MMS supports the Geo-tech. report shall also include the calculations, based on soil properties, for safe pile capacity under direct compression, lateral load and pull out as per IS:2911. For piles in rock, the safe pile capacity shall be calculated as per IS:14593. For single pile, Lateral load capacity shall be min. of the values obtained as per IS:2911 & Brom's method corresponding to free pile head. The report shall also include recommendations about type of pile, its depth and dia. to be used.

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

3.9.2 The contractor shall carry out field trials for initial load test on pile to verify the pile design to confirm the safe load carrying capacity under direct compression, Lateral load and Pull out. The min. of the two values (design value as per soil characteristics & field test results) shall be adopted.

3.9.3 The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area and as per the provisions of IS 2911 Part 4. However, minimum 5 nos. of piles shall be tested {min. 3 nos. in each block (block size < 25 acre) and min. 5 nos. in each block (block size >25 acres) if the plant site is divided in discrete blocks separated from each other} under each category of load.

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

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

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

3.9.7 The contractor shall submit detailed methodology for conducting the tests in line with IS: 2911 (Part 4) for Engineer's approval before commencement of any test. For reference, the standard pile test procedures for compression & pull out and lateral load test given under General Annexure - F. After completion of these tests the contractor shall compile the test results and submit the report in a proper format as specified in the BIS standard with recommendations/ conclusions for Engineer's approval. The pile work shall start only after approval of the final pile design duly verified/ confirmed with initial load test results.

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

4 **Other Investigations**

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

4.2 The contractor shall carry out Shadow Analysis at proposed site and accordingly design strings and array layout with optimum use of space, material and man power. In case of large variations in topography (3^{o} to the horizontal) the study shall also include the effect of topographical variations on array layout and MMS structure design adequacy and stability. The contractor shall submit all the details/ design to the Engineer for review/ approval.

4.3 The contractor shall also identify potential quarry areas for coarse and fine aggregates to be used for concrete and shall carry out the concrete mix design for concrete grades to be used in construction of all concrete works (M25 and above) before start of construction. However, for piling M25 concrete with nominal mix of (1:1:2) may be used. For grades of concrete less than M25 to be used in PCC works, nominal mix as specified in IS:456 may be used. The concrete mix shall be designed for each source of cement and aggregates as per provisions of IS:10262 Standard and confirmed through 28 days compressive strength of concrete trial mix samples. Target mean strength of concrete for mix design shall be based on σ (standard deviation) = 5. The concrete mix design shall be carried out through NABL accredited laboratory or any Govt. agency approved by the Engineer. In case the contractor proposes to use RMC, the same shall conform to IS: 4926. The Contractor shall submit the Concrete mix design proposed to be used by the RMC for review and approval by the Employer. (Reports of periodic quality tests for the supply concrete batch shall be maintained by the RMC supplier as per approved Quality Plan and the same shall be submitted to the Employer for review and record).

5 Area Grading and Land Development

5.1 The Finished Grade Level (FGL) of the proposed plant shall be fixed with reference to the highest flood level (HFL) and surrounding ground profile at proposed site to avoid flooding of plant site. The data regarding HFL at proposed site shall be obtained from the metrological department by the contractor. In case of absence of this data, the contractor shall assess the required information through local site reconnaissance. The area at and around (up to 10m beyond external wall/ area including access road & parking whichever is minimum) all buildings/ plinth for open installations (MCR, ICR, etc.), transformer yard and switchyard shall be uniformly levelled at suitable RL (i.e. FGL) to be finalized considering topography and HFL at site. The minimum plinth level of all buildings/open installations shall be 450mm above FGL. Module mounting structure foundation/ Pile cap or any other pedestal shall be min. 150mm above FGL. Top of transformer foundation pedestal shall be min. 500mm above the FGL.

5.2 A detailed drawing for site levelling and grading (if envisaged) shall be submitted by the contractor before commencement of construction of all buildings, plinth for open installation, BESS yard, transformer/switchyard, Sub-station works. The levelling and grading drawing shall provide finished grade levels of different grading zones over original ground contours as background. All the coordinates of the grading zones shall be clearly mentioned on the drawing. The estimated volume of cutting and filling shall also be marked on the Grading drawings for reference. The final grade levels to be adopted for different blocks shall be clearly marked on the Plant Layout/ Array Layout drawing.

5.3 It is envisaged that the MMS are installed on natural/ existing ground without any levelling or grading of the area. Contractor shall accordingly consider the effect of the existing ground slope on the design of MMS structure as specified elsewhere in the specifications. If any ground undulations at column locations are observed the same shall be filled up with well compacted local soil matching the level of adjacent ground before start of erection of other MMS members.

5.4 The contractor is responsible for making the site ready and easily approachable by clearing bushes, felling of trees (mandatory permissions/ licenses/ statutory clearances from competent authorities if required for cutting of trees, blasting or mining operations, disposal of waste material etc. shall be obtained by the contractor), cutting, filling with selected excavated earth or borrowed earth including identifying borrow areas. Except in exceptional cases (with approval of the Engineer), filling shall be made up of cohesive non-swelling material. The filling for levelling/ reclaiming the ground/ area shall be done in layers not more than 150 mm 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 with provisions of slope protection (as necessary). In case of filling with rock material, the edges shall be provided in line with provisions of relevant BIS standard.

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

5.6 In case the filled up earth is brought from outside the plant or borrow areas (when the material inside plant area is not found suitable for grading work or if directed by the Engineer), the contractor shall carry out all required soil investigations to ascertain the suitability of the borrowed soil for land development and filling purposes. Contractor’s scope shall also include arranging land lease, getting all necessary statutory approvals for mining, payment of necessary challan etc. Excess earth, if any, shall be disposed of properly at location as directed by the Engineer.

6 Roads

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

6.2 The Approach road connecting nearest public road and the Main gate shall be of min. 4.0 m wide carriage way with 0.5 m wide shoulders on either side. The access road connecting Main gate and MCR, roads providing access to BESS switchyard and plant end substation and internal roads of BESS Switchyard and plant end substation shall be of min. 4.0 m wide carriage way with 0.5 m wide shoulders on either side. Internal service road(s) connecting MCR to various facilities/ buildings/ open Installations shall be of min. 3.0m wide carriage way with 0.5 m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL to avoid flooding of roads during rains. The roads shall be provided with alongside drains as per design requirements of drainage system for effective disposal of storm water and to avoid cross flow of storm water over the road. The roads shall be designed as per IRC SP-72 corresponding to traffic category T4 (10 HCV per day) and critical field CBR value of the subgrade.

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

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

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

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

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

(iv) Compacted subgrade: 300mm thick below sub-base (non-expansive soil with max. dry density > 1.65 kN/m^3) conforming to Cl 303 of MORD specs, compacted up to 98% of standard proctor density in layers of 150mm thickness. In case of expansive soils like black cotton soil suitable treatment as per Cl. 403 of MORD specs shall be provided before laying sub-base course.

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

6.4 Soaked CBR value of sub-grade shall not be less than 2%. Where the CBR of the subgrade is less than 2 % a capping layer of 100 mm thickness of material with a minimum CBR of 10 % is to be provided in addition to the sub-base required for CBR of 2 %. When the subgrade is silty or clayey soil and the annual rainfall of the area is more than 1000 mm, a drainage layer of 100 mm over the entire formation width should be provided conforming to the gradation given in Chapter 6 of IRC SP-20. This layer will form a part of the designed thickness of sub-base.

6.5 In case of no-availability of murrum in the nearby areas of the project site, suitable other screening/ blending material for WBM construction may be used conforming to provisions of IRC SP 20.

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

6.7 Drain, cable or any other crossing shall be provided with RCC box or precast concrete pipe culvert. The culvert design shall conform to relevant IRC standard. The pipes for road culverts shall be of minimum class NP3 conforming to IS 458 with min. soil cover of 750mm above the pipe. In case of soil cushion less than 750mm the pipe shall be provided with 100 mm thick M20 reinforced concrete encasement with 10 dia. reinforcement rods @ 150mm c/c both ways. However, the water supply pipe for module cleaning and service/ drinking water shall be routed through Medium class GI steel pipe of required dia. conforming to IS: 1161.

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

6.9 2.5m wide well compacted corridor shall be left along inside of the plant boundary suitably maintained clean of any vegetation and shall be provided with adequate illumination for movement of security personnel. Any undulations shall be made good with locally available coarse grained material to have fairly level passage way.

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

7 Surface/ Area drainage

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

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

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

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

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

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

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

7.8 Diversion boundary drain (as required based on topography) shall be provided along the higher elevation plant boundary edge to ward off the entry of outside runoff into the plant. Min. Drain size for diversion boundary drain shall be 500 mm (depth) x 500 mm (bottom width).

7.9 Existing drainage paths in the plant area shall be kept free of any installation. Road side drain shall be provided wherever required (for eg. where the drainage path is transverse to the road), to avoid flow of rain water over the roads. Culverts at these roads and Nalla crossings shall be provided.

7.10 For effective drainage, drains shall be provided along the road side for switchyard and BESS yard area.

7.11 For areas of grading, toe drain shall be provided along the bottom of the slope.

7.12 Min drain size shall be 300 mm (depth) x 300 mm (bottom width).

7.13 All trapezoidal drains shall have side slopes not steeper than 1:1. Unlined drains may be provided depending upon the geotechnical characteristics and drainage design in the view of the stability and erosion of drain walls. However, the drain segments near outfalls and drain crossings shall be lined. Thickness of the lining shall be minimum 115mm for brick masonry, 75mm for concrete slabs, 100mm for RR masonry and 50mm for stone slabs. The lining shall be in CM (1:4) and the joints shall be raked and pointed with CM (1:3), however the joints in lining of plant peripheral drain may be left without pointing.

7.14 In case of rectangular drain, the thickness of the wall shall be checked against structural stability under action of the design loads as specified in Cl. No. 10 'Design Loads'.

However, the min. wall thickness shall be 230mm, 300mm and 125mm respectively for brick masonry, RR masonry and RCC work, except for garland drain around buildings where the min. wall thickness can be 115mm, 200mm and 100mm respectively for brick masonry, RR masonry and RCC work.

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

7.16 The drain outfall shall be connected to the nearest existing natural drain(s)/ water body outside plant premises and it shall be ensured that the drainage water shall not re-enter the plant nor encroach/ flood in the adjacent property/ plot.

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

8 Peripheral Fence & Main Gate

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

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

9 Plant Layout

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

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

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

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

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

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

10 Design Loads

10.1 Unless otherwise specified elsewhere, Dead load, Live load, Wind load and Seismic load for buildings and structures shall be considered as per provisions of relevant BIS standards.

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

S. No.	Area	Imposed (Live) Load
1	Roof	1.50 kN/ Sqm – for accessible roof 0.75 kN/sqm – for inaccessible roof
2	Building floors (GF) & Grade Slab	10.00 kN/ Sqm
3	RCC Floors (General)	5.00 kN/ Sqm
4	Outdoor platforms, Stairs, Landing and Balconies, Walkway, Chequred plate & Grating (except cable trench cover)	5.00 kN/ Sqm
5	Road culverts & allied structures over drain & pipe crossings subjected to vehicular traffic	Design for Class – 'AA' loading (Wheeled & Tracked both) and check for Class – 'A' loading as per IRC Standard
6	Underground structures such as Sump, Pit, Trench, Drain, UG tank etc.	In addition to Earth pressure and Ground water table at FGL, a surcharge of 20 kN/Sqm (10 kN/Sqm for drains) shall also be considered. The structure shall be designed for following criteria – (a) Inside empty with outside fill+ surcharge and water table at GL & (b) Inside water with no fill & water table outside
7	Pre-cast and chequred plate cover over cable trench	4.00 kN/ Sqm
8	Roads	As per IRC SP 72 corresponding to vehicular traffic of T4 (10 HCV per day) and critical in-field CBR

10.3 Primary Loads

i) Dead Load (DL)

ii) Live Load (LL)

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

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

v) Snow Load (SnL) - To be considered as per the provisions of IS 875 (Part 4): 2021, Ground Snow Load, S_o = 2.05 kN/m^2.

vi) Temperature Load (TL)

- Maximum recorded temperature at Leh = 35^{0}C
- Minimum recorded temperature at Leh = -28.3^{0}C
- Reference Temperature at time of erection for temperature load calculation = 10 ^{o}C
- The structures shall be designed for a rise in temperature of 25 ^{o}C and for a fall in temperature of 38.3^{o}C.

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

10.5 To calculate the design wind speed (V_z), the factors k_1 (probability factor or risk coefficient), k_2 (terrain roughness and height factor) and k_3 (topography factor) shall be considered as per IS 875 (Part-3). However, minimum values for k_1 and k_2 shall be 0.89 and 1.0 respectively. Topography factor 'k_3' shall be taken as 1.15.

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

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

10.8 To account for reduced air density at the site, design wind pressure (pd) may be reduced by 20%.

10.9 The Seismic Load calculation and design shall be as per the following:

- Seismic Load is to be considered as per IS 1893 Part 4.
- Seismic Zone = IV, Zone Factor (Z) = 0.24
- Importance Factor, I = 1.5
- Response Reduction Factor, R = 3
- Ductile design and detailing as per IS 13920 shall be followed in all RCC framed structures.

10.10 Module Mounting Structure (additional requirements):

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

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

(ii) WLx (upward, C_p-), WLz (upward, C_p-)): Load due to negative pressure on design tilt angles of MMS members for wind acting in both (±X, ±Z) directions.

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

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

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

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

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

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

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

10.11 Design Load combinations

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

10.11.2 Permissible Stresses:

- In addition to various partial safety factors as prescribed by IS: 456, IS: 800, IS: 801 and IS 802, an additional factor of safety of 1.17 shall be applied to the characteristic strength of steel for all purposes of structural design. Accordingly, in other words, the term 'Fy' shall be replaced with '0.85Fy' while referring to IS: 456, IS: 800, IS: 801 and IS 802.
- For the design of the MMS & steel structures, no increase shall be allowed in permissible stresses except for combinations with Temperature load where it may be increased by 33%.

10.11.3 Following load combinations along with appropriate load factors shall be considered in design:

- For MMS Design (N-S orientation at design tilt angle):
  - i.) DL
  - ii.) DL + SnL
  - iii.) DL ± WLx (upward) ± WLx (member load)
  - iv.) DL ± WLx (downward) ± WLx (member load)
  - v.) DL ± WLz (upward) ± WLz (member load)
  - vi.) DL ± WLz (downward) ± WLz (member load)
  - vii.) DL ± Elx
  - viii.) DL ± Elz
  - ix.) DL ± TL
  - x.) DL + SnL ± WLx (upward) ± WLx (member load)
  - xi.) DL + SnL ± WLx (downward) ± WLx (member load)
  - xii.) DL + SnL ± WLz (upward) ± WLz (member load)
  - xiii.) DL + SnL ± WLz (downward) ± WLz (member load)
  - xiv.) DL + SnL ± Elx
  - xv.) DL + SnL ± Elz

xvi.) DL + SnL -TL

xvii.) DL ± TL ± WLx (upward) ± WLx (member load)

xviii.) DL ± TL ± WLx (downward) ± WLx (member load)

xix.) DL ± TL ± WLz (upward) ± WLz (member load)

xx.) DL ± TL ± WLz (downward) ± WLz (member load)

xxi.) DL ± TL ± Elx

xxii.) DL ± TL ± Elz

xxiii.) DL + SnL ± WLx (upward) ± WLx (member load) - TL

xxiv.) DL + SnL ± WLx (downward) ± WLx (member load) - TL

xxv.) DL + SnL ± WLz (upward) ± WLz (member load) - TL

xxvi.) DL + SnL ± WLz (downward) ± WLz (member load) - TL

xxvii.) DL + SnL ± Elx - TL

xxviii.) DL + SnL ± Elz - TL

- For RCC and Steel structures except MMS:

i.) DL

ii.) DL + LL

iii.) DL ± WLx

iv.) DL ± WLz

v.) DL ± ELx

vi.) DL ± ELz

vii.) DL ± TL

viii.) DL + LL ± WLx

ix.) DL + LL ± WLz

x.) DL + LL ± ELx

xi.) DL + LL ± ELz

xii.) DL + LL ± TL

xiii.) DL ± WLx ± TL

xiv.) DL ± WLz ± TL

xv.) DL ± ELx ± TL

xvi.) DL ± ELz ± TL

xvii.) DL + LL ± WLx ± TL

xviii.) DL + LL ± WLz ± TL

xix.) DL + LL ± ELx ± TL

xx.) DL + LL ± ELz ± TL

xxi.) DL + SnL

xxii.) DL + SnL ± WLx

xxiii.) DL + SnL ± WLz

xxiv.) DL + SnL ± ELx

xxv.) DL + SnL ± ELz

xxvi.) DL + SnL ± TL

xxvii.) DL + SnL ± WLx - TL

xxviii.) DL + SnL ± WLz - TL

xxix.) DL + SnL ± ELx - TL

xxx.) DL + SnL ± ELz – TL

Where, DL – Dead Load; LL – Live Load; WL – Wind Load; EL – Seismic Load; SnL – Snow Load; TL – Temperature Load

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

11 Foundations (General)

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

11.2 No foundation for MMS, buildings, switchyard equipment and structures, sub-stations, Transmission line towers, transformers, etc. shall rest on filled-up ground. However, minor structures like cable trench, cable rack, pipe pedestal, etc. may rest on filled-up soil with max. safe bearing capacity for design considerations not more than 3 T/Sqm.

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

11.4 All foundations of a building shall be founded at same RL (Reduced level) with respect to foundation depth below lowest NGL (Natural ground level) in the building area. The Levels shall be obtained with reference to the already established TBM using digital survey instrument such as Total Station/ Auto Level. The foundations of all buildings and plinths for open installation platforms shall be constructed after grading the area to the design FGL.

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

12 MMS Foundation

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

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

12.2.1 In case the contractor proposes to provide bored cast-in-situ concrete pile; the type, dia. and length of pile shall be as per recommendations of Geotechnical investigation report corresponding to prevalent soil characteristics at site. However, the min. dia and depth of the pile shall be 300mm (Min 350 mm for column depth more than 175 mm) and 1500 mm respectively except when very hard strata/ rock (N>100) is encountered at a higher level, the pile shall be extended in to the hard strata minimum 1.5 times the diameter of the pile with total depth of the pile not less than 1200mm below cut-off level. A minimum clear cover of 50 mm shall be provided to the steel section or reinforcement in the pile.

12.2.2 As specified above, the MMS support shall project minimum 150mm above FGL (Finished grade level) to avoid any damage to the MMS column/stub support. This shall be ensured through either single stage construction of entire pile length including portion above FGL or by two stage construction.

12.2.3 In two stage construction, for proper bonding, the surface of first stage concrete shall be made rough by trowelling and cleaning out laitance and cement slurry by using wire brush on the surface of joint immediately after initial setting of concrete. The prepared surface should be clean watered to get saturated dry condition when fresh concrete is placed against it. The prepared surface shall be applied with a suitable bonding agent before construction of pile projection above FGL.

12.2.4 In case the column post/stub is supported through base plate-anchor bolt assembly, the same shall only be provided through RCC pile cap to be designed as per provisions of relevant BIS standard with min. clear overhang of 75mm. The pile shall be embedded min. 50mm in the pile cap and the pile reinforcement shall be extended in to the pile cap for proper anchorage.

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

12.2.6 The design & installation of piles shall conform to IS: 2911 and IS:14593.

12.2.7 The bore shall be free from water before poring of pile concrete. For under water concreting tremie shall be used.

12.3 Helical/ Screw Pile

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

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

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

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

12.3.5 All materials shall be hot dip galvanized conforming to relevant BIS standard with min. thickness of galvanization 60 microns.

12.3.6 Wherever the pile shaft is required to be infilled with concrete grout, the same shall be of min. grade M30 (anti shrink).

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

(i) Sum of the areas of the helical bearing plates times the bearing capacity of the soil or rock comprising the bearing stratum.

(ii) Capacity determined from well-documented correlations with installation torque.

(iii) Load capacity determined from initial load tests.

(iv) Axial capacity of pile shaft.

(v) Axial capacity of pile shaft couplings.

(vi) Sum of the axial capacity of helical bearing plates affixed to pile.

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

50% of the total lateral load at which the lateral displacement increases to 12mm.

12.3.9 Dimensions of the central shaft and the number, size and thickness of helical bearing plates shall be sufficient to support the design loads.

12.3.10 The Design Report shall include following details.

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

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

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

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

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

12.3.14.1 Helical pile pre-production load testing

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

- Programme of the testing, detailing the timing and sequence of each load test including any additional investigations proposed
- The general arrangement of the equipment

- A method for measuring the displacement at the head and toe of each test pile
- Template for the Pile load test report
- Confirming the criteria for determining the acceptability of the compression, tension and lateral load tests
- A contingency plan in the event that a load test is deemed not acceptable
- A procedure for verifying the capacity for each individual pile, this may include correlating the installation torque for each pre-production pile with the load test results
- All pile load tests shall be supervised by suitably experienced personnel, who are competent to operate, monitor and record each test throughout its duration. Each pile load test shall be continuously monitored throughout its duration.

12.3.14.2 Helical Pile Construction

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

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

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

12.5 Unless specified else were, the field trials for initial load tests on concrete and helical/ screw pile shall conform to IS: 2911 (Part 4) & Practice Note-28 (IPENZ Engineers New Zealand) as applicable. The no. and location of such tests shall be as per the provisions stipulated under Cl. No. 3.9.3.

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

12.7 RCC Sleepers

12.7.1 RCC Sleepers shall be designed to withstand the loads coming from MMS and effectively transfer them to the ground. Sleepers shall counter the resultant uplift and lateral loads by its self-weight plus weight of the superstructure and modules while ensuring soil pressure at foundation level within safe bearing capacity under critical design load combination(s) ensuring required factor of safety as per IS 456: 2000.

12.7.2 The founding level (top of mud mat) of the sleeper at 350mm below the existing ground level (EGL). The sleeper shall be supported on PCC (1:3:6) mud mat of 100 mm thickness over a 300 mm layerof gravel with interstices filled with sand to ensure fairly sound base foundation.

12.7.3 The sleepers may be cast in situ or may also be shop manufactured (or at a properly established casting yard near the project site) with proper casting and curing facilities and shall conform to approved design and shall be transported to site for installation. Due care shall be taken during transport that there shall not be any damage to the sleeper units. Any sleeper observed to be damaged shall not be used.

13 Module Mounting Structure (MMS)

13.1 The top of the table on each canopy slope shall be in one plane.

13.2 The module mounting structure design shall generally follow the existing land profile.

13.3 In MMS analysis the column support shall be assumed at EGL/NGL.

13.4 In case of topographical variations more than 3^o, the contractor shall carry out detailed study of its effect on array layout, shadow analysis and structural stability of MMS.

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

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

- IS: 2062 – Hot rolled Medium and High tensile structural steel
- IS: 811 – Cold formed light gauge structural steel sections
- IS: 1161 – Steel tubes for structural purposes
- IS: 4923 – Hollow steel sections for structural use

- Structural steel shall be of grade designation E350 Quality 'C' conforming to IS 2062:2011.

13.7 The contractor can also propose extruded structural aluminium sections, which shall be of minimum class designation 64430 and 65032 conforming to IS: 733 with minimum thickness of 4 mm. The structural design using aluminium shall conform to IS: 8147.

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

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

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

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

13.10 In case of fundamental natural frequency (first mode frequency) of MMS structure is less than 5 Hz, the design of the MMS structure shall also be checked against dynamic effects of wind as per provisions of IS – 875 (Part-3) using gust factor method.

13.11 The purlins shall be provided with min. following tie/sag rods or angles or channels:

- 1 no., in the mid of each span and shall connect all the purlin members
- 1 no., diagonal, at each corner in end spans

Note: This requirement shall not be applicable for the modules provided with steel back rails.

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

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

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

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

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

13.17 The MMS structure shall be hot dip galvanized with zinc coating of 400 GSM and/or minimum thickness of 60 microns for protection against corrosion. Galvanization shall conform to IS-2629, 4759 & 4736 as applicable.

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

13.19 The bidder shall ensure that inner side of tube or hollow section is also provided with galvanization coating by proper dipping in hot zinc molten mass.

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

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

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

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

13.24 All fasteners for module mounting shall be of anti-theft type. All fasteners for MMS connections and fixing of PV Module shall be provided with min. (2 round + 1 spring) washers.

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

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

13.27 MMS column post supported with base plate secured to foundation shall be fixed with galvanized high strength "J" bolts conforming to specifications of IS: 4000/ IS: 1367 and relevant IS code. Installation of foundation bolts and embedment of column leg in foundation concrete shall be done by using template to ensure proper alignment. The underside of base plate shall be provided with anti- shrink grout.

13.28 In case the contractor proposes to extend the column leg to embed it in the pile/pedestal as an alternate fixing arrangement, the column member shall be extended for full depth of the pile (100mm cover at tip of the pile) with an end plate of min. 4mm thickness, projecting min. 50 mm beyond the face, to be welded at the bottom of column leg or an angle section of minimum 2mm thick to be bolted on either face of the column web at bottom end of the column (However, for plants in coastal area or in case of marshy soil the column post shall be supported only with base secured to foundation through base plate and anchor bolt assembly as per Cl. No. 13.27 and no embedment of column leg in foundation is permitted).

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

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

13.31 The Bidder should design the structure height considering highest flood level at the site and the finished grade level. The minimum clearance between the lower edge of the module and the finished grade shall be the higher of (i) Highest flood level + 100mm and (ii) 400 mm, as applicable.

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

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

13.34 The purlin splice shall be near the zone of contra-flexure, i.e. within a distance of 0.15L to 0.25L from the support, where L is the respective span within which splicing is located.

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

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

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

14 Concrete Works

14.1 Construction of all RCC works shall be done with approved design mix as per IS 456 and the materials used viz. Cement, coarse & fine aggregate, Reinforcement steel etc.

shall conform to relevant BIS standards.

14.2 The min. grade of concrete shall be M30 for all RCC works except piling works for which min. grade shall be M25.

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

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

14.5 Reinforcement steel shall comply with all of the following requirements:

- Elongation shall be at least 14.5 percent,
- Ratio of ultimate stress to 0.2 percent proof stress shall not exceed 1.25,
- Ratio of ultimate stress to 0.2 percent proof stress shall be at least 1.15, and
- Steel shall be only of strength grades with minimum 0.2 percent proof stress of 415 MPa, 500 MPa or 550 MPa, in addition to other requirements of IS 1786.

14.6 All pockets, block-outs, sleeves and the openings around the embedment, inserts, bolts etc. and under pinning below the base/sole plate shall be grouted. Grouting shall be with anti-shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound. The grout shall be high strength grout having min. characteristic strength of 35 N/mm^2 at 28 days.

14.7 MS Angles of minimum size 50 x 50 x 6 mm with 8 mm dia - 150mm long MS lugs @ 150mm c / c shall be provided for edge protection around all cutouts / openings in RCC floor slabs / walls, edges of drains supporting grating / pre-cast covers, edges of manhole supporting covers, around periphery of all removable pre-cast covers and any other place where breakage of corners of concrete is expected.

15 Miscellaneous Steel Works

15.1 Structural steel hot rolled sections, flats and plates shall conform IS: 2062. Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects. Structural steel shall be of tested quality and shall be Mild steel of Grade/Quality ‘C’ conforming to IS 2062:2011.

15.2 Structural Pipes shall be medium (M)/ high (H) grade conforming to IS: 1161, chequered plate shall conform to IS: 3502 and Hollow steel sections for structural purposes shall conform to IS: 4923. Pipes for hand rail shall conform to medium grade IS: 1161.

15.3 All gratings shall be pressure locked/ electro forged. Minimum thickness of the grating shall be 40mm. The opening size shall not be more than 30mm x 100mm.The minimum thickness of the main bearing bar shall be 3mm. All gratings shall be hot double dip galvanized at the rate of 400 g/Sqm.

15.4 Minimum 900 mm high hand railing shall be provided around all floor/ roof openings, projections/ balconies, platforms, walkways etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) conforming to IS: 1161 and shall be galvanized as per IS: 4736 and IS: 1239. All rungs and ladders shall also be galvanized unless otherwise specified. Minimum weight of galvanizing shall be 400 g/sqm.

16 Buildings and Plinth (Support Structure) for Open Installations

16.1 General Requirement

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

16.1.2 Unless otherwise specified elsewhere, all buildings and plinth (support structure) for open installations except Security room/ cabin shall have RCC framed structure. Masonry partition walls shall be provided for Kitchen, Pantry, Battery room and Toilet units. For other rooms, AL Glass partitions shall be provided. The size of the plinth (framed structure) for open installations and equipment area shall as per OEM requirements.

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

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

16.2 Functional requirements

16.2.1 MCR Buildings

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

- Air-conditioned area (with provision of split A/C unit of adequate capacity) for SCADA room (min. carpet area 32m2), Conference room (min. carpet area 32 m2) & Supervisor cabin (15 m2) and office area (min. carpet area 25 m2)
- Switchgear, equipment room(s) as per OEM requirements (can be in a separate building adjacent to the MCR)
- Tool room (12.5 m2)
- Store cum record room (min. carpet area 15 m2)
- Battery room as per requirement (can be in a separate building adjacent to the MCR)
- Toilet block with separate gents and ladies wash room facilities (min. total carpet area 12 m2)
- Pantry with service platform and utensil washing facilities (min. carpet area 5 m2)
- Suitable provision for passage (for smooth movement of O & M personnel), cable trenches, operating area etc. (min. clear width 1500mm)
- GI Ladder with hand rail - for roof access
- MCR Building shall be RCC Framed Structure. MCR building shall be provided with dual walled system along periphery comprising of outer and inner walls. There shall be a gap of min. 50 mm between outer and inner walls which shall be filled with rockwool for the purpose of insulation.
- MCR building may be provided with mono/dual slope gable roof system with adequate slope (Min 10 deg) and the ridge line aligned with the predominant wind direction to minimize snow accumulation.
- All entry and exit gates of MCR shall be provided with double door system with provision of air-lock.

16.2.2 LCR/ ICR

- Building for installing inverter and associated equipment shall be of PEB (Pre-engineered building) type or RCC framed structure. Equipment inside LCR/ICR shall generally comprise of data loggers, battery, inverter, electrical panels, etc. as per requirements and as per approved system drawings.

- There shall be suitable provision for easy/smooth passage of O&M personnel, cable trench, operating area, etc.
- In case, RCC framed structure is proposed for ICR/LCR, the requirements shall be same as applicable for the MCR building detailed under Cl. 16.2.1.
- PEB for ICR/LCR shall have RCC framed structure up to plinth level (equipment support level) with foundations, columns, beams and RCC grade slab (if applicable). PEB superstructure (above plinth) shall be as detailed under Cl. 40.
- When LCR/ICR and MCR building facilities are clubbed in one single building, the building shall be a RCC framed structure in line with MCR requirements. The Equipment area (inverter room) and Office cum Control room area shall be separated by a 345mm thick brick wall with provision of internal fire proof entry door. Building shall have separate main entry to office area.
- The size of inverter/HT panel area shall be provided as per system requirements.

16.2.3 Storage cabin for plant Spares

- Contractor shall provide storage cabin having area adequate for storage of plant spares including PV Modules, cables, MMS spares, etc.
- Storage cabin shall be of PEB (Pre-engineered building) type with RCC framed structure up to plinth level with foundations, columns, beams and RCC grade slab (if applicable).
- Structural members for the superstructure shall be as detailed under PEB specifications under Cl. 40.
- The walls and roof shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.45mm, Al-Zn alloy coating -150 GSM total on both sides). The insulation shall be of PUF with min. density 40 kg/ cum and min. 120 mm thickness. Roof shall be provided with suitable slope, not less than 10° to the horizontal (approx. 1V:6H) and shall project 300 mm beyond the walls. The make and (color) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.
- The doors and windows shall have AL frame with 5.5 THK hermetically sealed double glazing and 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. Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used for all connections.

- Doors shall be of adequate size to facilitate movement of O & M personnel and spares. There shall also be provision of Ramp and rolling shutter for the storage cabin.
- Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

16.2.4 Security Room

16.2.4.1 Contractor shall provide required number of pre-fabricated security room at strategic locations.

16.2.4.2 The Security room shall be of min. clear size 3m x 3m x 2.75m height.

16.2.4.3 Security room shall be a pre-engineered & pre-fabricated structure. The walls and roof of the building shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.45mm, Al-Zn alloy coating -150 GSM total on both sides). The insulation shall be of PUF with min. density 40 kg/ cum and min thickness of 120 mm. Roof shall be provided with suitable slope, not less than 10° to the horizontal (approx. 1V:6H) to minimize snow accumulation and shall project 300 mm beyond the walls. The make and (color) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.

16.2.4.4 The Main security room shall be provided with one Aluminum (AL) glazed door (0.75m wide x 2.1m height) on one face and AL glazed sliding windows (1.2m width x 1.0 m height) with AL grill on remaining three sides. All doors and windows shall be hermetically sealed and provided with 5.5 mm thick double glazing.

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

16.2.4.6 Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used for all connections.

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

16.2.4.8 The Security Room shall be supported on RCC framed structure with columns supported on foundations. The Finished Floor Level shall be 450mm high above FGL.

16.3 The Design and drawings of all buildings shall be submitted for approval prior to fabrication/construction and installation.

16.4 All buildings/PEBs shall be provided with facilities of heating system to maintain the temperature suitable for performance of equipment and comfort of occupants.

17 Flooring, Skirting and Dado

17.1 Store area, Equipment Area

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

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

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

17.3 Battery Area/Room

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

17.4 Toilet

- Min. 40 mm thick Ceramic tile (8mm thick) flooring and glazed tile (6mm thick) upto roof level.
- 20mm thick Granite stone finish over platform for wash basin.

17.5 Pantry

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

17.6 Passage/ Corridor

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

17.7 Steps

Granite stone (20 thick)

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

18 Doors and Windows

18.1 Doors and windows shall be made of UPVC frame and shall be of approved make & colour shade. The window and door shutters shall be 5.5 mm thick double glazed and hermetically sealed. The doors in toilet area shall be framed with solid core (MDF) flush shutter, 35mm thick, with laminated finish on both sides conforming to IS: 2202.

18.2 UPVC Louvers, duct/ ventilation openings shall be provided as per functional requirement.

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

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

18.5 Dual float glass (temperature resistant) for window and door shutter shall be of min 5.5 mm thickness respectively. Wired/ ground glass where provided shall be of min 6mm thickness.

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

18.7 Rolling shutters shall be of required size and shall be made of cold rolled steel strips with adequate gauge thickness (min. 18 gauge) and shall conform to IS 6248. Rolling shutter shall be provided with all fixture, accessories, paintings etc. all complete and shall be mechanically operated type.

19 Roofing

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

19.2 The water proofing treatment shall be in situ five course water proofing treatment with

APP (Atactic Polypropylene) modified Polymeric membrane over roof consisting of first coat of bitumen primer @ 0.40Kg per sqm, 2nd & 4th courses of bonding material @ 1.20 kg/sqm, which shall consist of blown type bitumen of grade 85/25 conforming to IS : 702, 3rd layer of roofing membrane APP modified Polymeric membrane 2.0 mm thick of 3.00 Kg/sqm weight consisting of five layers prefabricated with centre core as 100 micron HMHDPE film sandwiched on both sides with polymeric mix and the polymeric mix is protected on both sides with 20 micron HMHDPE film. The top most layer (5th layer) shall be finished with brick tiles of class designation 10 grouted with cement mortar 1:3 (1 cement: 3 fine sand) mixed with 2% integral water proofing compound by weight of cement over a 12 mm layer of cement mortar 1:3 (1 cement: 3 fine sand) and finished neat. The water proofing treatment shall be extended over golla/ fillet and inner face of the parapet up to 450mm height.

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

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

20 Plinth protection and drain

20.1 750mm wide plinth protection with min. 75mm thickness of PCC (1:3:6) over 75 mm thick bed of dry brick ballast, 40mm nominal size well rammed and consolidated and grouted with fine sand, shall be provided around all the buildings.

20.2 A peripheral drain (except for Security room/ cabin) of min. internal size 250mm x 250mm with brick walls in CM 1:6 over 75mm thick PCC (1:3:6) bedding with 12mm thick plaster in CM 1:5 and 25thk PCC (1:3:6) coping at top shall be provided along the periphery of the plinth protection for collection and disposal of rain water from building roof.

21 Plinth filling for buildings

Plinth beam, when provided, shall be taken minimum 200 mm below FGL. The plinth filling below Ground floor (GF) for all buildings shall be provided with following specifications.

(i) Well compacted sub-grade

(ii) Well compacted boulder soling with interstices filled with sand over compacted sub-grade (Min 300 THK)

(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)

For RCC grade slab arrangement, 100 mm thick PCC 1:2:4 shall be replaced with grade slab.

22 **Anti- termite Treatment**

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

23 **Plumbing & Sanitary Works**

23.1 Toilet block shall have following min. fittings:

- Wall mounted WC (Western type) 390 mm high with toilet paper roll holder, low height flushing tank and all fittings
- A set of 2 wall mounted Urinals (430 x 260 x 350 mm size) with flushing tank and all fittings (Gent's wash room only)
- Under top Wash basin (550 x 400 mm) over WPC cabinet and granite topping with all fittings including 2-pillar cocks (having provision of both hot & cold water)
- Wall mirror (600 x 450 x 6 mm thick clear float glass) with hard board backing
- CP brass towel rail (600 x 20 mm) with C.P. brass brackets – one each in common area and bathroom (bathroom if applicable)
- Soap holder and liquid soap dispenser one each in common area and bathroom (bathroom if applicable)
- Shower and mixer for hot and cold water in bathroom
- Ventilators – Mechanical exhaust facility of adequate capacity
- Overhead PVC water storage tank (to be provided with thermal insulation) – Capacity min. 1500 litres (common for both wash rooms)

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

23.3 Toilet room with provision of, water tank, WC, Wash basin and other necessary fittings shall be provided adjacent to Security Rooms.

23.4 Necessary plumbing lines with for MCR building and toilets near Security Rooms.

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

BIS standards.

24 **Painting & Other Finishes**

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

Internal Walls except toilets & battery room	Acrylic emulsion (for MCR) & Oil bound distemper (for LCR/ Security Room)
Battery room	Acid/ Alkali resistant tiled dado of 2100 mm height & Acid resistant resin-based epoxy paint above dado (Vitrified tile flooring and dado with oil bound distemper in case of maintenance free batteries)
Toilet	Oil bound distemper
External Walls	All weather proof cement based acrylic emulsion paint, exterior grade
MMS foundations/ Earth pit Enclosure	Cement paint
Underside of roof slab, Plinth (support structure) for open installation	White wash
Air-conditioned areas	Underside of roof slab- Under deck insulation with 50mm thick mineral wool, min. density 45 kg/ m3 and Gypsum board false ceiling with GI grid/ Gypsum tile (600x600 mm x 12 thick) false ceiling with AL grid as per manufacturer’s details
Structural steel work	2 coats of synthetic enamel paint over 2 coats of suitable primer

25 **Air conditioning & Ventilation for MCR and Other Buildings**

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

25.2 In MCR building, the supervisor room, Conference room and SCADA room shall have Hot and Cold type air conditioning units.

25.3 All buildings/PEBs shall be provided with facilities of heating system to maintain the temperature suitable for performance of equipment and comfort of occupants.

26 **Fire Extinguishers**

26.1 All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. Liquefied CO_2 / foam / DCP type fire extinguisher shall be upright type of capacity 9 kg conforming to IS 15683 / IS 2878.

26.2 The fire extinguisher shall be suitable for fighting fire of Oils, Solvents, Gases, Paints, Varnishes, Electrical Wiring, Live Machinery Fires, and all Flammable Liquid & Gas.

27 Sand buckets

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

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

28 Sign Boards and Danger Boards

28.1 The sign board containing brief description of major components of the power plant as well as the complete power plant in general shall be installed at appropriate locations of the power plant as approved by Engineer.

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

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

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

29 Masonry Work

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

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

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

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

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

29.6 All concrete blocks shall be of min. compressive strength of 7.5 N/mm^2 and shall be of Grade-A conforming to IS: 2185.

29.7 The laterite blocks shall conform to IS: 3620.

29.8 All buildings shall be provided with suitable damp-proof course (DPC). The DPC shall be with PCC (1:2:4) using 6 down coarse aggregate and water proofing admixture. The min. thickness of DPC shall be 40mm.

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

30 Plastering, Pointing & Coping Works

30.1 All brick masonry work shall be provided with plaster.

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

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

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

30.5 Exposed top surface of brick or stone masonry shall be provided with 25 mm thick plain cement concrete (PCC) coping (1:2:4) with trawl finish. All exposed coping shall be provided with suitable slope and projection for easy drainage of water.

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

31 Building Water Supply & Plumbing Works

31.1 C-PVC pipes (pre-insulated with 50 mm thick layer of polyurethane) shall be used for all internal building water supply works while all external water supply pipes shall be uPVC (pre-insulated with 50 mm thick layer of polyurethane) conforming to relevant BIS standard.

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

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

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

32 Sewage Treatment facility

The Contractor shall design & provide soak pit and septic tank for treatment of sewage and waste water from MCR building and Security room. The design of the septic tank shall conform to IS 2470 (Part 1). However, in case of ground water within 1.5m of finished grade level or the soil strata being of low permeability (permeability ≤ 10^{-6} m/s) where septic tank and soak pit arrangement is not effective, suitable packaged sewage treatment plant of reputed make/manufacture shall be provided. The sewage treatment facility shall be of required capacity and of proven design suitable for total of 15 people.

33 **Pipe & Cable Trenches**

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

33.2 The trench shall be designed for loads as specified under Cl 10 'Design Loads'. External trenches shall be kept min. 150 mm above FGL to avoid entry of rain water. In case of straight length of the trench being more than 40m, suitable expansion joints with PVC water stop shall be provided.

33.3 Internal trenches (inside buildings) shall be provided with chequered plate (min. 8mm thick with stiffening angle ISA 50x50x6 @ 750 mm c/c for trench width greater than 800 mm) covers while external trench(if provided) shall have precast concrete covers.

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

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

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

33.7 The trench bed shall have a slope of approx. 1(V):250(H) along and 1(V):50(H) across the length of the trench. The cable trench shall have a dewatering sump(s) of size 450x450x450 mm depth at suitable location to facilitate collection & pumping out of rain water from the trench.

33.8 The external buried cables shall be laid in excavated trench as specified under specifications for Electrical works.

34 **Transformer Yard Civil Works**

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

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

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

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

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

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

34.6.1 The fencing shall be of galvanized iron chain link mesh fabric with internal, corner and stay posts of hot dipped GI angle (min. ISA 65x65x6 mm). MS angle posts shall conform to IS 2062. The fence post shall have split end of length 150 mm, for proper anchorage in to the foundation concrete.

34.6.2 All GI posts shall be supported with min. 300 mm dia. and 850 mm deep (below GL) piles in M20 cement concrete (nominal mix 1:1.5:3). The pile shall project 150 mm above GL. The column posts shall be extended into the pile up to 950mm with 50mm cover at the bottom. The intermediate, corner and stay posts shall be supported by angle struts that shall have the same foundation as that of the main posts.

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

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

34.6.5 Each fence panel shall be provided with 35x35x3 mm GI edge angle at top and bottom with mesh fabric firmly secured to them and to intermediate support angles.

34.6.6 All MS sections shall be painted with 2 coats of epoxy paint of approved make and shade over 2 coats of zinc chromate primer.

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

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

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

34.7 The requirement of fire barrier wall between transformers shall be as per Electricity Rules and IS: 1646 recommendations. Minimum wall thickness shall be 230mm for RCC wall and 300mm for masonry wall.

35 PV Module Cleaning System

35.1 Cleaning of photovoltaic modules shall be done at least once in 2 week or at closer frequency as per the soiling conditions prevailing at site, in order to operate the plant at its guaranteed plant performance.

35.2 Wet Cleaning System

35.2.1 For Cleaning of PV Modules, the Contractor shall arrange for Water tankers with pumps and spray arms on either side to sprinkle the water.

35.2.2 Water quality parameters including TDS, pH, hardness, chlorides, temperature, etc. shall be as per the OEM recommendations to maintain PV module warranty conditions.

35.2.3 Water pressure requirements shall also be as per the OEM recommendations to maintain PV module warranty conditions.

35.3 Dry Cleaning System

35.3.1 The dry cleaning system shall be with microfiber or polymer based brushes.

35.3.2 Module cleaning kit/tools shall be non-abrasive to module surface and as per the OEM recommendations to maintain PV module warranty conditions.

36 Underground Liquid Retaining RCC Structures

36.1 The top of the UG tank shall be 250 mm above FGL.

36.2 The tank shall have clear free board of 300mm above MWL.

36.3 The tank bottom shall have a slope of 1:100 towards drainage sump (500x500x500 mm deep). The slope shall be provided either in structural slab or in screed concrete (1:2:4) trawl finished. 1000x1000 mm size Manhole in roof slab and 20 mm MS rung ladder shall be provided for easy access to the storage tank and silting chamber for periodic cleaning. The manhole shall be covered with RCC precast cover. 50x50x6 mm MS angle with lugs shall be provided around precast cover and tank slab opening for edge protection. Rungs shall be painted with 2 coats of epoxy paint over 2 coats of primer.

36.4 The underground RCC tank shall be designed for following load conditions:

- External earth pressure + hydrostatic pressure due to ground water table (to be considered at FGL for design purposes) + Surcharge of 20 kN/Sqm and Tank Empty.
- Tank full up to MWL and no external loads

36.5 The design shall conform to IS: 3370 with maximum crack width of 0.1mm for wall, bottom slab and roof slab. Min. grade of concrete shall be M30 (M35 in coastal areas, marshy and saturated soils) conforming to IS: 456. Suitable construction joints shall be provided as per provisions of IS: 3370 (Part 1). Water proofing admixture conforming to relevant BIS standard and of approved make shall be added to concrete as per manufacturer’s recommendations.

36.6 The underground water tank shall be tested for water tightness as per the provisions of IS 3370 (Part-4). In case any leakage is noticed the same shall be repaired by injection of cement grout installing suitable nozzles around affected areas. Outside face of water tank in contact with water and soil and underside of roof slab shall be painted with 2 coats of epoxy paint

36.7 For the purpose of insulation, min. 30 mm thick polyurethane boards shall be provided around the walls of the water tank.

37 In-plant Sub-Station/ Switch-Yard Civil Works

37.1 The specifications cover levelling and grading, construction of all sub-station/ switchyard structures and facilities including gantry towers & beams, lightning mast, equipment supporting structures, transformer foundations including oil pit, rail track, fire wall, cable trenches, roads, culvert, drains, sewers, water supply, fencing with gates, gravel filling & anti-weed treatment etc. and other related works in switch yard area as per the scope.

37.2 Gantry towers & beams, lightning mast, equipment supporting structures

37.2.1 Gantry towers and beams, equipment support structures shall be latticed steel structures. Height & type of towers and beams shall be established based on electrical requirements.

37.2.2 Loads and Loading Conditions:

Switchyard structures shall be designed for the worst combinations of following loads. Structures shall be checked for safe design under Reliability (normal) and Security (short circuit) conditions:

- Dead loads (load of wires/conductors, insulator, electrical equipment and structural members)
- Imposed loads – These are vertical loads. Load of 1500 N considered acting at each cross arm, as a provision of weight of lineman with tools. Load of 3500 N considered acting at the tip of cross arms up to 220 kV and 5000 N for 400 kV and higher voltage for design of cross arms. All bracing and redundant members of the towers which are horizontal or inclined up to 15° from horizontal shall be designed to withstand ultimate vertical loads of 1500 N considered acting at centre independent of all other loads.
- Wind load on bus bars, shield wires, insulator strings, electrical equipment, structural members, etc.
- Seismic loads
- Conductor sag tension
- Loads due to line deviation (gantries shall be checked for ± 30^0 deviation in horizontal plane and ± 30^0 deviation in vertical plane.
- Temperature effects
- Erection loads – Erection loads at lifting points for 400 kV and higher voltage shall be taken as per Cl. No. 12.2.3 (d) of IS:802-part 1 (section-1)
- Short circuit forces including snap in case of bundled conductors, etc.

37.2.3 Wind load on Gantry structure (tower and beam), equipment, conductor, ground wire and insulator strings shall be calculated as per IS:802-part 4, IS:802-part 1 (section-1). Terrain roughness coefficient k_2 in calculation of design wind speed V_d shall be min. 1.0 (terrain category 2). However, for site with hills/ ridges the value of k_2 shall be taken as 1.08 corresponding to the next higher value (k_2 corresponding to terrain category 1).

37.2.4 Temperature effects shall be considered as per IS:802-part 4.

- The average everyday temperature shall be 32°C anywhere in the country, except in regions experiencing minimum temperature of –5°C or lower, where everyday temperature may be taken as 15°C or as specified elsewhere.
- The beam/column may generally be designed to suit the conductor temperature of 85°C (Max) for Aluminium Conductor Steel Reinforced (ACSR) and 95°C for All Aluminium Alloy Conductor (AAAC). The maximum temperature of ground wire exposed to sun may be taken as 53°C. If the new generation conductors such as AL-59, Aluminium Conductor Steel Supported (ACSS) Trapezoid Wire (TW), gap conductor, Aluminium Composite Core Conductor (ACCC) etc, are deployed, maximum allowable temperature of the conductor based on the permissible/designed ampacity, shall be considered.
- The minimum every day and maximum temperature of the conductors shall be as per electrical considerations.

37.2.5 Sag tension calculation for conductor and ground wire shall be made in accordance with the relevant provisions of IS 5613 (Part 2/Sec 1) for the following conditions:

(a) 100 percent design wind pressure at everyday temperature or 36 percent design wind pressure at minimum temperature after accounting for drag co-efficient and gust response factor (design wind pressure = $P_d * C_{dc} * G_c$).

(b) The values of sag and tension on conductor shall be corrected to account for the weight tension and wind effect on the droppers.

(c) Effect of insulator weight, spacer weight, dropper weight and weight of other hardware to be considered suitably in the sag tension calculations.

37.2.6 Transverse loads due to line deviation shall be the component of 100 percent mechanical tension of conductor and ground wire/OPGW.

37.2.7 The mechanical tension of conductor/ground wire is the tension corresponding to (a) 100 percent of design wind pressure at everyday temperature or (b) 36 percent of design pressure at minimum temperature after accounting for drag co-efficient and gust response factor. Mechanical tension shall be considered as a longitudinal load for reliability condition and security condition.

37.2.8 Design load cases, load combinations and design criteria for gantry structure (beam and column/tower) and equipment support structures shall be as per IS:802-part 4.

37.2.9 Following factor of safety/overload factor shall be provided in the design of members:

- *Normal Condition (Reliability Condition)* — In normal condition, factor of safety/overload factor shall be taken as 2.0 in the design of members and the bolts.
- *Short Circuit Condition (Security Condition)* — In short circuit condition, factor of safety/overload factor shall be taken as 1.5 in the design of members and bolts.

37.2.10 The equipment support structures shall be designed for the weight of the equipment, self-weight of the structure, tensions of strung conductor, wind on strung conductor or pipe, wind on equipment and the support structure. Short circuit forces shall also be considered as acting on the equipment and getting it transferred to the structure along the strung conductor or pipe.

37.2.11 Other structures like, lightning mast, lighting mast watch and ward towers etc. shall be designed for wind loads and self–weight.

37.2.12 Special design considerations for equipment support structures:

- The supporting structure for B.P.I., LA, CVT and Isolator equipment shall be comprised of GI (ERW) pipe of grade YST:210 or of higher grade conforming to IS: 1161 & shall be designed as per IS:806. Minimum diameter of the pipe type support for structures shall be 200NB.For higher voltage levels, relevant standard shall be followed.
- The supporting structure for CT equipment shall be comprised of lattice structural steel conforming to IS 2026 and shall be designed as per IS: 802.
- Common raft foundation shall be provided for each pole of isolator.

37.2.13 Special design considerations for Lightning mast (as applicable):

Diagonal wind condition shall be considered for Lightning Mast. Diagonal wind shall be taken as 1.2 times the wind calculated on longitudinal/transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and an internal ladder for climbing purpose shall be provided up to the platforms. Top of platform shall have grating, railing and two guard plates. The minimum width of platform shall be 900mm. Live load of 300kg/m2 above platforms shall be considered for design of Lightning Mast. The fabrication and erection of the switchyard works shall be carried out generally in accordance with IS: 802 and IS: 800. All materials shall be completely shop fabricated and galvanized.

37.2.14 Materials:

- Gantry structure, which consists of open web towers connected by girders, shall be made of structural steel conforming to Grade IS:2062 or IS: 8500 and duly galvanized conforming to IS: 2629 and IS: 4759.

- Minimum thickness of Leg members, ground wire peak members and lower members of cross arms in compression shall be 5 mm and min thickness of gusset plates shall be 6 mm. Minimum section thickness for other members shall be 4 mm.
- All joints shall be bolted connections.
- All bolts for connections shall be of 16mm dia. conforming to IS: 12427, property class 5.6 as specified in IS: 1367 (Part 3). Nuts shall conform to I.S 14394 (Part 3) of property class 5. Foundation bolts shall conform to IS: 5624, property class 4.6 as specified in IS: 1367 (Part 3).
- Butt splice shall be used for splicing the main members and splice shall be located away from the node point.
- Washers shall conform to IS 2016 with thickness as required based on connection details. Spring washers shall conform to type B of IS 3063. Heavy washers shall conform to IS 6610.
- Washers to be used with high strength bolts and nuts shall conform to IS 6649.
- All gratings shall be blast cleaned to Sa 2½ finish of Swedish standard SIS–05-5900 and shall be hot dip galvanised at the rate of 400 GSM.
- All handrails and ladders shall be galvanised at the rate of 400 GSM as per IS: 4736.
- Other material used in the construction of switch yard structures shall conform to appropriate Indian Standards, wherever available.

37.2.15 Galvanization:

- All steel sed in construction of switchyard structures such as Towers & Beams, Lightning mast and equipment supporting structures shall be galvanized in accordance with the provisions of IS 4759. Weight of zinc coating shall be at least 0.400 kg/m2 and foundation bolts shall have heavier zinc coating of at least 0.610 kg/m2.
- Threaded fasteners shall be galvanized to conform to the requirements of IS 1367 (Part 13).
- Spring washers shall be electro galvanized as per grade B of IS 1573 as and plain washers shall be hot dip galvanized as per service Grade 4 of IS 4759 or electro galvanized as per service Grade 3 of IS 1573.

37.3 Tie-Transformer/ power transformer foundations:

Foundations of transformer shall be designed for Equipment, seismic and wind loads. Block foundations shall be provided for the main transformer block. Oil soak pit shall be provided around the transformer to prevent spillage of oil from transformer onto the ground. The oil soak pit shall be filled with gravel of size 40 mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer along with 10 minutes of fire water considering only 40% of the volume as available voids between gravel filling. However, in case a separate oil collection pit (burnt oil pit) is provided for the transformer, the minimum volume of oil soak pit around transformer shall be provided as one-third of the oil volume of transformer. The oil collection pit (burnt oil pit) in such cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. Free space of 250mm height above gravel fill shall be provided in the soak pit. This free volume above the gravel free shall not be considered in effective capacity calculations. In capacity calculations for oil collection pit (burnt oil pit) the volume below the invert level (IL) of inlet pipe shall be considered, the inlet pipe shall be laid with adequate slope to avoid back flow of oil to the transformer soak pit. In oil collection pit, a min. free board of 300 mm shall be provided over IL of the inlet pipe. The transformer oil soak pit and oil collection pit (burnt oil pit) shall also be provided with a sump (min. 500x500x500mm) at the corner to allow disposal of water/oil from the soak pit. A rung ladder with 20 dia. MS rungs (painted with 2 coats of epoxy paint over 2 coats suitable primer) shall be provided in the oil collection pit.

Arrangement for moving the transformer in place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer foundations.

Fire protection wall shall also be provided between the transformers wherever required as per relevant standards and statutory requirements. The height and thickness of fire protection wall between transformers shall be as per system and statutory requirements Fire wall shall be provided with an independent foundation.

300 mm thick PCC M20 (1:1-1/2:3) encasement all around the pylon supports for firefighting system shall be carried out up to top of gravel filling. Supply and erection of complete fire-fighting system including pylon supports with anchor fasteners for HVW / N2 spray system shall be as defined under scope of work.

Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

37.4 Gravel filling:

Gravel filling shall be provided in the switchyard extension area inside the fence as indicated in the tender drawing with broken stone filling which shall consist of two layers. The first layer shall be 75mm thick base course of 20mm of normal size and second layer shall be 75mm thick surface course of 40mm nominal size. Each layer shall be compacted by using half ton roller with 4-5 passes and suitable water sprinkling. Before laying the gravel/stone fill, the top layer of the soil shall be treated for anti-weed considering the type of weeds found in the vicinity. The anti-weed - soil sterilization details such as manufacturer's name, their specification, test certificate, etc. shall be furnished for Owner's approval. Any modification if required in the proposed anti-weed treatment chemical shall have to be done by the contractor at no extra cost to the Owner. The contractor shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall be commenced from the date of completion of work or date of handing over, whichever is later.

37.5 Cable trenches:

RCC cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 250 mm above the finished grade level (FGL) so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits. Heavy duty precast RCC covers with 20 dia. MS lifting hooks shall be provided over the cable trench. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. The design and other requirements of the cable trench shall be as specified under Cl. No. 33.

37.6 Switch yard storm water drains:

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

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

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

37.7 Switch yard roads:

Internal service roads shall be provided in the switch yard as required and per the approved layout. The road shall be of 4.5 m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL to avoid flooding of roads during rains and shall be provided with alongside drains as per design requirements of drainage system for effective disposal of storm water and to avoid cross flow of storm water over the road. The design and other requirements of roads shall be a specified under Cl. No. 6.

37.8 Chain link fencing:

The entire switch yard area shall be provided with chain link fencing with main gate(s) and wicket gate(s) as per approved layout. The design and details shall be as specified under Cl. No. 34.6.

37.9 Switch yard control building and other buildings shall be provided as required as per approved building layout. The buildings shall be of RCC framed structure. The design and details including finishing items and construction of all the buildings shall be as specified under relevant clauses of this specification.

37.10 Duct banks consisting of PVC conduits for cables shall be provided with proper sealing arrangement consisting of fire-retardant sealing compound.

37.11 Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.

37.12 Design, construction and joints of all the structures shall be as per relevant Indian Standard Codes unless specified otherwise.

37.13 All foundation embedment, inserts, block-outs required for mounting of equipment and supporting any other facility like pipes etc. shall be provided.

37.14 All cable trenches shall be provided with suitable MS insert plates for fixing support angles of cable trays.

37.15 Broad gauge rail (52kg/m minimum) shall be used for rail tracks required for movement of Transformer.

38 Miscellaneous structure

38.1 Support structure for weather monitoring device

38.1.1 Weather monitoring device shall be mounted on tubular steel pole of required height. The pole shall conform to IS: 2713.

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

38.1.3 The support structure shall be hot dip galvanized.

38.2 Support structures for SCB/String Inverter

38.2.1 SCB/String Inverter shall be mounted on a structural steel supporting frame comprising of ISMC columns at both ends, horizontal framing members and members for cable support. Minimum size for column members shall be ISMC 75.

38.2.2 Column post shall be supported on Pile with 300 mm (min.) diameter and 850 mm (min.) deep below ground. The column post shall be extended into the pile maintaining 50mm cover at the bottom. Alternatively, isolated footing can also be provided.

38.2.3 The pile/foundation shall project 150 mm above GL.

38.2.4 The support structure shall be hot-dip galvanized and of adequate height to ensure min. ground clearance of 800 mm to SCB/String Inverter unit.

38.3 LA Mast and Foundation (Other than Sub-station)

38.3.1 LA Mast shall be self-supporting structure with GI tubular pole of required height. The pole shall conform to IS 2713.

38.3.2 The pole shall be supported on RCC pedestal and foundation structure through base plate and anchor bolt assembly.

38.3.3 The support structure shall be hot-dip galvanized. Minimum depth of foundations shall be 1200 mm below GL.

39 BESS Yard Civil Works

39.1 The specifications cover levelling and grading, construction of all structures and facilities including BESS container support structure, equipment supporting structures, transformer foundations including oil pit, rail track, fire wall, cable trenches, roads, culvert, drains, sewers, water supply, fencing with gates, gravel filling & anti-weed treatment etc. and other related works in BESS yard area as per the scope.

39.2 Grading and levelling shall be carried out in line with Cl. No. 5: Area Grading & Land Development.

39.3 BESS container shall be supported on RCC framed structure with plinth and shallow foundations. Support structure shall be in line with the OEM requirements.

39.4 BESS PCS and associated equipment shall be installed in buildings with specifications as applicable for ICR/LCR (Cl. No. 16.2.2).

39.5 BESS Transformer Area:

Design and other requirement for BESS transformer foundation, Soak Pit, Burnt Oil Tank, etc. shall be as per Cl. No. 34: Transformer yard Civil Works.

39.6 BESS yard storm water drains:

Design and other requirements of BESS yard drainage system shall be as specified under Cl. No. 7: Surface/ Area drainage.

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

39.7 BESS yard roads:

Roads shall be provided in the BESS yard as required and as per the approved layout. The road shall be of 4.0 m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL. The design and other requirements of roads shall be a specified under Cl. No. 6: Roads.

Area between the BESS containers envisaged for forklift/equipment movement shall be provided with 150 THK PCC (1:1.5:3) course to be laid over well compacted subgrade.

39.8 Chain link fencing:

The entire BESS yard area shall be provided with chain link fencing with main gate(s) and wicket gate(s) as per approved layout. The design and details shall be as specified under Cl. No. 34.6. Separate fencing is not envisaged for BESS transformers.

40 Pre-Engineered Building (PEB)

40.1 General:

The PEB shall be made of structural steel construction with double skinned metal roofing and wall cladding of appropriate profile. PEB shall be complete with painting, metal fascia, metal gutter, rain water down comers, sun-shades, openings, etc., along with associated structural steel, cladding and roofing work insulation, trims & flashings, etc. Each item of PEB like panels, masonry, plastering, flooring, foundation, fittings etc. shall be suitable for complete life of solar plant.

40.2 Design parameters and design loads shall be as per Cl. 10: Design Loads. Limiting deflections shall be as per IS 800.

40.3 Structure and material specification:

Component	Description	Reference Standard
Primary Structural Members: including the transverse rigid frames, columns, corner columns, end wall wind columns, beams, truss member, base pate.	Steel frame members with minimum thickness 4 mm with minimum yield strength of 350 MPa	IS 2062 min Grade E350 Quality C
Secondary Members: including the purlins, Girts, eave struts, bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings, sag rods to be reckoned while designing the structure.	Minimum thickness 3.15 mm. Secondary members for purlins and Girts shall have minimum yield strength of 350 MPa. Miscellaneous secondary members shall have minimum yield strength of 250 MPa.	IS 2062: Quality C
Other Details:		
Paint and Coating	The structural steel shall be hot-dipped galvanized (Min 400 GSM), conforming to IS: 4759 or relevant Indian standard. Cladding sheet steel shall be colour coated with total coating thickness of 25 microns (nominal) dry film thickness (DFT) comprising of silicon modified polyester (SMP with silicon content of 30% to 50 %) paint or Super Durable Polyester (XRW) paint of 20 microns (nominal) on one side (exposed face) over 5 micron (nominal) primer coat and 10 microns (nominal) SMP or Super Durable Polyester paint over 5 micron (nominal) primer coat on other side. SMP and polyester paints system shall conform to Product type 4 as per AS/ANZ 2728.	
Rolling shutter	Shall conform to IS: 6248.	
Wall & Roof Cladding	Unless specified otherwise, Insulated wall cladding or roofing shall consist of double skin metal cladding with	

	Poly Urethane Foam (PUF). PUF must be made of continuous method PU foam and must be CFC free, self-extinguishing, fire retardant type with density 40+/-2 kg/m3 and thermal conductivity 0.019-2.2 W/ (m.K) at 10°C. The PUF panels shall be a factory made item ready for installation at site.
Roof Insulation and detail	Both metal sheets shall have an under insulation of minimum 150 mm thick PUF with gutters and down take pipes along with Flashing & Top cap of required size and colour complete with all necessary hardware. Roof shall be projected at-least 300 mm from the wall. Both upper and lower sheets shall be separated through spacers and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations. Contractor may also alternatively make the PEB roofing with composite slab (RCC slab with permanent formwork). The composite slab scheme, design and drawings shall be subject to approval from Employer/Owner before start of work.
Wall Insulation and detail	Unless specified otherwise, all voids of external and internal metalled walls shall have an under insulation of minimum 120 mm thick PUF with proper supports etc. as approved. Both the walls should be separated by spacers system made up of steel and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations.

40.4 PEB shall be provided with suitable bracing system including roof (plan) and vertical bracings.

SUB-SECTION D

GENERAL ANNEXURE A

Equipment Category

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

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

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

S. No.	Equipment Code	Equipment
Category – A		
1.	PCU	Power Conditioning Unit
2.	ITR	Inverter Transformer
3.	HTP	HT Switchgear Panel
4.	PTR	Power Transformer
5.	CRP	Control & Relay Panel
6.	MMS	Module Mounting Structure[#]
7.	SCADA	SCADA
8.	BESS-ACC	Battery Modules/Racks[##]
9.	BESS-PCS	BESS Bi-directional Power Conditioning System
10.	BESS-TR	BESS Transformer
11.	BESS-EMS	BESS Energy Management System
Category – B		

1.	SMU	String Monitoring Unit
2.	ATR	Auxiliary Transformer
3.	SC	Solar Cable (Module to SMU)
4.	DCC	DC Cable (SMU to PCU))
5.	LTC	LT Cable (PCU to Inverter Transformer)
6.	HTC	HT Cable (Inverter Transformer to Power Transformer)
7.	LTP	LT Panels (ACDB & DCDB)
8.	SWO	Substation Equipment – CT, PT, CB, Isolator etc.
9.	ABT	Metering Set (Main, Check, Standby)
10.	NIFPS	Nitrogen Injection Fire Protection System
Category – C		
1.	TLC	Transmission Line Conductor/Cable
2.	LDC	LT Distribution Cable
3.	UPS	Uninterrupted Power Supply
4.	BBC	Battery Bank and Battery Charger
5.	EES	Earth Electrode and Accessories
6.	LPS	Lightning Protection System
7.	CMC	Communication Cable
8.	TEA	Telemetry Equipment and accessories
9.	LED	Plant Illumination equipment and accessories
10.	WMS	Weather Monitoring Station
11.	CCTV	CCTV Camera
12.	FAS	Fire Alarm System
13.	TI	Testing instruments
14.	CPC	Control and Power Cables
15.	SCC	Solar Cable Connector

16.	CTK	Cable Termination Kits
17.	TLT	Transmission Line Tower/Pole and Accessories
18.	FST	Fasteners
19.	OTR	Equipment Pre-Approved by DISCOM/TRANSCO

* Material inspection to be done prior to manufacturing

Proto-type inspection to be done prior to manufacturing

Proto-type inspection of Container housing the Battery Modules/Racks, along with control and auxiliary systems (as per approved GA) to be done prior to manufacturing.

A Category – A

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

B Category – B

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

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

C Category – C

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

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

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

SUB-SECTION D

GENERAL ANNEXURE B

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

Contents

Pre-dispatch inspection procedure

1. Objective:

The objective of this document is to establish General inspection protocol with objectivity for verification of Quality Parameters of Solar Modules by the customer (or its authorised inspection agency) prior to dispatch. The decision rules and procedure specified herein seek to uphold quality standards based on industry best practices and technical specifications laid out in tender documents as well as to control risks associated with item procurement.

2. Standards and Codes (as applicable):

1. Sampling for determining Acceptance Quality Level (AQL) shall follow ISO 2859-1: 1999.
2. IEC TS 60904-1-2:2019 - Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices

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: • Encapsulant • PV Module Back sheet • Sealant and potting material (Silicone)	Verify the expiry date/shelf life and storage conditions *The PV Module manufacturer shall submit all required information to prove that materials being used are within their shelf life.*

Note: Supplier shall provide the necessary documents for approval of BOM as per IEC standards and tender Technical Specifications.

Witness Tests:

Manufacturer shall assist the Inspecting agency to witness following checks, the details of which are provided elsewhere in this document:

I. Flash test- As per sampling Plan

For Bifacial Modules, Measurement of current-voltage characteristics shall be done as per IEC TS 60904-1-2:2019 - Photovoltaic devices - Part 1-2

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. In case of deviation for Inspection Lot size, approval form the Employer shall be required.

b. Supplier will arrange to move the PV Modules from FG to Inspection area.

c. Same samples shall be used for all Witness Tests stated at 5.2 above.

d. Inspector shall commence Inspection process by randomly selecting samples from the list of serial nos. (pallet-wise) provided by Supplier as per ISO 2859: Single Sampling Plan for Normal Inspection, General Inspection plan level-I. However, the Inspector shall reserve the right to switch to tightened or reduced level of Inspection as per the lot quality.

7. Decision Rules for Acceptance/Rejection

Following is a summary of Decision Rules for Acceptance/Rejection of a given Sample in a lot offered for Inspection:

Table 1: AQL Levels

Defect Type	AQL (%)
Major (Ma)	2.5
Minor (Mi)	4

Table 2: Inspection Levels

Inspection steps	Inspection item	Inspection level
1	Flash Test	General inspection level I
2	Visual	General inspection level I
3	EL	General inspection level I
4	EC (Other than Flash Test)	10 Nos. per lot

8. Inspection Process

a. Electrical Inspection – Flash Test

For flash test of PV Modules, following preparation shall be done:

(i) Module Temperature Stabilization: Modules shall be kept in controlled environmental condition till it reaches 25 ± 2ºC.

(ii) Calibration of Sun-simulator: Sun-simulator will be Class AAA type as per IEC 60904-9 (Photovoltaic Devices – Part 9: Solar Simulator Performance Requirements) with a valid calibration certificate on the date of testing.

(iii) Reference PV Module for testing shall be traceable to accredited calibration laboratory lab (TUV / Fraunhofer etc.).

Note:

(i) All modules selected for sampling inspection will be re-tested in the sun-simulator.

A Pmax retest (repeatability test) variation of ± 2 % on flash Pmax (Production value) will be acceptable.

(ii) The Supplier shall provide a valid calibration certificate of the apparatus used.

b. Visual Inspection

(i) The inspector(s) shall visually verify characteristics of PV Module as per the Visual Inspection Criteria which shall be finalized after award of the contract prior to start of manufacturing.

(ii) Visual Inspection shall be carried out in a well illuminated room. It shall be the responsibility of the Supplier to ensure adequate brightness in the room.

c. Electroluminescence (EL) Inspection

(iii) The inspector(s) shall verify EL image of PV Module as per the Electroluminescence Inspection Criteria which shall be finalized after award of the contract prior to start of manufacturing.

(iv) The EL image shall have sufficient resolution for analysis of defects.

Electrical Characteristics

The following tests shall be performed on min 10 nos. of PV Modules selected from the Sample from the lot. The Supplier shall submit valid calibration certificate of the testing equipment which shall be attached in the inspection report.

S. No.	Test	Defect	Standard	Test Condition	Acceptance Criteria
1	Insulation test	Major	IS 14286: Part 2: 2019	4000 V for 1 min	No dielectric breakdown
				1500 V for 2 min	(Insulation Resistance × Area) ≥ 40 MΩ.m^2
2	Continuity test of equipotential bonding	Major	IS/IEC 61730-2: 2016	2.5 times of the maximum overcurrent protection rating for 2 min	Resistance < 0.1 Ω
3	Wet leakage current test	Major	IS 14286: Part 2: 2019	Water Resistivity ≤ 3,500 Ω/cm Water Temperature = (22 ± 2) °C 1500 V for 2 min	(Insulation Resistance × Area) ≥ 40 MΩ.m^2

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 Report:

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 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 the Employer without any extra cost to the purchaser.

Sampling Plan

(Sampling Plan as Per ISO 2859) -1

Table 1 - Sample size code letters (see 10.1 and 10.2)

Lot size		Special inspection levels				General inspection levels		
		S-1	S-2	S-3	S-4	I	II	III
2 to	8	A	A	A	A	A	A	B
9 to	15	A	A	A	A	A	B	C
16 to	25	A	A	B	B	B	C	D
26 to	50	A	B	B	C	C	D	E
51 to	90	B	B	C	C	C	E	F
91 to	150	B	B	C	D	D	F	G
151 to	280	B	C	D	E	E	G	H
281 to	500	B	C	D	E	F	H	J
501 to	1 200	C	C	E	F	G	J	K
1 201 to	3 200	C	D	E	G	H	K	L
3 201 to	10 000	C	D	F	G	J	L	M
10 001 to	35 000	C	D	F	H	K	M	N
35 001 to	150 000	D	E	G	J	L	N	P
150 001 to	500 000	D	E	G	J	M	P	Q
500 001 and over		D	E	H	K	N	Q	R

(Sampling Plan as Per ISO 2859) – 2 – Normal, Tightened and Reduced)

Table 2-A — Single sampling plans for normal inspection (Master table)

Sample size code letter	Sample size	Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (normal inspection)																									
		0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1 000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1 250	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2 000	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

⇩ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 % inspection.

⇧ = Use the first sampling plan above the arrow.

Ac = Acceptance number

Re = Rejection number

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

Sample size code letter	Sample size	Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (tightened inspection)																								
		0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1 000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1 250	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2 000	0 1	↑	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
S	3 150			1 2																							

↓ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 % inspection.

↑ = Use the first sampling plan above the arrow.

Ac = Acceptance number

Re = Rejection number

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

Sample size code letter	Sample size	Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (reduced inspection)																									
		0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1 000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2														⇩	0 1			1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	2													⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
C	2												⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	14 15	21 22	⇧
D	3											⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	14 15	21 22	⇧	
E	5										⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	14 15	21 22	⇧		
F	8									⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧	⇧	⇧			
G	13								⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧						
H	20							⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧							
J	32						⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧								
K	50					⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧									
L	80				⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧										
M	125			⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧											
N	200		⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧												
P	315	⇩	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧													
Q	500	0 1	⇧		⇩	1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧														
R	800	⇧			1 2	2 3	3 4	5 6	6 7	8 9	10 11	⇧															

⇩ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 % inspection.

⇧ = Use the first sampling plan above the arrow.

Ac = Acceptance number

Re = Rejection number

Customer inspection Report

CUSTOMER INSPECTION REPORT			
Ref. No. & Date:			
Client: SECI	**PMC**: SECI	**EPC Contractor**: PO Ref. No.:	
Place of Inspection:	**Date of inspection:**	**Lot Size**	**Sample Quantity**
Problem Quantity: **Detail:** **<u>Inspection Result (OK/Not OK):</u>**			
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/ PMC 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				
….				

SUB-SECTION D

GENERAL ANNEXURE C

Mandatory Spares

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

S. No.	Equipment/Material	Quantity (For each type and rating)
	(v) Buchholz relay	1 set
	(vi) Magnetic Oil Gauge	1 set
	(vii) Breather assembly of Main tank	1 set
	(viii) Cooler Fan with motor, Contactor, Relay and MCB	1 set
	(ix) Insulating Oil	10%
	(x) Complete set of gaskets & valves	1 set
	(xi) Tap Changer Contact Assembly Spares	1 set
	(xii) Pressure release device	1 set
7	11 kV switchgear assembly	
	(i) Circuit breaker pole	2 nos.
	(ii) Contact assembly (for indoor panels)	Suitable for one 3-phase CB
	(iii) Closing coil	2 nos.
	(iv) Tripping coil	2 nos.
	(v) Spring charging motor	2 nos.
	(vi) Relay (each type)	2 nos.
	(vii) Meter (each type)	2 nos.
	(viii) Current Transformer	2 nos.
	(ix) MCCB	2 nos.
	(x) MCB	2 nos.
	(xi) Fuse	10% of total supply
	(xii) Indicating lamp	10% of total supply
	(xiii) Rotary switch	10% of total supply
8	11kV LA, CT & VT	One of each type together with terminal connectors
9	Control and Relay Panel	
	(i) Relay (each type)	1 no.
	(ii) Meter	1 no.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Indicating lamp	10% of total supply
	(vi) Rotary switch	10% of total supply
	(vii) BCU	1 no.
10	LT Switchgear	

S. No.	Equipment/Material	Quantity (For each type and rating)
	(i) ACB	1 no.
	(ii) MCCB	2 nos.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Relay	2 nos.
	(vi) Meter	2 nos.
	(vii) Current Transformer	2 nos.
	(viii) Voltage Transformer	2 nos.
	(ix) Contact Assembly	2 sets
	(x) Indicating lamp	10% of total supply
	(xi) Rotary switch	10% of total supply
11	DC Cable	1 Drum
12	AC Cable	1 Drum
13	Communication Cable	1 Drum
14	Control Cable	1 Drum
15	Fuse	10% of total supply
16	11kV Internal Transmission Line	
	(i) Line supports, MS Angle, Back Clamp, Top Clamp, Earthing Coil, Insulators	2 set
	(ii) Conductor	1 km
	(iii) Jointing Sleeves, Stay set complete with turn buckles, stay wire, stay insulators, Anti-climbing Devices, Danger Boards	2 set
17	Battery Packs/Modules (Smallest Field replaceable Unit) along with connectors, cables, monitoring devices etc.	2% of total supply

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

SUB-SECTION D

GENERAL ANNEXURE D

Quality Assurance & Inspection of Civil Works

TABLE OF CONTENTS

1 Introduction

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

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

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

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

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

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

2 QA and QC Manpower

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

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

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

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

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

3 Laboratory and Field Testing

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

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

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

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

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

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

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

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

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

4 Sampling and Testing of Construction Materials

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

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

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

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

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

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

5 Purchase and Service

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

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

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

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

6 Field Quality Plan

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

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

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

7 General QA Requirements

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

Equipment	**UOM**	**Approx. Qty.**
Cube moulds for cement testing	nos.	4
Sieve shaker	nos.	1
Sieve for sand, coarse and fine aggregate	set	1
Sieve for coarse aggregate	set	1
Slump testing equipment	nos.	6
Oven	nos.	2
Physical balance	nos.	1
Thermometer	nos.	4
Burret	nos.	2
Measuring cylinder	nos.	9
Measuring flask	nos.	3
Compression testing machine	set	1
Cube mould for concrete	nos.	10

Mechanical weighing machine	nos.	1 (100kg capacity)
Drum type concrete mixer (for trial mixes)	nos.	1
Proctor testing equipment	set	1

7.2 Notes

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

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

SUB-SECTION D

GENERAL ANNEXURE E

FQP & MQP for Civil & MMS Works

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

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

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

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

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sr.No.	Activity & Operation	Instruments	Class of Check	Type of Check	Quantum of Check	Reference Documents & Acceptance Standard	Format of Record	D* (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	Cheking Agency			Remarks
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
106	iv	Check for proper cover,spacing of bars, spacers & chairs after the reinforcement cage has been put inside the foundation			Visual								
107	v	Check whether lapping of bars are tied properly with right gauge and annealed wire			Visual								
109	8	**Concrete**											
110	i	Availability of approved Design Mix (for all specified grades)		Critical	Physical	For each specified grade of concrete	IS :456, Tech Specs, Construction Drawings	Approved mix design	√		x	x	The concrete shall be as per approved design mix and the materials (cement, coarse and fine aggregate shall be from the same source considered during mix trials. The mix design shall be verified and approved in case of change of source of any of the matearials
111	ii	Minimum cement content (as applicable in MMS piling and foundation/ below ground works)		Critical	Physical	For piling and foundation works	IS: 456, Tech. specs, Construction drawings	SR	√		x	x	The minimum cement content shall correspond to exposure conditions and/ or, suplphate contents in ground water/ soil
112	iii	Trial mixes to ascertain the workability and cube strength	As per recommended mix design from specialist agency	Critical	Physical/ Testing	One for each mix proportion	Tech. Specs, IS: 456	Lab Test Reports	√	x	x	x	Necessary correction for moisture content and water absoption according to mix design recommendations may be carried out during trial mix
113	iv	Mixing of concrete- check for quanities of cement, CA, FA and water used, Concrete shall be homogenous	Mixing shall be done in a approved mixer/ batching plant (conforming to IS: 4926/ 4925)	Major	Physical	Mixer/ Batcher to be calibrated at the time of starting and subsequently once in tree months	IS: 4925, IS: 4926	Calibration Report/ Certificate	√	x	x	x	Review of calibration chart/ Certificate as per IS: 4926 Qty. of materials including cement consumptionshall be available through on line printer
114	v	Handling & trasportation	As required	Major	Physical	100%	As per approved/ agreed construction methodology	SR		x	x	x	Concrete shall be placed within 30 minutes of its removal from mixer
115	vi	Placement of concrete	As required	Major	Visual/ Physical	100%			√	x	x	x	
116	vii	Compacting	As required	Major	Physical	At Random			√	x	x	x	
117	viii	Curing	As required	major	Physical	At Random	IS: 456	SR		x	x	x	
119	9	**Concrete Testing & Acceptance**											
120	i	Workability - Slump Test		Critical	Physical	At the time of concrete pouring at site every 2 hrs	IS:456, IS:516,IS:1199, Tech Specs, Construction Drawings	Test Results / SR	√	x	x	x	
121	ii	Crushing strength - (Works test cubes)		Critical	Physical	Testing	IS:456, IS:516,IS:1199, Tech Specs, Construction Drawings	Test Results/ SR	√	x	x	x	**MMS Pile** - 6 cubes (3 for 7 day test & 3 for 28 day strength) per sample for each 5 cum or part there off **Building work and Equipment/ Misc foundations etc.** - 6 cubes (3 for 7 day test & 3 for 28 day strength) per sample for each 25 cum or part there off
122	iii	Acceptance of concrete work - Dimensional check (dimensions, levels etc), placement of bolts, inserts, pockets, pitch distance for bolts etc.	As required & dimensional tolerences	Major	Visual/ Measurement	100%		Joint Protocol between Civil Conractor, EPC Vendor and SECI/ Owner where applicable/ SR	√	x	x	x	
124	10	**Acceptance of Hardened Concrete**											
125	i	Dimensional check (dimensions, levels etc), workmanship, finishing after removal of shuttering	As required & dimensional tolerences	Major	Visual/ Measurement	At Random			√	x	x	x	

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

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149	i	Quality & Grading of sand, Check for mix proportion, wetting the surface etc		Major	Physical	At Random	IS: 2116, IS: 2386 (Pt. I & II), IS: 1542, Tech Specs	Lab Test Results/ SR		x	x	x	Sand to be used shall be free from deleteriousmaterials, Grading shall conform to Table-I of IS: 2116
150	ii	Plaster & grooves - Thickness, Evenness & Finishing, Trueness os palstering system		Major	Visual/ Measurement	At Random in each shift	Tech Specifications, Construction Drawings	SR	√	x	x	x	Trueness - Deviation not more than 4mm when checked with straight edge of 2m length
151	iii	Hacking, Raking of joints, Cleaning the surface, Removing all loose particles, Wetting the surface etc		Major	Visual	At Random in each shift	IS 1661, Tech Specs	SR		x	x	x	
152	iv	Curing		Minor	Physical	100%	IS 1661, Tech Specs	SR		x	x	x	
154	**14**	**Painting System - Plastered Masonry & Concrete surface**											
155	i	Materials & accessories - Approval for Paint, Color shade and Brand- Dry distemper, Oil Bound Distemeper, Acrylic Emulsion, Chemical resistant, Oil resistant Paint, Weather proof acrylic exterior paint, water proof cement paint etc.	As approved by SECI/ Owner	Critical	Review of MTC	Each batch of delivery	Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	MTC shall be correlated with the material received
156	ii	Surface preparation	As required	Minor	Physical	Random in each shift	IS: 2935 (Pt.1), Tech Specs, Construction Drawings	SR	x	x	x	x	
157	iii	Number of coats	As required	Major	Physical	Random in each shift	Tech Specs, Construction Drawings	SR	x	x	x	x	
158	iv	Application and Acceptance of painted surface	As required	Major	Physical	Each surface at Random							
160	**15**	**Floor finishes & Alied works**											
161	i	Preperation of Sub-grade			Physical	At Random for each building	Tech. Specs, Construction Drawings	SR	√	x	x	x	
162	ii	Plinth filling in layers (stone agrregates/ rubble with interstices filled with sand), ramming & compaction			Physical	At Random for each building	IS: 2720, Tech. Specs, Construction Drawings		√	x	x	x	Quality Checks as aplicable to Fill/ Back fill
163	iii	Check providing shuttering, reinforcement (if applicable)			Physical	At Random for each building	Tech. Specs, Construcion Drawings			x	x	x	Quality Checks as aplicable to Shuttering/ Reinforcement placement
164	iv	Checking the Panel size (as applicable)			Physical	At Random for each building	IS: 5491, Tech. Specs, Construcion Drawings			x	x	x	The concrete shall be cast in alternate panels in chess board fashion, panel size as specified in Construction Drawing or 25 sqm
165	v	Availability of Design mix (if applicable)			Visual	At Random for each building	Tech. Specs, Construcion Drawings	Mix Design Report/ SR		x	x	x	
166	vi	Clearance for concreting (as applicable)			Physical	100%	Tech. Specs, Construction Drawings	Joint Protocol between Civil Contractor, Eqpt. Supplier/ EPC Vendor & SECI/ Owner SR		x	x	x	
167	viii	Performing concreting ensuring Grade/Mix Proportions, Compaction, Thickness and Finish			Physical	At Random per shift	IS; 456, Tech. Specs, Construction Drawings	SR	√	x	x	x	Quality Checks as aplicabel to Concrete Work
168	viii	Curing			Visual	100%	IS: 456, Tech. Specs	SR		x	x	x	Minimum up to 10 days from date of casting
169	ix	Testing of Concrete Cubes for Flooring			Physical	One sample for every 20 Cum of concreting or part thereof for each days concreting (one sample consists of min 3 test cubes for 28 days strength)	IS:456, IS:516,IS:1199 and Design specification	Lab Test Reports					
170	x	Tiled flooring/ dado											

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171	a	Material - Glazed ceramic Tiles, Vitrified Ceramic Tiles, Mosaic Tailes, Acid alkali Tiles, Heavy duty cement concrete tiles	As agreed/ required	Critical	Review of MTC & Test Reports	Each lot of material received	IS:13755, IS:1237, IS:8042, Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	MTC shall be correlated for all the parameters specified in Tech. Specs, BIS Standard
172	b	Finishing & Acceptance		Major	Physical	100%	IS: 1443, Tech Specs, Construction Drawings						
173	xi	IPS with or without IRONITE (as aplicable)		Major	Physical	At Random per shift	IS: 5491, Tech. Specs, Construction Drawings	SR	√	x	x	x	
174	xi	Fixing of Panel Dividers for finishing course (3 mm Thk Glass/ 2mm Thk Aluminium strip) (if applicable)		Major	Physical	At Random per shift	Tech Specs, Construction Drawings	SR	√	x	x	x	
175	xii	Anti abrasion/ anti wearing epoxy coating (if aplicable)											
176	a	Material	As agreed/ required	Critical	Approved Make and Type	Each lot of material received	Tech Specs, Construction Drawings, Manufacturer's Brochure/ Recommendations	manufacturer's Brochure/ SR	√	x	x	x	Material specifications to be correlated with Manufacturer's Brochure
177	b	Finishing & Acceptance		Major	Physical	100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
178	xiv	Kota stone flooring and skirting (as aplicable)											
179	a	Material	Quality, Texture, Thickness, Colour fro approved source	Major	Physical	Each batch of delivery	Tech Specs, Construction Drawings	SR	√	x	x	x	
180	b	Finishing & Acceptance		Major	Physical	100%	Tech Specs, Cosntruction Drawings	SR	√	x	x	x	
181	xv	Acid/ Alkali resistant tile flooring/ dado											
182	a	Material -Tiles, Mortar, Sealing, Fillers etc.	Thickness, Quality,	Critical	Approved source, Review of MTC/ Test Report	Each batch of delivery	Tech Specs, Construction Drawings	SR	√	x	x	x	The acid alkali resistant tile flooring nd dado shall be provided in battery room as per approved Arch finishing details
183	b	Finishing & Acceptance	Workmanship	Major	Physical	100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
184	xvi	Interlocking Blocks											
185	a	Materials	Size/ Shape, colour shade, Grade of Concrete	Critical	Approved source, Review of MTC/ Test Report	Each batch of delivery	BS: 6717, Tech Specs, Construction Drawings	SR	√	x	x	x	
186	b	Final finishing & Acceptance	As agreed/ required	Major	Physical	100%	BS: 7533 (Pt.3), Tech Specs, Construction Drawings	SR	√	x	x	x	
188	**16**	**Damp Proof Course**											
189	i	Material - Hot bitumen & water proofing materials etc.	As agreed/ required	Critical	Review of MTC	Each batch of delivery	IS: 702, Tech. Specs, Cosntruction Drawings	SR	√	x	x	x	
190	ii	Acceptance of Damp Proof Course - Thickness, Grade of PCC, Application of Bitumen layer etc.	As agreed/ required	Major		100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
192	**17**	**Grouting of pockets/ underside of base plate**											
193	i	Material	As required/ Agreed	Critical	Review of MTC/ Physical	Each batch of delivery	Tech. specs, Construction Drawings, Manufacturerr's catelogue	SR	√	x	x	x	In case of ready mixed grout MTC to be correlated with Manufacturerr's catelogue
194	ii	Type of Mix	Anti shrink cement grout/ Ready mixed - Fluid mix, stiff mix as required	Major	Physical	At Random prr shift of grout application	Tech. specs, Construction Drawings	SR	√	x	x	x	In case of cement grout anti shrink compound shall be added as per provisions of relevant IS/ Cosntruction Drawing
195	iii	Mixing, placement, application	As required	Major	Visual	At Random prr shift of grout application	Tech. Specs, Construction Drawings	SR	√	x	x	x	
196	iv	Crushing Strength - Test cubes	As required	Major	Physical/ Testing	3 cubes for entire grouting work	IS: 4031 (Pt.6), Tech Specs, Construction Drawings	SR/ Lab Test Report	√	x	x	x	

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

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

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

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

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

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

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

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

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

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438		**Strucural Steel (Raw Material)** Hot rolled & cold formed sections - Angle, Channel, Z-section, Box section, Plate, rod & bar											
439	i	Ultimate Tensile Strength (UTS), Yield Strength (YS), Percentage Elongation, Bend Test, Chemical Composition, Section dimensions	As agreed/ Required	Critical	Chemical composition, Mechanical, Measurement	1 Sample per 50 MT or part thereoff/ for every heat no.	IS 2062, IS 513, IS 811, IS 1079, IS 808, IS 1852, IS 1730 -Part I	MTC	√				Raw material to be procured from reputed manufacturers - like SAIL, RINL, JSPL, JSW, TISCO, ISSAR
440	ii	Visual Examination - Cracks, Scaling, Rust, Pitting, Lamination etc.	As agreed/ Required	Major	Visual	10% IS 2500, Level II, AQL 1.5	IS 2062, IS 513, IS 811, IS 1079, IS 808, IS 1852, IS 1730-Part I	SR	√	x	x	x	Material shall be free from surface defects like cracks, lamination,roughness, imperfect edges, rust, pitting & other harmful defects. Removal of minor surface defects as per IS;2062 is acceptable. Witness for 10% sample. Record review for every material
441		**Boughtout Items (Hardware - Nuts, Bolts and Washers - plain, spring)**											
442	i	Mechanical & Chemical Properties	As agreed/ Required	Critical	Chemical composition, Mechanical	1 sample per 5 MT or part thereoff	IS 1327 (Part 17) eq./ ASTM standard	MTC/ Lab test Report	√	x	x	x	
443	ii	Dimensional check (Dia., Thickness, Total stem length & Threaded length etc.)	As agreed/ Required	Major	Measurement	IS 1327 (part 17) eq 10 pieces per lot per member type	IS 6639, IS 2016,IS 6610 & IS 3063 / ASTM standard	Vendor Records	√	x	x	x	Witness for sample. Record review for every material
444	iii	Galvanizing - Mass per Sqm, Thickness (DFT)	As agreed/ Required Alcometer	Major	Visual, Measurement	IS 1327 (part 17) eq 10 pieces per lot per member type	For Hot dip galvanizing should be maintained 43 microns (min) and average 54 microns as per IS 1367 (part XIII) eq.	Vendor Records	√	x	x	x	Record review Random sample inspection/ measurement
445	b	**In Process Inspection**											
446		**Structural Item Fabrication**											
447	i	Straightening	As agreed/ Required	Major	Visual	100%	0.2% of total length	Vendor Records	√	x	x	x	Record review
448	ii	Cropping (Cutting)	As agreed/ Required	Major	Visual	100%	Approved drawing	Vendor Records	√	x	x	x	Record review
449	iii	Identification/ Marking	As agreed/ Required	Major	Visual	100%	Approved drawing Marking Shall be done with the help of permanent paint marker using stencil as per Drawing	Vendor Records	√	x	x	x	Record review Random sample inspection
450	iv	Punching/ Drilling of Holes	As agreed/ Required	Critical	Measurement	1 piece per 25 pieces	IS 802/ Approved drawing	Vendor Records	√	x	x	x	Record review
451		Edge Security							√	x	x	x	
452	v	Overall Length	As agreed/ Required	Major	Measurement	1 piece per 25 pieces	IS 802/ Approved drawing	Vendor Records	√	x	x	x	Record review Random sample measureemnt
453	vi	Bending	As agreed/ Required	Critical	Measurement	100%	IS 801, 811/ Approved drawing	Vendor Records	√	x	x	x	
454		Cross Section Dimensions							√	x	x	x	Record review
455	vii	Welding	As agreed/ Required	Major	Visual	100%	Approved Welding Procedure & Welder Qualification	Vendor Records	√	x	x	x	Record review Random sample ispection
456	viii	Visual Examination - Black spots, Porosity, Spatter, Rust bleed points, Weld dimensions	As agreed/ Required	major	Visual	100%	Tech. Specification, Approved Drawing	Vendor Records	√	x	x	x	Record review Raddom sample inspection (The fabricated material shall be free from
457	ix	DP Test (as necessary)	As agreed/ Required	Major	Chemical	Shift wise/ random	As and when required	Vendor Records	√	x	x	x	
458	x	Final Inspection of Fabricated Parts - Cross section dimensions, Thickness (before galvanization)	As agreed/ Required	Critical		10 % in lot size of 100 nos.	IS- 802, IS 807, IS 811 and relevant applicable eq. standards , approved drawings, Tech spec	Vendor Records	√	x	x	x	
459		**Galvanizing**											
460	i	Zinc - Ingot, Molten metal in galvanizing bath	As agreed/ Required	Critical	Chemical	1 sample from each batch of ingot supply	IS 2629	MTC Lab test report	√	x	x	x	Purity of Zn 98.5%, MTC to be correlated. Molten metal in the galvanizing bath ≥ 98.5 % by mass of zinc.
461		**Pre Galvanizing**											

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

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sr.No.	Activity & Operation	Instruments	Class of Check	Type of Check	Quantum of Check	Reference Documents & Acceptance Standard	Format of Record	D* (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	Cheking Agency			Remarks
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		M'fr/ Supplier or Sub-Contractor	EPC Contractor	SECI or Owner	
480	ii	Packaging, Storing, Bundling, Handling	As agreed/ Required	Major	Visual	100%	As per IS-802. Packing of Column. Bracing, Rafters and Purlins shall be done by strapping. Packing of smaller items by wires or in gunny bags/ or as per approved procedure	IR	√	x	x	x	Separate packaging for different type of members like Col, Purlin, Rafter, Front/ rear/ diagonal bracings, fasteners, cleats etc. Small members shall be bundled with wire. Damage to galvanization and form (shape) of the member during handling and trasporting shall be controlled
481		**Site Installation**								x	x	x	
482	i	Receipt of materials and Checking as per packing list	As agreed/ Required	Critical	Visual	Random			√	x	x	x	
483	ii	Fabricated members - Dimensional Check	As agreed/ Required	Major	Visual	100%				x	x	x	
484	iii	Visual checks for defects/damages, rusting, pitting, galvanising etc.	As agreed/ Required	Major	Visual	Random	Tech. Specification, Approved Drawing & Method Statement.			x	x	x	
485	iv	Nut/Bolt/Washers	As agreed/ Required	Major	Measurement	100%				x	x	x	
486	v	Mounting of structures & Accessories - Coordinates, Levels, Fitment, Alignment etc.	As agreed/ Required	Critical	Visual /Measurement	100%			√	x	x	x	
487	vi	Torque Checking - Daily calibration check, Bolt installation	As agreed/ Required	Major	Measurement	100%				x	x	x	
489	35	**Module Mouting - Pre Installation Check**			Visual	100%							
490	i	Check for site physical layout as per drawing / Design Specification		Major	Physical	100%				x	x	x	
491	ii	Check for Structure, Mounting readiness		Major	Physical					x	x	x	
493	36	**String Combiner Boxes (SCB) - Mouting - Pre Installation Check**											
494	i	Check for foundation readyness - location & coordinates, dimensions & levels, foundation bolts etc.		Major	Physical	100%				x	x	x	
496	37	**Inverter Panel**											
497		**Pre Installation**											
498	i	Check for site physical layout as per drawing.		Major	Visual	100%	Design Specification, Drawings, Manufacturer Manual Method Statement	SR	√	x	x	x	
499	ii	Ensure that no fouling with civil/structural		Major	Physical	Random				x	x	x	
500	iii	Check for Foundation readiness and level of foundation.		Major	Physical	100%				x	x	x	
502	38	**Burried Cables**					Design Specification, Drawings, Manufacturer Catalogue Method Statement (SW-SEPC-MS-CAB-006)						
503	i	Cable Trench - Dimensions, alignment		Critical	Physical	100%	Design Specification, Drawings, Manufacturer Catalogue Method Statement	SR		x	x	x	
504	ii	Sand filling before cable laying, sand filling after cable laying, placing of precast concrete slabs/ bricks, backfilling with soil		Major	Visual	100%				x	x	x	
586													
587													
588													
589													
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591													

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

SUB-SECTION D

GENERAL ANNEXURE F

Pile Test Methodology

1.0 GENERAL

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

2.0 DEFINITIONS

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

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

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

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

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

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

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

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

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

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

3.0 SAFETY PRECAUTIONS

General

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

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

Personnel

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

Kentledge

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

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

Reaction Piles and Ground Anchors

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

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

Testing Equipment

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

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

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

4.0 MATERIALS AND LABOUR

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

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

5.0 INITIAL TEST PILES

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

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

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

6.0 MEASURING DEVICES

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

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

7.0 SUPERVISION

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

8.0 LOADING TEST PILES

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

9.0 READINGS

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

10.0 INSTALLATION OF A TEST PILE

Inclusive Works

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

Notice of Construction

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

Method of Construction

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

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

Boring Record

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

Concrete test cubes

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

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

Pile Head for Compression Test

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

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

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

Pile Connection for Tension Pile

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

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

11.0 REACTION SYSTEMS

Compression Tests

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

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

Tension Tests

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

Spacing

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

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

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

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

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

Adequate Reaction

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

Care of Piles

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

Working Piles as Reaction Piles

The Contractor shall not use working piles as reaction piles.

Loading Arrangement

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

Pile caps and Structural Elements

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

12.0 EQUIPMENT FOR APPLYING LOAD

General

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

Jack Capacity

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

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

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

13.0 MEASUREMENT OF LOAD

Load Measurement Procedure

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

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

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

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

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

Calibration of Load Measuring Devices

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

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

Measurement of Settlement

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

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

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

Initial Zero Load Readings

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

14.0 MEASURING MOVEMENT OF PILE HEADS

Maintained Load Test

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

Primary System

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

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

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

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

Independent Reference Frame

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

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

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

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

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

Secondary Systems

Reference Wire

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

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

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

Other Methods

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

Instrument Calibration

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

Night Readings

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

15.0 PROTECTION OF TESTING EQUIPMENT

Protection from Weather

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

Prevention of Disturbance

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

16.0 SUPERVISION

Notice of Test

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

Records

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

17.0 TEST PROCEDURE

Failure Load Tests (Initial Tests)

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

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

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

LOADING CYCLES FOR INITIAL TEST PILES

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

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

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

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

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

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

Working Load Test on Working Piles

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

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

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

LOADING CYCLES FOR WORKING PILES

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

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

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

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

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

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

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

18.0 ABANDONMENT OF PILE TEST

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

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

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

19.0 PRESENTATION OF RESULTS

Results to be Submitted

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

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

(ii) Load vs Settlement curve.

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

Schedule of Recorded Data

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

General

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

Pile Details

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

Installation Details

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

Test Procedure

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

Test Results

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

Site Investigation

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

20.0 COMPLETION OF A TEST

Measuring Equipment

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

Kentledge

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

Ground Anchors and Temporary Piles

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

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

Initial Test Pile

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

1.0 GENERAL

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

2.0 DEFINITIONS

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

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

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

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

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

3.0 SAFETY PRECAUTIONS

General

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

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

Personnel

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

Reaction Piles/ Reaction Pedestals

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

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

Testing Equipment

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

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

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

4.0 MATERIALS AND LABOUR

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

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

5.0 INITIAL TEST PILES

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

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

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

6.0 MEASURING DEVICES

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

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

7.0 SUPERVISION

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

Engineer's Representative.

8.0 LOADING TEST PILES

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

9.0 READINGS

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

10.0 INSTALLATION OF A TEST PILE

Inclusive Works

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

Notice of Construction

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

Method of Construction

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

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

Boring Record

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

Concrete test cubes

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

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

Pile Connection for Lateral Test

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

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

11.0 REACTION SYSTEMS

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

Spacing

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

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

Where vertical reaction pile penetrates deeper than the test pile, the center-to-center spacing of the reaction pile from the test pile shall be not less than two and half times the diameter of the test pile or the reaction pile whichever is the greatest.

Adequate Reaction

The size, length and number of reaction piles/ pedestals or reaction beam if so provided shall be adequate to transmit the maximum lateral test load to the ground in a safe manner without movement or influence on the test pile.

Care of Piles

The method employed in the installation of any reaction piles/ pedestals or beam shall be such as to prevent damage to any test pile or working pile.

Working Piles as Reaction Piles

The Contractor shall not use working piles as reaction piles.

Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

Pile caps and Structural Elements

Temporary pile caps and other structural elements forming part of the reaction system proposed by the Contractor shall be designed and built by the Contractor, and to the approval of the Engineer. The cost of building and demolishing such pile caps and structural elements shall be borne by the Contractor.

12.0 EQUIPMENT FOR APPLYING LOAD

General

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The rams or jacks shall be arranged in conjunction with the reaction system to deliver a lateral load to the test pile. The complete system shall be capable of transferring the maximum load required for the test. In case the test load is applied by jack located between the reaction and the test pile, the full load imposed by the jack shall be taken as the lateral resistance of each pile. If the load is applied by installation of two jacks placed diametrically opposite at 45^0 inclinations with respect to the axis of the test pile the value of net applied test load along the test pile axis shall be worked out accordingly.

Jack Capacity

The total capacity of the jacks shall exceed by 50% or more the required maximum test load, thereby avoiding heavy manual pumping effort when nearing maximum load and minimizing the risks of any leakage of oil through the seals.

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of load test.

The length of stroke of a ram shall be sufficient to cater for deflection of the reaction system under load plus a deflection of a pile head up to 15% of the pile shaft diameter unless otherwise specified.

13.0 MEASUREMENT OF LOAD

Load Measurement Procedure

The load shall be measured by a load measuring device and by a calibrated pressure gauge included in the hydraulic system. The technical specifications of the load cell and pressure gauge shall be submitted to the Engineer prior to the test. The load cell and pressure gauge shall be of appropriate range of the testing load. Reading of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used. The pressure gauge readings are required as a check for gross error. The pressure gauge shall have been recently calibrated.

The load measuring device may consist of a proving ring, load measuring column, pressure cell, vibrating wire load cell or other appropriate system. The load cells or proving ring shall be calibrated immediately prior to the test and a certificate shall be submitted to the Engineer.

A spherical seating shall be used in conjunction with any device that are sensitive to eccentric loadings; care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in their length in order to achieve the best possible stability. The Contractor shall pay attention to details in order to ensure that lateral loading is properly maintained.

Any increment of load shall not be allowed to fall below 1% of the specified load.

The Engineer’s agreement shall be obtained in writing prior to any modification of this procedure.

Calibration of Load Measuring Devices

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together.

Certificates of calibration performed by an NABL accredited testing laboratory shall be supplied to the Engineer prior to carrying out the load test.

Measurement of Deflection/ Displacement

Deflection/Displacement shall be measured by use of a reference/datum beam supported independently of the test pile, reaction pile or piles supporting reaction loads. Settlements shall be measured to the nearest 0.1mm A precise optical level shall also be used to check movements of the reference frame against an independent datum. The reference beam supports shall be located at least 3m from the test pile, reaction pile or piles supporting reaction loads. The reference beam shall be protected from the effects of temperature changes. Construction equipment and persons not involved in the test shall be kept well clear to avoid disturbance of the measuring system. Pile driving or similar operations will not be permitted in the vicinity of the test unless the Engineer is satisfied that the measuring system will not be affected.

Deflections shall be precisely measured by min. two dial gauges of 0.01 mm sensitivity spaced at 300 mm and kept horizontally one above the other on the test pile and the displacement interpolated at cut-off level from similar triangles where cut-off level is unapproachable. For approachable cut-off level one dial gauge placed diametrically opposite to the jack shall directly measure the displacement. The dial gauge shall be firmly attached to the reference beam (datum beam), so that the plungers are perfectly horizontal and are aligned along pile axis. One of the methods for keeping the dial gauge on pile surface is to chip off uneven concrete on the side of the pile and to fix a piece of glass 20 to 30 mm square. The dial gauge tips shall rest on the central portion of the glass plate.

Initial Zero Load Readings

Before the first increment of test load is applied, all gauges shall be read at 30 minutes intervals over a period of 3 hours under zero load to determine the effect of variable site conditions on the test pile. Air temperature shall be recorded with each set of readings. The test set- up shall be exactly as during the test proper, with the loading jack in position but clear of the loading frame.

Instrument Calibration

Prior to carrying out the load test, the Contractor shall submit to the Engineer the calibration certificates of dial gauges performed by NABL accredited testing laboratory.

Night Readings

The entire test area shall be adequately lighted up during the night to facilitate taking readings.

14.0 PROTECTION OF TESTING EQUIPMENT

Protection from Weather

Throughout the test period, all equipment for measuring load and movement shall be protected from direct exposure to sunlight, wind and rain.

Prevention of Disturbance

Construction equipment and persons who are involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

15.0 SUPERVISION

Notice of Test

The Contractor shall give the Engineer at least 24 hours of notice prior to commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test as required under the section headed 'Presentation of Results' in this specification shall be available for inspection by the Engineer.

16.0 TEST PROCEDURE

Failure Load Tests (Initial Tests)

Failure Load Tests shall be performed on initial piles designated by the Engineer at the commencement of the contract to verify the design pile capacity the initial test piles shall be the only ones made in the first instance, and the load tests carried out prior to the installation of any other piles. Piling works shall not commence until after the failure load test results have been analyzed, and upon instruction by the Engineer.

The provisional number of Failure Load Tests shall be as agreed subject to min. of 3 numbers. The locations of initial test piles shall be so chosen to properly represent the total plant site and shall be subject to the approval of the Engineer. However, the Engineer reserves the right to alter the number of tests subject to the nature of subsoil conditions encountered and the pile system adopted vis-a-vis the method of installation, material and plant usage.

The test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load taken as 100%. In case of any variation with respect to approved pile test procedure, the approved procedure shall have the precedence.

LOADING CYCLES FOR INITIAL TEST PILES

Load (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till rate of lateral displacement of pile head is less than or equal to 0.1mm/per 30 minutes subject to min. 30 minutes.	
20		
40		
60		
80		
100		
120		
140		
160		
180		
200		
220	12 hr from start of first stage loading	
250	12 hr from start of first stage loading	Test loading shall continue till one of the following take place (a) Max. test load reaches 250% of the safe load or (b) Total lateral displacement reaches 18mm.
200	10	
150	10	
100	10	
50	10	
0	0	

(NOTE: Unloading stages stated above are indicative and shall be per approved test procedure)

LOADING CYCLES FOR ROUTINE TEST PILES

Load %	Time of Holding the Load (Minutes)	Remarks
0		
20		
40		
60		
80		
100		Test load shall be carried out till one of the following takes place (a) Max. test load reaches the safe load or (b) till the total displacement is less than 5mm
75	10	
50	10	
25	10	
0		

The test schedule for Lateral Load test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

For failure load test, the Contractor shall provide adequate reinforcement in the test pile to carry the ultimate lateral load.

All loading and unloading operations shall take place during the day. Pressure gauge readings shall be recorded at each load increment or at each decrease in load. During waiting periods at various loading stages, all readings shall be recorded after the load has been applied and before the commencement of next loading stage. Take readings at 15-minute intervals at 100% and 200% of working load.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

17.0 ABANDONMENT OF PILE TEST

Test shall have to be discontinued if any of the following occurs:

- faulty jack or gauge,
- improper setting of datum, or
- unstable Bench Marks or Scales,
- measuring instruments used are found to have been tampered with by anyone,
- pre-jacking or pre-loading before commencement of the test.

Should any test be abandoned due to any of the above causes, the Contractor shall carry out further tests to the Engineer instructions after rectification of the errors.

18.0 PRESENTATION OF RESULTS

Results to be Submitted

A written summary to the Engineer within 24 hours (or unless otherwise directed) of the test, which shall give:

(i) For each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

(ii) Load vs Settlement curve.

The completed schedule of recorded data (hard & softcopy) as described hereunder in this section shall be submitted to the Engineer within seven days of completion of the test in the format generally as specified in IS: 2911 (part 4) and approved by the Engineer.

Schedule of Recorded Data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

General

* Site location
* Contract identification
* Proposed structure
* Name of EPC Contractor
* Name of Piling Contractor & Testing Agency
* Name of SECI/ Owner Engineer
* Name of EPC Contractor's Engineer
* Name of Testing Agency/ Piling Contractor Engineer
* Data of test

Pile Details

All piles
* Identification (no. and location)
* Position relative to adjacent piles
* Brief description of location (e.g. in marshy land, rocky area, high water table etc.)
* Existing Ground level at pile location
* Head level (cut-off level) at which test load is applied
* Type of pile (e.g. bored cast in situ, pre-cast driven etc.)
* Shape and size of cross-section of pile (diameter), position of change in cross-section (in case of under reamed pile – the position and dimensions of the bulb)
* Shoe or base details
* Head details
* Length in ground
* Level of toe

Installation Details

* Test cube results
* Design grade of concrete
* Reinforcement
* Whether construction under water

Test Procedure

* Max. test load
* Reaction pile details
* Plan of test arrangement showing position and distances of reaction piles and reference frame to test pile
* Jack capacity

* Calibration certificates of pressure gauges and dial gauges
* Method of load measurement
* Method(s) of lateral displacement measurement
* Proof test by maintained loading
* Relevant dates and times

Test Results

* In tabular form
* In graphical form: log P plotted against log S (only for Failure Load Tests), load plotted against settlement
* Ground heave

Site Investigation

* Site Investigation report reference number and coordinate or grid reference
* Nearest Borehole reference

19.0 COMPLETION OF A TEST

Measuring Equipment

On completion of a test, all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in future tests or removed from the Site.

Temporary Piles/ Pedestals

On completion of the Load Test, temporary pile shall be cut off below ground level, removed from the Site and the ground made good with approved material.

The pile cap, if formed in concrete, shall be broken up and removed from the Site. If the pile cap is made of steel, it shall be cut off and either stored so that it is available for use in further tests or removed from the Site.

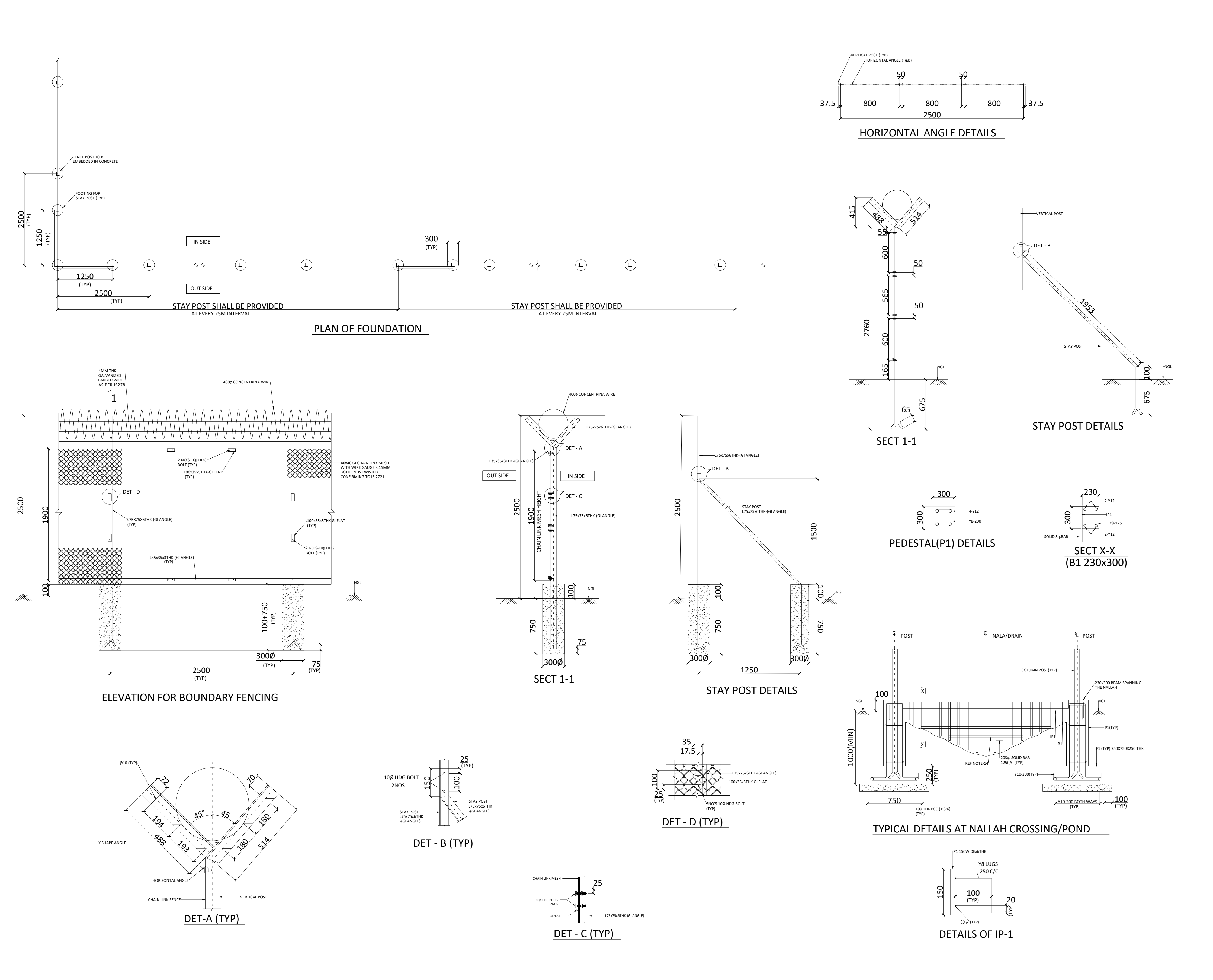
Initial Test Pile

Test piles which are not to be incorporated into the permanent works shall be broken down to 2m below ground level or as required, and the ground backfilled to the original level with approved material. For test piles which are to be incorporated into the permanent works, the pile head shall be made good or extended to the cut off level

SUB-SECTION D

GENERAL ANNEXURE G

Tender Drawings



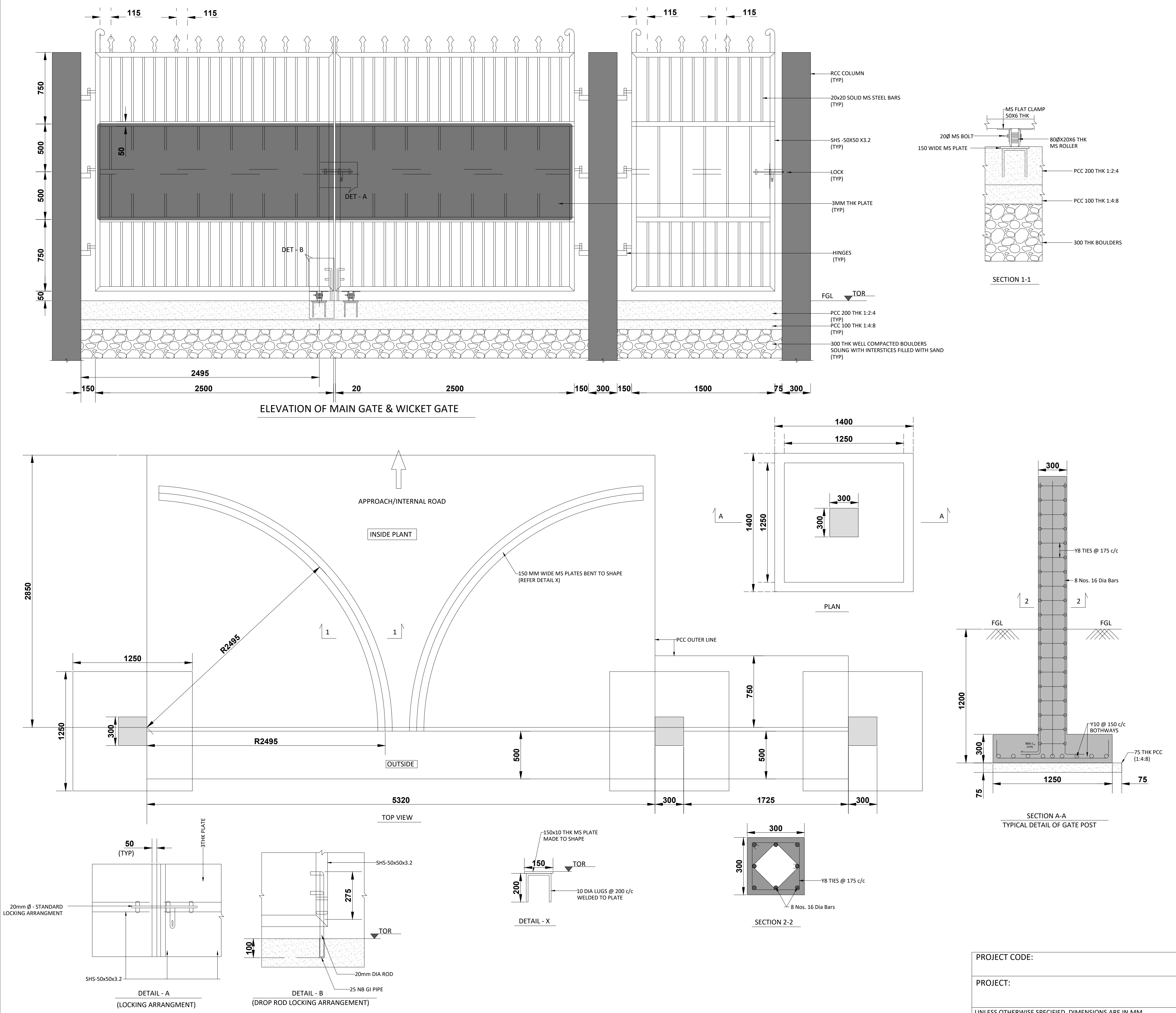
LEGEND

PCC	PLAIN CEMENT CONCRETE
NGL	NATURAL GROUND LEVEL
DET	DETAIL
TYP	TYPICAL
HDG	HOT DIP GALVANIZED
GI	GALVANIZED IRON
Eq	EQUAL
T&B	TOP & BOTTOM

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATION IN METERS.
2. ALL STRUCTURAL STEEL WORKS SHALL CONFORM TO IS:2062 GRADE-E250.
3. ALL DIMENSIONS TO BE CHECKED BEFORE FABRICATION OF STEEL WORK.
4. GALVANIZATION ON WIRES SHALL CONFORM TO IS:4826 HEAVY DUTY.
5. GALVANIZATION THICKNESS SHALL BE 60 MICRONS MIN.
6. TOP OF FENCE SHALL FOLLOW THE NATURAL CONTOUR OF LAND.
7. BARBED WIRE SHALL BE OF MINIMUM 4MM DIA AND OF APPROVED MAKE. IT SHALL CONFORM TO IS:278.
8. THE BARBED WIRES SHALL BE INSERTED IN THE SLOTTED HOLE AND BINDED WITH BINDING WIRES.
9. TWO STAY POST SHALL BE PROVIDED AT EVERY CORNER COLUMN POST AND WHEREVER CHANGE IN ELEVATION/LEVEL.EVERY TENTH INTERMEDIATE POST SHALL BE PROVIDED WITH A STAY POST.
10. GRADE OF CONCRETE SHALL BE M20 (1:1.5:3) WITH 20MM NOMINAL SIZE GRADED AGGREGATES AS PER IS:456.
11. ALL REINFORCEMENT SHALL BE HIGH STRENGTH TMT BARS OF GRADE FE500D CONFORMING TO IS:786.
12. CLEAR COVER TO REINFORCEMENT SHALL BE AS FOLLOWS: FOOTING = 50MM, COLUMN = 40MM & BEAM = 25MM.
13. HOLE DIAMETER SHALL BE 2MM LARGER THAN BOLT DIA.
14. A GRILL OF 20MM SQ. SOLID MS BAR WELDED TO IP1 AT SPACING OF 125MM C/C, WITH 20SQ HORZ.BARS OR 35MMX5MM THK FLAT WELDED TO VERTICAL SQ BARS AT SUITABLE INTERVALS (MIN. 3 NO OF THE BARS/FLATS) SHALL BE PROVIDED IN LIEU OF TOE WALL.
15. HEIGHT OF THE VERTICAL SQ SOLID MS BAR WILL VARY BASED ON ACTUAL NALLAH/DRAIN DEPTH.
16. POST ON EITHER SIDE OF NALA SHALL BE SUPPORTED WITH PEDESTAL & FOOTING ARRANGEMENT WITH A BEAM SPANNING ACROSS THE NALLAH/POND TO SUPPORT THE GRILLAGE AS SHOWN.
17. THE FOUNDATION OF THE STAY POSTS SHALL BE OF THE SAME SIZE AS THAT OF THE MAIN POSTS.
18. THE CHAIN LINK MESH FABRIC SHALL BE FIXED AT THREE POINTS EACH TO THE TOP AND BOTTOM EDGE ANGLES USING 100x35x5 GI FLATS.
19. ALL MS PART SHALL BE PAINTED WITH 2 COATS OF EPOXY PAINT OVER 2 COATS OF ZINC CHROMATE PRIMER.
20. ALL WELDS SHALL BE 6MM THICK UNO.
21. THREE NOs. OF 4MM THICK BARBED WIRES SHALL BE FIXED TO EACH ARM OF THE Y-SHAPED ANGLE SUPPORTS, ALONG WITH 400MM DIAMETER GI CONCERTINA WIRE.
22. SPACING BETWEEN BOTTOM OF FENCE AND GROUND LEVEL SHALL NOT BE MORE THAN 100MM.

PROJECT CODE:					CHAIN LINK FENCE DRAWING	DRAWN	CHKD.	APPR.	SHEET
PROJECT:						DATE	DATE	DATE	REV.
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MM						PART/DWG NUMBER-			SHEET SIZE A1
TOLERANCES									
NO D.P.	ONE D.P.	TWO D.P.	ONE D.P.	SCALE NTS					



LEGEND

FGL — FINISHED GROUND LEVEL
TYP — TYPICAL
THK — THICK
NB — NOMINAL BORE
TOR — TOP OF ROAD

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. DO NOT SCALE THE DRAWING. ONLY DIMENSIONS PROVIDED SHALL BE FOLLOWED.
3. CONCRETE SHALL BE OF M25 WITH 20MM NOMINAL SIZE GRADED AGGREGATES CONFORMING TO IS:456-2000.
4. REINFORCEMENT BARS SHALL BE OF HIGH YIELD STRENGTH TMT BARS OF GRADE FE500D CONFORMING TO IS:1786.
5. BENDING OF BARS SHALL CONFORM TO IS:2502.
6. LAP LENGTH/DEVELOPMENT LENGTH OF BARS SHALL BE 50xDIA OF BAR.
7. ANY DISCREPANCY IN THE DRAWING SHALL BE BROUGHT TO THE NOTICE OF ENGINEER IN CHARGE BEFORE EXECUTE OF WORK.
8. DRAWING SHALL BE READ IN CONJUNCTION WITH THE RELEVANT LAYOUT DRAWINGS.
9. CLEAR COVER TO MAIN REINFORCEMENT:
   a) FOOTING - 50 MM b) PEDESTAL - 40 MM c) COLUMN - 40 MM
10. HINGE, LOCKING ARRANGEMENT AND DROP RODS SHALL BE OF HEAVY DUTY TYPE.
11. ALL STRUCTURAL STEEL WORKS SHALL CONFORM TO IS:2062 GRADE-A & E-250.
12. WELD SIZE SHALL BE MIN 5 MM UNLESS NOTED OTHERWISE. ONLY SHOP WELDING SHALL BE PERMITTED.
13. GATE SHALL BE PROVIDED WITH THE PROJECT NAME PLATE (2.5 M X 1 M, 3 MM THICK MS PLATE) ON BOTH PANELS. DETAILS TO BE PROVIDED ON NAME PLATE SHALL BE SUBJECT TO APPROVAL FROM SECI.
14. ALL STRUCTURAL STEEL, GATE AND NAME PLATE SHALL BE PAINTED WITH 2 COATS OF EPOXY (TOTAL DFT 150 MICRONS) PAINT OF APPROVED MAKE AND SHADE OVER 2 COATS OF SUITABLE PRIMER.

PROJECT CODE:				
PROJECT:				
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MM				
TOLERANCES				
NO D.P.	ONE D.P.	TWO D.P.	ONE D.P.	SCALE NTS

ENTRANCE GATE DRAWING

DRAWN	CHKD.	APPR.	SHEET
DATE	DATE	DATE	REV.
PART/DWG NUMBER-			SHEET SIZE A1

SUB-SECTION D

GENERAL ANNEXURE I

Plant Documentation, Commissioning & Test Procedure

TABLE OF CONTENTS

1 INTRODUCTION

This document lays down the procedures, requirements and templates for conducting commissioning tests and inspection of the Plant Facilities after installation and for subsequent re-inspection, maintenance or modifications in accordance with the Tender Specifications, IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection)- and industry best practices.

2 CODES AND STANDARDS

The Testing and Commissioning Procedures shall, in general, comply with the following standards:

1. IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection).
2. IEC 60364-6:2016 - Low voltage electrical installations - Part 6: Verification.
3. IEC 61829:2015: Photovoltaic (PV) array - On-site measurement of current-voltage characteristics.
4. IEC 60904-4:2019 Photovoltaic devices - Part 4: Reference solar devices - Procedures for establishing calibration traceability
5. IEC TS 60904-1-2:2019 - Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices
6. IEC 62305-3– Protection against lightning - Part 3: Physical damage to structures and life hazard
7. IS/IEC 61557 : Part 2 : 2007 - Electrical safety in low voltage distribution systems up to 1000 V ac and 1500 V dc - Equipment for testing, measuring or monitoring of protective measures: Part 2 insulation resistance

3 COMMISSIONING

3.1 GENERAL

3.1.1 Objective

The Commissioning Procedure defined in this document aims to:

- Verify that the power plant is structurally and electrically safe
- Verify that the power plant is structurally and electrically robust to operate for the specified lifetime of a project
- Verify that the power plant operates as designed and its performance is as

expected

3.1.2 General Requirements before Starting the Commissioning Process

- The modules shall be stabilized (sufficiently exposed after 200 kWh/m² reaching the PV plane)
- The tests shall be conducted under stable weather conditions
- The process shall be witnessed by the Owner or their duly appointed representative.
- Soiling losses shall not be accounted for in the assessment of Results. Therefore, adequate Module cleaning exercise shall be undertaken prior to commencement of Commissioning process.

- The following equipment shall be used during the commissioning process (Refer Section VII B:Technical Specifications for testing instruments):
  - Earth resistance tester
  - IV curve tracer
  - Insulation tester
  - Digital multi-meter
  - Clamp meter
  - Infrared camera
  - Digital lux meter
  - Electroluminescence camera, power supply and accessories
- All testing equipment shall possess valid calibration certificate issued from approved laboratories.

4 Cold Commissioning

4.1 DC COMMISSIONING

4.1.1 Visual Inspection

The visual inspection shall be conducted on 5% of the system split in subareas equally distributed in the field. Unless otherwise specified, Approved Cat I Drawings shall be referred for correctness/verification. At least following aspects shall be verified visually on the DC side:

- Sizing of the DC fuses for running conditions, for the maximum voltage and the maximum current.
- Sizing of the string cables including overcurrent protection considering the current carrying capacity under operating conditions

- Cables protected against mechanical damage
- Functionality of the main DC switch
- Fixation of the modules to the mounting structure
- Termination of the cables to the inverter
- Where the PV system includes functional earthing of one of the DC conductors, the functional earth connection shall be specified and installed to the requirements of IEC 62548.
- Laying and installation of cables
- Fixation of the grounding electrodes
- Grounding of all conductive parts and connected to the equipotential bonding system of the PV plant
- The torque values in the mounting structure, combiner boxes, bars and joints shall match the manufacturer specifications
- Where protective earthing and/or equipotential bonding conductors are installed, they shall be parallel to and bundled with the DC cables
- Electrical circuits and devices shall be labelled.
- The PV modules shall be in a good condition (no visible serial defects such as yellowing, delamination, scratches, etc.).
- Functioning of fire protection equipment.

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. All items shall be categorized as "critical", "important" or "minor".

4.1.2 Pre-Energizing Tests

4.1.2.1 Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the DC circuit forming the PV array in accordance with a Sampling Plan:

- Electrical Continuity test: This test shall be performed on the earthing and/or equipotential bonding conductors, in the PV array field. Connection of such conductors to earthing pit shall also be verified.
- Polarity test: Polarity of DC cables shall be verified. After verifying the correctness of

polarity, marking on cable shall be checked for correctness

Note: Polarity test shall be performed before closing the switches or string overcurrent protective devices are inserted

- Combiner box test: The purpose of this test is to ensure all strings are connected correctly to the combiner box. The test procedure is as follows and shall be performed before any string fuses / connectors are inserted for the first time:

i) Select a volt meter with voltage range at least twice the maximum system voltage.

ii) Insert all negative fuses / connectors so strings share a common negative bus.

iii) Do not insert any positive fuses / connectors.

iv) Measure the open circuit voltage of the first string, positive to negative, and ensure it is an expected value.

v) Leave one lead on the positive pole of the first string tested, and put the other lead on the positive pole of the next string. Because the two strings share a common negative reference, the voltage measured should be near-zero, with an acceptable tolerance range of ±15 V.

vi) Continue measurements on subsequent strings, using the first positive circuit as the meter common connection.

vii) A reverse polarity condition will be very evident if it exists – the measured voltage will be twice the system voltage.

- String open circuit voltage test, V_{oc} (under stable weather conditions): The purpose of this test is check the modules connection in string as per the design. The V_{oc} of PV string should be measured using suitable measuring device before closing any switch or string overcurrent protective devices, where fitted.

  The measured string V_{oc} will be assessed to ensure it matches the expected value (typically within 5 %) in one of the following ways:

  a) Compare with the expected value derived from the module datasheet or from a detailed PV model that takes into account the type and number of modules and the module cell temperature.

  b) Measure V_{oc} on a single module, then use this value to calculate the expected value for the string.

  c) For systems with multiple identical strings, voltages between strings can be compared.

- String circuit current test, Isc (under stable weather conditions): The purpose of this test to check the correctness of system, operational characteristic and PV array wiring. These tests are not to be taken as a measure of module / array performance. The test procedure will be as follows:

i) Ensure that all switching devices and disconnecting means are open and that all PV strings are isolated from each other.

ii) Create a temporary short circuit into string under test by using any of the following method:

(a) use of a test instrument with a short circuit current measurement function (e.g., a specialized PV tester);

(b) a short circuit cable temporarily connected into a load break switching device already present in the string circuit;

(c) use of a "short circuit switch test box" – a load break rated device that can be temporarily introduced into the circuit to create a switched short circuit.

iii) Measure the short circuit current (Isc) using a suitably rated measuring instrument.

iv) After taking the reading, interrupt the short circuit using a suitable load break switching device and check the zero value of current before changing any other connections.

v) Compare the measure value of Isc with the expected value. For systems with multiple identical strings, measurements of currents in individual strings shall be compared. These values should be the same (typically within 5 % of the average string current).

Note: An I-V curve test can be performed as an alternative to this test (see 4.3).

- Functional tests: The following functional tests shall be performed:

i) Switchgear and other control apparatus shall be tested to ensure correct operation and that they are properly mounted and connected.

ii) All inverters forming part of the PV system shall be tested to ensure correct operation. The test procedure should be as defined by the inverter manufacturer.

Functional tests that require the AC supply to be present (e.g., inverter tests) shall only be performed once the AC side of the system has been tested.

- Insulation resistance of the DC circuits: Test procedure to conduct this test will be as follows:

i) Before commencing the test adopt the following safety measure to avoid any potential shock hazard

(a) Isolate the testing area.

(b) Do not touch any metallic surface, module back sheet or the module terminals when performing the insulation test.

(c) Appropriate personal protective clothing / equipment should be worn for the duration of the test.

ii) Isolate the PV array from the inverter (typically at the array switch disconnector)

iii) Disconnect any piece of equipment that could have impact on the insulation measurement (i.e. overvoltage protection) in the junction or combiner boxes.

iv) The insulation resistance test device shall be connected between earth and the array cable(s) or combiner bus bar. Connections can be made between earth and array negative followed by a test between earth and array positive or between earth and short circuited array positive and negative.

v) Follow the IR test device instructions to ensure the test voltage and readings in megaohms. When the system voltage (Voc at STC X 1.25) is higher than 500V, the test voltage shall be 1,000V and the minimum insulation resistance 1 MΩ.

vi) Ensure the system is de-energized before removing test cables or touching any conductive parts.

4.1.2.2 Sampling Plan:

At least 2 strings from 2 SMUs shall be randomly chosen by the Owner connected to each Inverter.

Acceptance criteria

The DC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 62446:2016 – 6.

4.2 AC COMMISSIONING

4.2.1 Visual Inspection

The visual inspection shall be conducted on 5% of the system. In general, the requirements specified in the IEC 60364-6 -6.4.2 apply. At least following aspects shall be verified visually on the AC side:

4.2.1.1 General requirements

- Protective requirements against electric shock
- Protection against fire and heat

- Choice, setting, selectivity and coordination of protective and monitoring devices
- Sizing of cables regarding voltage drop and ampacity as per approved Drawings.
- Sizing of protective and monitoring devices as per approved Drawings
- The circuit breakers are correctly located
- Selection, location and installation of suitable isolating, overvoltage protective devices and switching
- The equipment and protective measures are appropriate for the external influences and mechanical stresses
- The diagrams, warning notices or similar information attached to the wall inside the inverter housing or the control room
- Proper fixation of the cables to the collector bars in the AC combiner box
- Proper labelling of all electrical circuits and devices including the neutral conductor and protective conductor as well as correct connection of single pole devices to the phase conductors
- Adequacy of termination and connection of cables and conductors
- The warning labels and technical documentation physically displayed
- Selection and installation of earthing arrangements, protective conductors and their connections
- The existence and correct use of protective conductors and protective equipotential bonding conductors (PEB)
- Measures against electromagnetic disturbances implemented
- Easy access to the operational devices for maintenance
- Any exposed conductive parts connected to the earthing system
- The RCD type has been selected according to the requirements of the IEC 62548
- The isolation means of the inverter on the AC side are functional and correctly sized
- The fire protection requirements according to the approved design shall be given

4.2.1.2 Requirements for the inverter

- Installation as per manufacturer's instructions and compliance with IEC 62548
- Inverters properly fastened to the ground
- Inverter properly earthed
- Inverter incoming/outgoing cables properly isolated, labelled and connected
- The connections for phase sequence L1, L2, L3 and N in the correct order

- All cable terminations properly done
- Nameplate data. The minimum requirements for the production of a name plate are –
    - name and origin of the manufacturer; –
    - model or type name;
    - serial number;
    - electrical parameters: Vdcmax, Vmppmin, Vmppmax, Idcmax, Pac,r, Vac,r, f r , Iacmax;
    - degree of protection;
    - overvoltage category;
    - safety class.
- The displays - check / readout show plausible results
- The filters are clean and properly maintained
- The cooling outputs of the inverters are free from obstruction
- The DC circuit breaker is functional
- The DC insulation monitoring correctly installed
- The fuses at the DC entrance correctly sized
- The location of the inverter(s) in the field matches the approved design
- Protection against self-loosening of clamps and screws
- The string inverter anchored to the mounting structure
- The mechanical assembly is robust
- The inverters are fixed to non-flammable mechanical elements

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as “critical”, “important” or “minor”.

4.2.2 Pre-Energizing Tests

Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the AC circuit forming the PV array:

- Continuity of conductors. The requirements in IEC 60364-6:2016 – 6.4.3.2 apply
- Insulation resistance of the electrical installation. The requirements in IEC 60364-6:2016

– 6.4.3.3 apply

- Insulation resistance testing to confirm the effectiveness of protection by SELV, PELV or electrical separation. The requirements in IEC 60364-6:2016 – 6.4.3.4 apply
- Insulation resistance/impedance of floors and walls. The requirements in IEC 60364-6:2016 - 6.4.3.5 apply
- Polarity test. The requirements in IEC 60364-6:2016 - 6.4.3.6 apply
- Testing to confirm effectiveness of automatic disconnection of supply. The requirements of the IEC 60364-6:2016 – 6.4.3.7 apply
- Testing to confirm the effectiveness of additional protection. The requirements of the IEC 60364-6:2016 – 6.4.3.8 apply.
- Test of phase sequence. The requirements of the IEC 60364-6:2016 – 6.4.3.9 apply
- Functional tests. The requirements of the IEC 60364-6:2016 – 6.4.3.10 apply
- Voltage-drop. The requirements of the IEC 60364-6:2016 – 6.4.3.11 apply

Acceptance criteria

The AC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 60364 – 6.

4.2.3 Additional Pre-Energizing Tests

All of the below tests shall be conducted in accordance with the supplier's installation/commissioning manuals.

4.2.3.1 Distribution boards and combiner boxes

Site testing on distribution boards shall include:

- Mechanical functional test of all components including mechanical interlocks
- Electrical functional test of all control and protection wiring against the approved switchgear schematics
- Power frequency overvoltage test (flash test) on the switchgear including circuit-breakers in the test circuit
- Low resistance duct or test on the switchgear including circuit-breakers in the test circuit
- Visual inspection
- Verification of earthing

4.2.3.2 Inverters

Site testing on inverters shall include:

- Full test procedure as defined by the inverter manufacturer
- A full mechanical functional test of all components including mechanical interlocks
- Verification that the inverter operational parameters have been programmed to local regulations
- Electrical functional test of all control and protection wiring against the approved switchgear schematics as per approved MQP/FQP
- Insulation resistance test and earth residual current monitoring test
- Anti-islanding functionality
- High Voltage overvoltage test
- SCADA and metering calibration & functionality test

4.2.3.3 HT Switchgear

Site testing on outdoor circuit-breakers shall include:

- Functional check of all wiring, interlocks, auxiliaries and pressure devices
- Timing test and travel curve
- Visual inspection

4.2.3.4 LV/MV transformers

Transformer commissioning shall include:

- Visual inspection, alignment, earthing and labelling
- Functional check of all wiring against the approved transformer schematics
- Testing and calibration of all transformer protection and monitoring devices
- Insulation resistance test
- Functional test of off-circuit/on Circuit tap changer and check of the continuity of all windings

4.2.3.5 Substation/Power Transformers

- Ratio measurement on all tap changer settings
- Winding resistance measurement on highest, lowest and nominal tap settings
- Insulation resistance between all windings, and each winding to earth
- Insulation resistance core-to-earth
- Oil sample tests: breakdown strength, moisture content, and dissolved-gas content
- Transformer differential protection scheme testing

Acceptance criteria

The test results shall be aligned with the manufacturer specifications stated in the installation manual.

4.3 IV CURVE TESTING

The requirements of the IEC 62446-1:2016 – 7.2 apply. Following normative references shall be considered while performing the IV curve test:

- IEC 61829:2015 Photovoltaic (PV) array - On-site measurement of current-voltage characteristics
- IEC 60891:2009 Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics

2 % of the module strings shall be measured. If $\Delta P_{stringN}$>5%, all the modules within that string shall be I-V characterized. Modules with ΔP_N>5% shall be replaced. If more than 5% of the measured strings of the first sample show ΔP_N>5%, another 2% shall be inspected. If more than 5% of the measured strings in the second sample show ΔP_N>5%, another 5% shall be inspected. If more than 5% of the measured strings in the third sample show ΔP_N>5%, another 10% shall be inspected. If more than 5% of the measured strings in the fourth sample show ΔP_N>5%, another 10% shall be inspected. The reference power value is the flash list value minus the light induced degradation (LID) value in the datasheet/module warranty.

Acceptance criteria

The power determination analysis will be passed when less than 5% of the modules measured in the last sample show ΔP_N<5%.

5 Hot Commissioning

5.1 INFRARED INSPECTION

Following normative references apply:

- PV array infrared camera inspection procedure **(**IEC 62446-1:2016 - 7.3) and IEC 62446-3 TS Ed.1.0 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 3: Outdoor infrared thermography of photovoltaic modules and plants (draft)

- The infrared inspection shall be applied both to the PV modules and the BOS components

The inspection sample will depend on the project size and shall be agreed with the OWNER. The following values serve as an orientation:

- Large scale ground mounted PV plants
  - PV modules: 100%
  - Inverters: 100%
  - Combiner boxes: 100%

Acceptance criteria

The following conditions shall be met simultaneously:

- 0.2% or less of the inspected modules show thermal gradients at the cell level of T > 10 K
- 0.2% or less of the inspected modules show thermal gradients at the junction box level of T > 10 K
- 0.2% or less of the inspected modules show inactive cell strings
- No PID is detected
- All module strings are connected and producing
- All inverters are connected and producing

5.2 INVERTER AVAILABILITY TEST

5.2.1 Calculation of the Operation Time

It shall be calculated on inverter level. The operation time starts as soon as the inverter switches on. Therefore, only the logged irradiation values during the operation time of the inverter shall be considered. Irradiation values logged before or after the inverter running time shall be disregarded.

5.2.2 Calculation of the Downtime

The downtime relevant for the availability calculation is any time in which a part or a subpart of the system is not operational. The outage periods shall be considered again on inverter level. Only complete outages shall be taken into consideration. System black-out periods due to following reasons shall not flow into the calculation (i.e., excluded events):

- A failure in the distribution grid or the transformer substation, making it impossible to transmit the generated power
- Solar radiation below the level needed to obtain the minimum operating voltage to start the inverter operation

- Causes of Force Majeure.
- Occurrences of anomalies in the power supply system (frequency differences or voltage surges) that trigger the protective systems of the plant or the limit settings of the inverter

Any forced disconnection shall be documented and recorded.

Acceptance criteria
The system availability shall be at least 99% during the testing period.

5.3 SINGLE AXIS TRACKER AVAILABILITY TEST (IF APPLICABLE)

The tracker availability test shall be carried out in parallel to the inverter availability test and shall have the same duration. During the test, all trackers shall follow the sun according to the angles established in the tracking mechanism. A loss of availability shall be considered when the angle of inclination of one or more trackers deviates by more than 2° from the theoretical angle. The angles of inclination of each tracker shall be recorded with a resolution of 1min via the SCADA system.

Acceptance criteria
The tilt angle of each tracker shall lie within a ±2° range during 99.5% of the operational time.

5.4 SCADA AND WEATHER STATION RELIABILITY

5.4.1 Visual Inspection

- Installation of the communication system architecture diagram according to the specifications
- Functional Tests conducted during FAT for Pre-Dispatch Inspection shall be repeated.
- SCADA shall be linked to all protection relays, disturbance recorders and other substation equipment using the communications protocol
- Visual check on the assembly of all joints and on the as-installed condition of all components, including:
    - The irradiation sensor is not shaded and is installed at the correct tilt angle and under CCTV coverage.
    - Ambient temperature and module temperature sensor are installed properly (Reference IEC 61724)

- Mechanical anchorage of the sensors is robust
- Complete calibration certificates of all the instruments shall be provided

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as “critical”, “important” or “minor”.

6 Battery Energy Storage System

6.1 VISUAL INSPECTION

Before energizing the BESS, following visual checks shall be made to check the required design compliance:

- Installation of protective cover for live, hot and cold parts, and the adequate distance from the person;
- Installation of fence, wall, locking system of doors and access panels, and notice boards
- Installation of ventilation system;
- Installation of firefighting system;
- Installation of lightning protections devices.
- Wiring
    - All wiring shall be continuous and without splices.
    - Wiring that may be exposed to mechanical damage are placed in conduit or armoured.
    - Wires have permanent and durable identifying labels or markings on both ends.
    - Control and instrumentation wiring shall be separated from power and high-voltage wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips.
    - BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner.
    - Cable systems do not block access to equipment by personnel. There are no exposed current-carrying or voltage-bearing parts.

6.2 CONTINUITY TEST

Continuity of power, control and auxiliary circuit in the system shall be verified through visual inspection, continuity tester and insulation resistance test.

Phase sequence and terminal marking shall also be verified with drawing and design documents.

6.3 EARTHING TEST

Following element to be check according to the design and applicable standards:

- Proper connection of the earthing busbar to the local earthing busbar;
- Individual earthing connection of main equipment to the earthing busbar;
- Connection of earthing cables to structures via proper connectors to prevent corrosion from dissimilar metals.

6.4 INSULATION TEST

For low-voltage EES systems, the insulation resistance test and withstand voltage test shall be performed according to IEC 60364-6.

For EES systems exceeding 1 kV AC or 1,5 kV DC, the withstand voltage test shall be performed according to IEC 61936-1.

6.5 FUNCTIONAL TEST

6.5.1 Start and stop test

Check start and stop operation of BESS system with the startup/shutdown command manually and automatically.

6.5.2 Alarms Functional Test

Alarms initiation from the BESS in case of following conditions:

- Emergency trip switch.
- Loss of the low-voltage AC or utility grid voltage.
- An AC circuit breaker trip (either side of transformer).
- Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
- Smoke/fire alarm.
- A DC ground fault (simulated).
- Remote disable (no reset required).
- Grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
- Abnormal voltage
- Islanding condition.
- Protection or control scheme failures, including the following:
  - Failure of local interconnection protection system
  - Failure of critical breaker trip coil
  - Loss of Container DC Control supply

6.5.3 Load tripping test

Check the interlock of BESS with the main

6.5.4 Operating cycle test

Check for any abnormalities such as rise in temperature, noise level and vibration in ESS system during rated input and output power operation.

6.5.5 Verification of Settings/Control Points

Verification of settings/control points and provision for modification of various set points and fixed operation/control settings associated with the various control functions, as available.

Operator Controls:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.
- Selector to select remote or local operation
- Selector to manually set the operating state or have the control system set the operating state automatically.

6.5.6 Communication test

Verified that measuring, alarm, fault indication, message and control and monitoring system operations are correct transmitted and received by the SCADA system.

6.6 SYSTEM RATING VERIFICATION

BESS rating including rated power, energy available at rated power, and the performance of the BESS associated with different performance metrics mentioned herein taken at the beginning of life shall be based on a set of ambient operating conditions specified by the BESS Original Equipment Manufacturer (OEM) for the Project site. The Contractor shall also provide an indication of how the performance of the BESS with respect to the metrics is expected to change over time, to account for time and use of the system, and report the same periodically.

1. Energy Content Test:

Energy Content Test shall be performed in accordance with the following steps:

a) The BESS shall be charged to its full available energy level at rated input power in accordance with the system specifications and operating instructions.

b) The BESS shall be discharged at the rated power of the system in accordance with the system specifications and operating instructions. The system shall be discharged to the minimum available energy level associated with the system specification and operation instructions (including the needed rest times between input and output power operation).

(c) The constant output power, output time and energy consumption of the auxiliary subsystem shall be measured and recorded during output. The actual energy capacity is calculated as follows:

Case I: If the auxiliary subsystem is fed internally, actual energy capacity is calculated by following equation.

$$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t \quad (1)$$

where,

Eo is the calculated total output energy at the POC (kWh);

POi is the active output power at time i, measured at the POC (kW);

Δt is the sampling time of the measurement (h);

n is the discharge time (h).

Case II: If the auxiliary subsystem is fed from other feeder, actual energy capacity is calculated by following equation.

$$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t - E_{aux\_o} \quad (2)$$

where,

Eo is the calculated total output energy at POC (kWh);

POi is the active output power at time i, measured at the POC (kW);

Δt is the sampling time of the measurement (h);

Eaux_o is the energy consumption of the auxiliary subsystem measured at the auxiliary POC during the output operation (kWh);

n is the discharge time (h)

This test shall be conducted 3 times for 100% Rated Power, 1 time each for 75%, 50%, 25% of rated power. Data shall be collected from the Plant SCADA and the following data shall be tabulated in Table 1 for each case.

<table>
<tr><td colspan="4">Case 1: Auxiliary subsystem is fed internally</td><td colspan="3">Power: ___ % of Rated Value = _____ MW</td></tr>
<tr><td rowspan="2">Parameter</td><td colspan="3">Observed during Charging</td><td colspan="3">Observed during Discharging</td></tr>
<tr><td>Power
P_I</td><td>Energy
E_I</td><td>Duration
T_I</td><td>Power
P_O</td><td>Energy
E_O</td><td>Duration
T_O</td></tr>
<tr><td>Unit</td><td>kW</td><td>kWh</td><td>h</td><td>kW</td><td>kWh</td><td>h</td></tr>
<tr><td></td><td>(a)</td><td>(b)</td><td>(c)</td><td>(d)</td><td>(e)</td><td>(f)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Actual Energy Content (kW</td><td colspan="3">$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t$</td><td colspan="2"></td></tr>
</table>

Case 2: Auxiliary subsystem is fed from other feeder					Power: ___ % of Rated Value = _____ MW			
Parameter	Observed during Charging				Observed during Discharging			
	Power P_I	Energy E_I	Duration T_I	Aux Con. E_{aux_I}	Power P_O	Energy E_O	Duration T_O	Aux Con. E_{aux_O}
Unit	kW	kWh	h	kWh	kW	kWh	h	kWh
	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)
Actual Energy Content (kWh)	$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t - E_{aux\_o}$							

Criterion: BESS stored Energy capacity shall be at least total energy dispatchable as specified in the Section V: Technical Specifications at rated Power at the time of commissioning.

2. Round-trip energy efficiency (RtE, η)

The EES system shall be tested for its roundtrip efficiency following the test procedures a) to c) presented in Section 1. This test shall be performed under the rated input active power and rated output active power.

The roundtrip efficiency ηrt shall be determined in accordance with Formulae (3) and (4) for N cycles (at least three for 100% and 1 each for 75%, 50% and 25% of Rated Power) based on the data secured from the tests conducted in accordance with the provisions in 5.1.1, taking into account possible auxiliaries power consumption from auxiliary POC during idle/rest times.

Case I:

$$\eta_{rt} = \frac{E_{out}}{E_{in}} \quad \text{................(3)}$$

Where,

Eout is the Total Energy Discharged from BESS as recorded in the Energy Meter(s) at the POC.

Ein is the Total Charging Energy into the BESS as recorded in the Energy Meter(s) at the POC.

Case II:

$$\eta_{rt} = \frac{E_{out} - E_{aux,o}}{E_{in} - E_{aux,i}} \quad \text{................(3)}$$

The roundtrip efficiency shall be reported as shown in Table 2. In case more than 1 cycle is performed, round trip efficiency shall be reported based on average values:

	Energy E_{in}	Energy E_{out}	Aux Cons. $E_{aux,i}$	Aux Cons. $E_{aux,o}$	Roundtrip Efficiency
	kWh	**kWh**	**kWh**	**kWh**	**%**
	(p)	**(q)**	**(r)**	**(s)**	**(t)**
Test 1					
Test 2					
…					
Test N					
Average					

Criterion: $\eta_{p,}$ as determined through the process described above shall be at least equal to the guaranteed RtE described elsewhere in this document at the time of commissioning.

SUB-SECTION D

GENERAL ANNEXURE J

Functional Guarantee (FG) Test Procedure

TABLE OF CONTENTS

1 INTRODUCTION

This document lays down the procedures and requirements for conducting Functional Guarantee tests including scope of the tests, procedures for the tests, reporting formats and process for determining test results in accordance with the Tender Specifications, applicable standards and industry best practices.

2 FUNCTIONAL GUARANTEE TESTS FOR SOLAR PV PLANT

The Functional Guarantee shall comprise of a set of visual/mechanical/Electrical checks followed by a Performance Guarantee (PG) Test of the Plant Facilities in which estimation of Performance Ratio (PR) shall be carried out.

2.1 PERFORMANCE GUARANTEE (PG) TEST

A Performance Guarantee test shall be carried out after the commissioning of Plant Facilities to demonstrate that the plant has achieved the **Guaranteed Performance Ratio** in line with requirements under section VII of the bidding document. This will be one of the pre-conditions for the Plant Operational Acceptance. Performance Guarantee (PG) test period would be continuous measurement of 30 consecutive days. The test shall be conducted in accordance with the IEC-61724 as per the methodology described in Technical Specifications under section VII of the bidding document. General requirements & Procedure of PG test are described further in Section 2.1.3 & Section 2.1.4 respectively. The report shall contain all the measured energy and Met data values, calculations, results and conclusions.

2.1.1 Pre-PG Test

2.1.1.1 The EPC Contractor shall perform start-up tests after completion of Commissioning and Test Procedure as per Annexure – C: Plant Documentation, Commissioning and Test Procedure and recording of punch points.

2.1.1.2 Performance Guarantee Test shall commence immediately after all issues arising from the functional/ start-up test have been rectified.

Note:

(a) All measurement(s) shall be carried out taking proper safety precaution.

(b) Also it shall be ensured that to avoid any loose connection at the terminal points for which measurement procedure is conducted.

(c) Ensure proper functioning (e.g. Mustimeters shall be calibrated) of all measuring instruments before conducting above measurement procedure.

(d) The above test procedure shall be conducted in presence of site in-charge.

2.1.2 Performance Ratio

The Performance Ratio (PR) of the PV Plant **in a reporting period** shall be calculated as follows (according to IEC 61724).

$$PR_{temp.corrected} = \frac{E_{out}}{\sum_k \left(\frac{(C_k \times P_n) \times (G_{i,k} \times \tau_k)}{G_{i,ref}} \right)}$$

Where,

E_{out} Cumulative Plant Generation measured at Plant End ABT meter over the **duration of reporting period** (kWh), (1/4) hour

P_o Installed nominal peak power of PV modules, i.e. Nameplate rating at STC (kW_p)

P_n $P_n = P_o X(1 - DFXn)$, where DF is the module degradation factor, which shall be considered as per PV Module Datasheet, n is the is the number of years of operation after operational acceptance. For operational acceptance, $n = 0$

τ_k Duration of the k^{th} recording interval, i.e. (1/60) hour

$\sum_k$ Summation over all recording intervals in the reporting period, (1/4) hour

$G_{i,k}$ Average irradiance measured at the Plane of Array (POA) at the commencement of time interval τ_k (kW/m^2) (**average of all Pyranometers installed in various sites**)

$G_{i,ref}$ Irradiance value at which P_o is determined, i.e. 1 kW/m^2

C_k Power rating temperature adjustment factor and can be calculated as below

Ck = 1 + γ x ($T_{avg\_mod,k}$ – T_{ref})

γ Temperature coefficient of power with negative sign ($°C^{-1}$)

$T_{avg\_mod,k}$ Avg. PV Module temperature measured at the commencement of time interval 'τ_k' (°C) (**average of all Module Temperature sensors installed**)

T_{ref} PV Module temperature at which P_o is determined, i.e. 25°C

2.1.3 **General Requirements**

- The PG test shall commence within 60 days of the commissioning of Plant Facilities.
- The PG test shall be carried out for a period of 30 days at site by the Contractor in presence of the Employer/ Employer's Representative/ Owner's Engineer.
- The date of commencement of the PG Test shall be communicated in advance and agreed upon by both parties i.e. SECI and EPC Contractor. Any consecutive 30 days period (excluding interruptions that last entire day on account of grid outage or as per hindrance record maintained at site or weather conditions) for the purpose of conducting PG test shall be mutually discussed and agreed between SECI and EPC Contractor.
- These tests shall be binding on both the parties to the contract to determine compliance of the equipment with the guaranteed performance parameters.
- The test shall consist of guaranteeing the correct operation of the Plant Facilities, by way of the performance ratio based on the reading of the energy produced and delivered to the grid (ABT meter) and the Plane of Array incident solar radiation.

2.1.4 **PG Test Procedure**

2.1.4.1 Pre-Test Requirements

(1) Before the commencement of PG test, the plant shall have completed Pre-PG tests as per Clause 2.1.1 above and SCADA system and WMS shall be fully commissioned and functional.

(2) Pyranometer Tilt Angle & Cleanness: The pyranometers & Tilt Angle shall be verified before the test commences and **then visually inspected at regular intervals for cleanliness during the tests**.

(3) The Pyranometers and Temperature sensors used for the purpose of the PG Test shall have valid calibration certificates.

(4) Trial Run: The PG Test for Plant Facilities shall commence with a trial run for 7 consecutive days. SECI shall estimate the PR for the Trial Run period and revert within 3 working days. Post the trial run period, the 30 days PG test will commence after communication from SECI.

2.1.4.2 **General Procedure for the PG Test**

(1) **Data Collection**: The EPC Contractor shall provide the raw data as per **Annexure-1 (Format for Raw Data Submission)** to SECI. PV Power Plant test related parameters are collected in one-minute and 15 intervals for the 30 (Thirty) days reference period. The data shall consist of the following at a minimum:

- Irradiance at Collector's (i.e. PV Module) POA; (Source: SCADA, Temporal Resolution: 1 minute) Average values form all the sites will be considered
- Other Met Data received from installed WMS; (Source: SCADA, Temporal Resolution: 1 minute)
- Energy generated at Plant (kWh) (Source: Plant TVM Meter from SCADA, Temporal Resolution: 1 minute)
- Energy injected into grid (kWh) (Source: Plant End ABT Meter, Temporal Resolution: 15 minute)
- PV Module Temperature recorded from the temperature Sensors (^{o}C) (Source: SCADA, Temporal Resolution: 1 minute)

(2) **Data Cleaning/Filtering:** The data shall be filtered so that the data set is free of nuisance data points and bad data that exhibit a high degree of error (such as errors caused by faulty instrumentation). The following criteria shall be excluded from the dataset used for this test:

- **Missing data:** Time blocks with missing 1-minute records shall be interpolated using average interpolation method.
- **Nuisance or bad data** – Nuisance data points or bad data that clearly exhibit a high

degree of error (eg. due to rainy/cloudy weather or meteorological measurement equipment that is identified as being out of calibration or requiring adjustment). A 15-minute time-block shall be *explicitly* flagged through a flag parameter on account of this factor after recording reasons thereof (**Note**: no filtration shall be done on site data). The same shall be corroborated/verified by SECI. Suitable statistical methods may be applied to identify such erroneous data.

- **Grid Interruptions** – Time periods (15-minute time blocks) of the grid interruptions at the utility substation, recorded manually jointly by EPC Contractor and SECI representatives shall be eliminated. Grid outage period, if any, shall be verified from SCADA.
- Any Force majeure conditions
- **Radiation Criteria –** Radiation on Plane of Array (POA) less than 200 W/m^2
- Shutdown explicitly demanded by the Owner/DISCOM/STU/CTU.
- **Note**: Minimum 24 Nos of 15-minute time blocks shall be considered to account the day for PR estimation. Otherwise the PR test shall be extended to another day.

(3) Estimation of Daily PR

- **For each reporting period (15-min time-block)** of cumulative plant generation measured at plant end ABT meter, PR shall be calculated as per the formula given in Clause no. 2.1.2
- The same shall be recorded on daily basis for each reporting period from 6:00 am to 6:00 pm as per the format provided at **Annexure-2: Sample for Daily PR Report**
- Considering minimum 24 Nos of 15-minute time blocks to account the day for PR estimation, **Daily PR shall be estimated as the average of PR calculated for 15-min time blocks falling within 99% confidence interval**.
- This exercise shall be carried out & recorded for a period as specified in Point (4) below.
- The filled-in format (Daily PR Report) shall be signed by both the parties (EPC Contractor and SECI) and each party will keep one copy for record.

(4) Final PR Calculation

- Final PR of the plant facility shall be calculated as the **average of daily PRs for 30 consecutive days.**

2.1.4.3 PG Test Pass/Fail Criterion:

The Functional Guarantee condition for the purpose of Provisional Acceptance of the Plant Facilities shall be considered to have been met if **the average of daily PRs (for 30 days*) is greater than or equal to the guaranteed Performance Ratio (PR).**

***** 30 days excluding any interruption due to rainy/cloudy day or allowable Interruptions as per this document. Interruptions due to communication breakdown only may be exempted based on specific approval to the effect that generation is not affected and equipment failure is not attributable. In such case, the test shall be extended for affected no. of days (up to 5 days)

- During the PG test, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of a breakdown, the test may be resumed once the complete system is rectified and working properly.
- If the If the EPC Contractor is not able to demonstrate guaranteed PR during this period, **two more chances shall be given** to demonstrate the same after incorporation of suitable corrective measures. In case the contractor fails to achieve guaranteed PR even after the two more chances, further action shall be taken as per the provisions of contract.

Note: The test shall be repeated for 30 days in case of any outage of following equipment (as applicable) for more than 7 days.

- Power Transformer/Inverter Duty Transformer
- Power Conditioning Unit
- HT Switchgear Panel
- SCADA and data logger combined
- Tilted pyranometer
- Other WMS sensors

3 LIQUIDATED DAMAGES FOR SHORTFALL IN PR

For every 0.01 shortfall in PR below the specified PR value, liquidated damages of 1% of the Contract Value shall be levied. In case the Plant PR Shortfall is more than 0.05 below the specified PR value, then the total plant will be accepted on "as-is basis" & no payments will be made to the contractor pertaining to 'Operation Acceptance' milestone in line with the defined payment terms. However, any other earlier pending/running payments as may be applicable, will be paid to the contractor as usual.

Annexure -1 (Format for Raw Data Submission)

Temporal Resolution: 1 Minute

Date & Time dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source: TVM)

Temporal Resolution: 15 Minute (Every 15th Min record from the 1 Min Data)

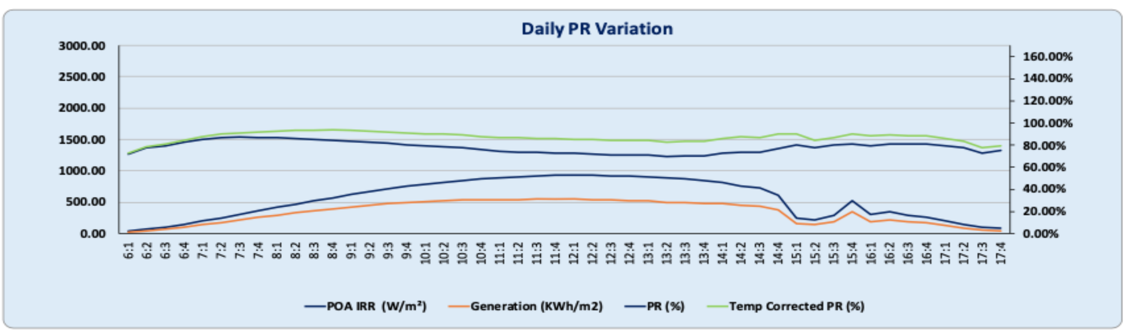
Date & Time Dd/mm/yyyy hh:mm:ss format	Wind Spe ed (m/s)	Modul e Temp. (° C)	Ambie nt Temp. (° C)	Horizontal Irradiance (W/m²)	POA Irradian ce (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Directio n(°)	Generatio n (kWh) (Source: TVM)	Explicit Remova l Flag* (0 or1)	Remarks

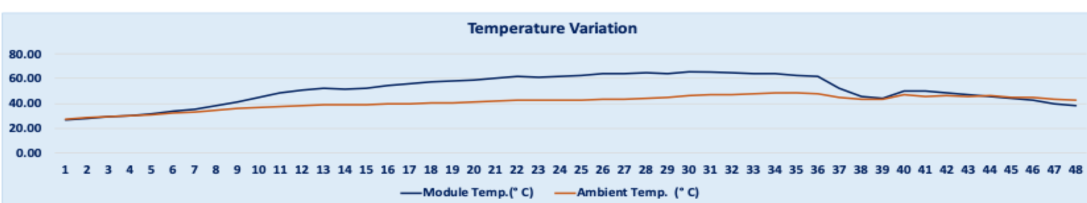
***** Explicit Removal Flag: 0 indicates time block considered; 1 indicates time block not considered.

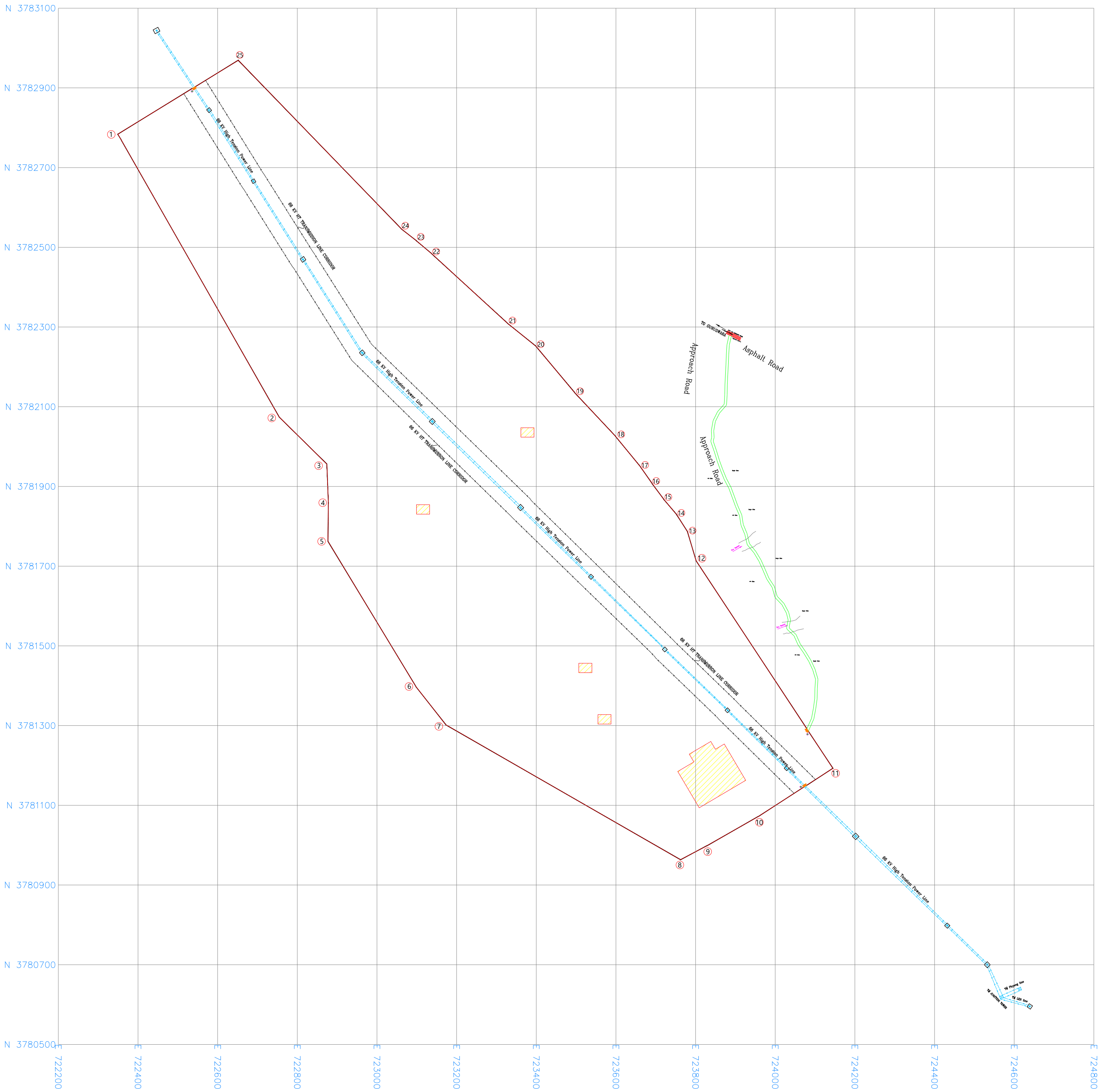
Annexure-2 (Sample Daily-PR Report)

SPV Power Plant								PG Test Start Date	-
Date	PR	Temp corrected PR	Valid No. of Time Blocks considered (out of 48)	Avg Module Temperature	Avg POA IRR (W/m2)	Total Generation (KWh) (from 6:00 am to 6:00 pm)	Criterion	1. Time period from 6:00 AM to 6:00 PM (48 15-min Time Blocks) is con	
								2. Average PR (temp corrected) of 15 min time blocks where POA Irradiance is greater than 200W/m2 and not explicitly removed	
03/06/23	76.77%	87.15%	40	54.81	573.04	32718.71		3. Guranteed PR : 80 %	

Time Block	Date & Time	Humidity	Wind Speed (m/s)	Module Temp.(° C)	Ambient Temp. (° C)	POA IRR (W/m²)	POA RAD (k-Wh/m²)2	GHI (W/m²)	Cum Generation (kW-h)	Gen ABT	Scaled Generation	PR	Temp Corrected PR	Date	Explicit Removal	Flag for POA <200 W/m2	Comments
6:1	03/06/2023 06:00:00	95.89	0.48	26.70	27.25	40.80	0.0104	53.93	48.86	48.864488	24.43	72.17%	72.66%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
6:2	03/06/2023 06:15:00	91.75	0.07	28.17	28.36	69.47	0.0176	93.67	137.77	88.90599	44.45	77.57%	78.56%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
6:3	03/06/2023 06:30:00	86.78	0.55	29.41	29.53	105.33	0.0267	138.93	275.76	137.98499	68.99	79.58%	81.01%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
6:4	03/06/2023 06:45:00	84.72	0.77	30.42	30.20	151.00	0.0382	193.67	480.07	204.31882	102.16	82.38%	84.20%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
7:1	03/06/2023 07:00:00	80.69	0.87	31.78	31.16	199.67	0.0503	250.33	758.53	278.45999	139.23	85.14%	87.51%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
7:2	03/06/2023 07:15:00	76.63	0.73	33.92	32.47	249.33	0.0628	304.40	1113.87	355.33982	177.67	87.09%	90.31%	03/06/23	TRUE	FALSE	
7:3	03/06/2023 07:30:00	74.26	0.90	35.49	33.37	303.00	0.0762	358.53	1546.21	432.33266	216.17	87.29%	91.11%	03/06/23	TRUE	FALSE	
7:4	03/06/2023 07:45:00	67.05	1.39	37.86	34.43	359.27	0.0903	415.87	2056.76	510.55665	255.28	86.98%	91.70%	03/06/23	TRUE	FALSE	
8:1	03/06/2023 08:00:00	59.38	1.03	41.49	35.65	415.40	0.1043	474.20	2643.43	586.66199	293.33	86.53%	92.65%	03/06/23	TRUE	FALSE	
8:2	03/06/2023 08:15:00	52.85	1.83	45.13	36.73	468.87	0.1176	529.47	3299.72	656.29699	328.15	85.83%	93.34%	03/06/23	TRUE	FALSE	
8:3	03/06/2023 08:30:00	49.11	1.68	48.43	37.79	520.73	0.1306	582.00	4020.24	720.51816	360.26	84.85%	93.63%	03/06/23	TRUE	FALSE	
8:4	03/06/2023 08:45:00	44.38	2.29	50.74	38.50	572.47	0.1435	632.93	4804.83	784.59082	392.30	84.11%	93.77%	03/06/23	TRUE	FALSE	
9:1	03/06/2023 09:00:00	41.76	2.54	52.16	39.10	620.47	0.1555	679.27	5646.61	841.77632	420.89	83.26%	93.41%	03/06/23	TRUE	FALSE	
9:2	03/06/2023 09:15:00	40.55	4.05	51.82	38.87	669.87	0.1679	725.67	6549.93	903.32567	451.66	82.80%	92.75%	03/06/23	TRUE	FALSE	
9:3	03/06/2023 09:30:00	39.99	3.41	52.56	39.19	715.27	0.1792	767.80	7499.37	949.43499	474.72	81.52%	91.62%	03/06/23	TRUE	FALSE	
9:4	03/06/2023 09:45:00	38.73	3.49	54.55	39.67	757.40	0.1897	805.67	8485.80	986.42998	493.21	80.01%	90.73%	03/06/23	TRUE	FALSE	
10:1	03/06/2023 10:00:00	38.57	3.65	55.64	39.91	792.47	0.1984	836.80	9505.12	1019.3182	509.66	79.05%	90.09%	03/06/23	TRUE	FALSE	
10:2	03/06/2023 10:15:00	37.93	3.45	57.07	40.46	820.87	0.2055	861.73	10549.49	1044.3768	522.19	78.20%	89.71%	03/06/23	TRUE	FALSE	
10:3	03/06/2023 10:30:00	37.61	3.93	57.89	40.60	846.67	0.2119	884.80	11613.24	1063.7515	531.88	77.25%	88.95%	03/06/23	TRUE	FALSE	
10:4	03/06/2023 10:45:00	36.27	3.19	59.07	41.27	867.93	0.2171	904.27	12680.44	1067.1957	533.60	75.63%	87.56%	03/06/23	FALSE	FALSE	
11:1	03/06/2023 11:00:00	33.92	3.00	60.34	41.89	887.00	0.2219	920.07	13753.89	1073.4476	536.72	74.43%	86.69%	03/06/23	FALSE	FALSE	
11:2	03/06/2023 11:15:00	32.28	3.12	61.58	42.26	903.13	0.2260	932.60	14838.29	1084.3995	542.20	73.83%	86.48%	03/06/23	FALSE	FALSE	
11:3	03/06/2023 11:30:00	30.53	3.63	61.13	42.43	916.07	0.2291	935.73	15931.49	1093.1985	546.60	73.41%	85.81%	03/06/23	TRUE	FALSE	
11:4	03/06/2023 11:45:00	29.64	3.03	61.88	42.77	927.73	0.2320	945.67	17033.21	1101.7213	550.86	73.07%	85.72%	03/06/23	TRUE	FALSE	
12:1	03/06/2023 12:00:00	28.59	3.60	62.34	42.92	932.93	0.2334	946.47	18131.91	1098.7028	549.35	72.43%	85.15%	03/06/23	TRUE	FALSE	
12:2	03/06/2023 12:15:00	28.19	2.63	63.76	43.63	931.53	0.2328	947.47	19216.36	1084.4462	542.22	71.66%	84.81%	03/06/23	TRUE	FALSE	
12:3	03/06/2023 12:30:00	27.93	2.67	64.24	43.42	923.80	0.2309	937.00	20282.07	1065.717	532.86	71.01%	84.23%	03/06/23	TRUE	FALSE	
12:4	03/06/2023 12:45:00	27.50	2.84	64.46	43.81	917.13	0.2292	926.87	21338.36	1056.2852	528.14	70.90%	84.19%	03/06/23	TRUE	FALSE	
13:1	03/06/2023 13:00:00	26.58	2.51	64.25	44.78	903.67	0.2257	909.73	22377.62	1039.265	519.63	70.83%	84.02%	03/06/23	TRUE	FALSE	
13:2	03/06/2023 13:15:00	25.43	1.87	65.22	46.47	886.80	0.2216	889.53	23380.47	1002.8472	501.42	69.64%	82.99%	03/06/23	TRUE	FALSE	
13:3	03/06/2023 13:30:00	24.70	1.92	65.29	47.12	867.87	0.2168	868.07	24368.03	987.56266	493.78	70.08%	83.54%	03/06/23	TRUE	FALSE	
13:4	03/06/2023 13:45:00	24.78	2.01	64.69	47.11	847.33	0.2117	845.00	25337.71	969.67798	484.84	70.48%	83.78%	03/06/23	TRUE	FALSE	
14:1	03/06/2023 14:00:00	23.28	1.75	63.95	47.59	817.87	0.2021	813.60	26293.31	955.59632	477.80	72.75%	86.18%	03/06/23	FALSE	FALSE	
14:2	03/06/2023 14:15:00	22.54	1.81	64.01	48.47	752.20	0.1897	763.60	27201.72	908.41583	454.21	73.68%	87.31%	03/06/23	FALSE	FALSE	
14:3	03/06/2023 14:30:00	22.63	1.35	62.69	48.45	727.80	0.1816	725.00	28071.84	870.11766	435.06	73.70%	86.78%	03/06/23	FALSE	FALSE	
14:4	03/06/2023 14:45:00	21.79	1.90	61.46	47.88	615.27	0.1496	614.33	28820.61	748.77165	374.39	77.01%	90.15%	03/06/23	TRUE	FALSE	
15:1	03/06/2023 15:00:00	23.19	1.24	51.98	44.87	245.40	0.0613	258.40	29141.19	320.58199	160.29	80.50%	90.24%	03/06/23	TRUE	FALSE	
15:2	03/06/2023 15:15:00	25.40	1.69	45.63	43.02	219.73	0.0550	217.00	29417.98	276.78165	138.39	77.40%	84.36%	03/06/23	TRUE	FALSE	
15:3	03/06/2023 15:30:00	25.75	1.64	44.08	43.21	289.07	0.0749	291.80	29807.40	389.42049	194.71	79.99%	86.60%	03/06/23	FALSE	FALSE	
15:4	03/06/2023 15:45:00	23.97	1.47	49.73	47.23	521.73	0.1304	512.87	30493.75	686.35149	343.18	80.96%	89.85%	03/06/23	TRUE	FALSE	
16:1	03/06/2023 16:00:00	24.38	1.39	50.12	45.49	299.73	0.0743	294.93	30876.56	382.80898	191.40	79.26%	88.11%	03/06/23	FALSE	FALSE	
16:2	03/06/2023 16:15:00	23.92	1.03	48.38	46.33	343.53	0.0849	335.27	31323.22	446.66715	223.33	80.96%	89.31%	03/06/23	TRUE	FALSE	
16:3	03/06/2023 16:30:00	23.79	1.42	46.76	45.77	289.40	0.0721	287.73	31701.29	378.06216	189.03	80.70%	88.39%	03/06/23	FALSE	FALSE	
16:4	03/06/2023 16:45:00	23.65	1.11	45.91	46.01	260.53	0.0647	256.33	32041.65	340.35866	170.18	80.92%	88.31%	03/06/23	FALSE	FALSE	
17:1	03/06/2023 17:00:00	23.53	1.12	44.35	45.17	208.73	0.0517	207.00	32309.09	267.44699	133.72	79.57%	86.25%	03/06/23	FALSE	FALSE	
17:2	03/06/2023 17:15:00	23.64	1.03	42.25	44.59	151.27	0.0373	150.67	32497.32	188.22849	94.11	77.71%	83.46%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
17:3	03/06/2023 17:30:00	25.35	0.84	39.84	43.49	103.07	0.0256	103.60	32618.57	121.24699	60.62	72.82%	77.41%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2
17:4	03/06/2023 17:45:00	26.49	1.11	38.09	42.43	83.13	0.0205	84.53	32718.71	100.14316	50.07	75.00%	79.14%	03/06/23	TRUE	TRUE	Radiation less than 200 W/m2







SITE CORNER COORDINATES

UTM ZONE - 43S

Corner Point No.	EASTING	NORTHING
1	722349.16	3782783.93
2	722754.21	3782074.57
3	722874.23	3781956.04
4	722877.98	3781857.99
5	722876.86	3781762.72
6	723097.81	3781397.80
7	723173.00	3781302.00
8	723762.01	3780963.52
9	723827.83	3780998.26
10	723957.59	3781071.99
11	724144.79	3781192.72
12	723801.05	3781714.04
13	723779.73	3781786.40
14	723752.57	3781829.32
15	723720.08	3781867.74
16	723690.90	3781907.24
17	723661.88	3781949.01
18	723598.90	3782025.93
19	723496.08	3782135.74
20	723399.43	3782251.54
21	723327.38	3782309.73
22	723137.74	3782483.68
23	723098.90	3782516.48
24	723061.10	3782546.40
25	722651.84	3782969.34

N

NOTES :-

LEGEND

PROJECT BOUNDARY FENCING	
66 KV HIGH TENSION POWER LINE	
APPROACH ROAD	
NALLAH	
66 KV HT TRANSMISSION LINE CORRIDOR	
ON SITE GRADING AND CONSTRUCTION AREA	
SECURITY ROOM	
GATE	

SUN FOR EVER

SOLAR ENERGY CORPORATION OF INDIA

PROJECT NAME	LEH 25 MW WITH BESS
DRAWING TITLE	SITE LAYOUT
DRAWING NO.	-------

	DRAWN BY	CHKD. BY	APPR. BY
	-------	-------	-------
DATE	-------	-------	-------

SHEET	SHEET SIZE	REV	SCALE
1 OF 1	A3	-------	-------

SUB SECTION E

Specific Annexure B

General Site Information

1. Based on the available geotechnical details of the site, silty fine sand and gravel size particles are encountered from the ground surface to about 0.5 m depth beyond which the strata comprises of gravel and boulders intermixed with fine to coarse sand. Based on visual observation, there is presence of scattered rock/boulder outcrops. The substrata comprising of gravel and boulders is non-conducive to pile boring. Drilling of pile bore may be possible with DTH. However, there is significant issue of bore collapse necessitating the use of casing. On account of colder climate, the sub-strata shall also be prone to permafrost. The Contractor is advised to inspect the site and study the nature of soil, topography and other conditions to decide the area grading, ground compaction, and foundation systems to be provided before submission of the Bid.

   Note: The above information is given for general information of the bidder. The Employer shall not be responsible for any variations in soil characteristics and other conditions, between above stated information and detailed investigations to be carried out by the Contractor during contract execution.

2. The Contractor is advised to ascertain the availability of good quality ground water at site for construction, drinking and module cleaning purpose. In case of non-availability of ground water source, the contractor shall explore the option of supply of water through water tankers. In case the water quality is not suitable for construction, drinking or module cleaning purpose, the Contractor shall install suitable water treatment facilities.

3. The possibility of encountering weakened bridges that may limit the quantum of transport, in addition to the consideration of navigating through sharp turns and narrow valleys in their logistics strategy as regards to vehicle type and weight transported, shall also be considered by the EPC contractor.

SECTION - VII

SUB-SECTION F

OPERATION & MAINTENANCE AGREEMENT

1 CONTRACT PERIOD

The term of employment under this Agreement shall begin on the date of signing of this O&M Agreement, by and between the Employer and the Contractor (the "Effective Date" or "Commencement Date") and unless terminated earlier as set forth herein, shall continue through and including the **tenth** (**10th**) anniversary of the Effective Date.

Unless otherwise agreed, the Effective date shall be the date of Issue of Completion Certificate by the Employer.

Note: Operational Acceptance of the Plant Facilities by the Employer shall be a necessary condition for signing of the O&M Agreement.

2 CONTRACTOR'S OBLIGATIONS

1.1. **Services**

During the Term of the Contract, the Contractor shall perform the services in accordance with the Operation and Maintenance Scope of work as described in Annexure-1 (Scope of Work for Operation and Maintenance) (hereafter the "Services"), and also in accordance with the other conditions as prescribed related to the operational performance under Section - VII of the Bid Document.

1.2. The Contractor shall be deemed to have allowed correct and sufficient O&M Price to cover all its obligations under the Contract and to have allowed the necessary resources to enable it to perform the Services to the standards and in the manner required. The Contractor's failure to acquaint itself with or assess any applicable condition shall neither relieve it from the responsibility for performing its obligations under the Contract nor entitle the Contractor to any additional costs or any other relief.

1.3. To the extent the Contractor reasonably believes that it is necessary to enhance the overall performance or safety of the Plant, the Contractor may propose changes and improvements to the Plant [(including the software included with respect thereto)]. The Contractor shall ensure that no modification of any equipment, change of software settings or any other alteration of equipment shall:

(i) cause a negative impact on the performance of the safety and reliability of the Plant;

(ii) adversely impact the Warranties;

(iii) adversely affect the warranties provided by the Contractors under the Contract;

(iv) conflict with the requirements under the contract; or

(v) bypass any protective equipment.

(vi) Violates any National/International Trade & IPR laws.

1.4. Any proposed modifications/changes shall not be carried out without the approval of the original equipment manufacturer and the Employer and in accordance with Performance Standards, and Technical Specifications. The Employer shall be notified of the proposed modifications along with reasons and technical note for such modifications, changes, alterations, etc., and after the modifications are carried out in accordance with the contract, an alterations activity report is to be shared with the Employer.

1.5. The Contractor shall, while rendering the Services, observe and comply with all the Applicable Laws, Good Solar Industry Practices, Ministry of New & Renewable Energy (MNRE), Ministry of Power (MoP), CEA, CERC, GRID India, SLDC/RLDC, Local DISCOM & TRANSCO, CTU guidelines and Performance Standards pursuant to the contract. The Employer shall have the right to, to the extent applicable to Services rendered by the Contractor, conduct monthly audit on Applicable Laws, health, safety and environment and all other relevant compliances. The Contractor shall provide all necessary access and supporting documents during audit which are applicable to the same. However, such audits will be planned well in advance in coordination with the Contractor, without affecting the site operation plan.

1.6. The Contractor shall provide and make available as necessary, all such skilled, experienced and qualified labour and other competent personnel as are required to perform the Services the Contractor shall ensure that its Personnel hold and continue to maintain all qualifications and licenses as required under Applicable Law to allow its Personnel to lawfully undertake performance of the Services and carry out the Contractor's other obligations under the contract. For works/services being performed on a continuous basis, the O&M Price shall be deemed to include and the Contractor shall obtain all required Government Approvals and bear any costs related thereto (including any shift or permitted overtime working, allowances, wage orders, night shift differentials, etc.).

1.7 The Contractor shall ensure that all its Personnel deployed for providing the Services have undergone adequate safety training and are appropriately skilled, qualified and experienced in performing the Services for solar farms of a similar size, scope and complexity as the Plant. The Contractor shall be responsible for all matters relating to labor relations, working conditions, training, employee benefits, safety programs and related matters pertaining to its Personnel. The Contractor shall at all times have full supervision and control over its Personnel and shall at all times maintain appropriate order and discipline among its Personnel.

1.8 Contractor shall be solely liable for and, at its sole cost and expense, arrange for the response, reporting, removal, transportation, disposal, investigation, cleanup or other remedial action (in all cases by licensed, insured, competent and professional contractors in a safe manner and in accordance with Applicable Laws) for any hazardous substances/waste existing at, in, on or under the Project.

1.9 The Contractor shall ensure availability of such Consumable Parts, Spare Parts, and Contractor's Equipment as may be necessary for the performance of the Services. The Contractor shall ensure that such Contractor's Equipment does not interfere with the operational or structural integrity of the Plant

1.10 The Contractor shall make available to the Employer the Reference Documents set forth in the Reference Documents and shall also provide the Employer with updates and revisions to the Reference Documents to the extent such updates and revisions are necessary and applicable to the performance of the Services. The Contractor shall provide the Employer with a latest version of update available of all the Reference Documents at the time of termination of the contract.

1.11 The Contractor acknowledges and agrees that other contractors of the Employer may be present at the Plant and it shall cooperate with such other contractors to allow the performance of its and their respective obligations to occur concurrently.

1.12 The Contractor shall through relevant agencies, if applicable, promptly investigate all accidents, damage or destruction, diagnosis, assessment of any potential consequential effects, estimating cost of repair, arranging for any remedial action required, making of any claims under the insurance policies and co-operating with and making reports required by the Employer or insurers.

1.13 The Contractor shall ensure that any Warranties provided under the Project Contracts are not invalidated or adversely affected by any act or omission of the Contractor during the period of such warranties.

1.14 The Energy Management System (EMS)/ Power Plant Controller (PPC) and SCADA system shall be connected with the Plant and the Contractor shall make arrangements to provide monthly reports from the SCADA system. The Contractor shall arrange to connect the Plant to the SCADA system operating at the Site enabling the remote operation of the Plant by the Contractor and to provide access to information pertaining to the Plant to the Employer's Representative at Site and SLDC/RLDC. The Employer may collect the data generated by the SCADA system in respect of the Plant from the Contractor.

1.15 The Contractor shall further provide support for the operation and maintenance of any Employer installed scope including any third-party support as may be required by any relevant Government Authority.

1.16 The Contractor shall notify and communicate to the Employer about any condition which may cause any malfunction or failure in the Project.

2. FUNCTIONAL GUARANTEES/WARRANTIES

2.1. Technical and Functional Performance Guarantee

2.1.1 The Contractor shall be responsible for meeting the performance guarantee of the Plant Facility as described in the contract. (**Annexure 2:** Functional guarantees to this O&M Agreement)

2.1.2 In case of failure to meet the functional guarantees as described in section 2.1.1 above, the Contractor shall be liable to pay applicable Liquidated damages as described in the Bid Document and represented in Annexure-2 of this document.

2.3. Guarantee of compliance in relation to Curtailment Plans (curtailment plans)

The Employer may communicate to the Contractor any curtailment plans either linked to load management, or Applicable Law, the ("**Curtailment Plans**").

The Contractor shall ensure compliance with all Curtailment Plans provided by the Employer in accordance with Performance Standards and Technical Specifications. If either the Contractor or the Employer detects a variation with respect to the Curtailment Plans, the Contractor will, at its own expense, characterise the problem, isolate the source of the problem and propose solutions to solve the problem to Employer (at the Employer' expenses in all cases other than cases where it's ascertained that the deviation was caused by a non-respect of the obligations under the contract).

2.4. Grid Connection and balance of electricity commitments

The Contractor acknowledges that to allow the Employer to inject the energy generated by the Plant Facility to the Grid and be eligible for the full tariff under the PPA, the Plant and the Contractor must comply with the requirements prescribed by Applicable Law, Good Solar Industry Practices, Performance Standards and the Grid documents and that failure to comply with such requirements may cause the Employer to either: (i) not be able to collect the tariff energy injected; and/or (ii) be subject to penalties payable to the Grid operator and/or the DISCOM and/or the power purchaser and/or any Government body. The Contractor therefore undertakes to diligently comply the requirements referred to Grid Connection and balance of electricity commitments, as prescribed under the Grid documents as provided by or on behalf of the Employer from time to time (or of which the Contractor otherwise becomes aware), and/or with the reasonable requests of the Employer associated with the compliance therewith.

3. PERFORMANCE STANDARDS

3.1 Contractor shall perform its obligations under the contract in compliance with the contract and otherwise, as applicable, in accordance with the following order of precedence (collectively, the "Performance Standards") as from time to time in force:

3.1.1 the Applicable Laws, and the requirements from the Grid Operator/SLDC/RLDC;

3.1.2 the Permits and all the related documents;

3.1.3 the terms of the contract;

3.1.4 the functional Guarantee;

3.1.5 the Reference Documents including the manufacturers recommendations;

3.1.6 Employer’s health and safety manuals and procedures and ESMP;

3.1.7 the Site Regulations;

3.1.8 the Equator Principles and the Equator Principles Requirements;

3.1.9 Good Solar Industry Practice;

3.1.10 Any relevant and reasonable instructions issued by the Employer, relevant to the scope of the contract, to the Contractor at least 15 days before the implementation of such instructions without any cost to the Contractor.

3.1.11 The terms of insurances directly relating to the Project and

3.1.12 Comply with all operation and maintenance obligations as set out under the PPA or do anything which results in a breach of the Employer's obligations under the PPA.

3.2 If there is any inconsistency between the Performance Standards, [it shall be interpreted in the order of precedence listed above provided that(i) the application of a Performance Standard does not derogate, breach, contradict, obstacle or circumvent the application of a Performance Standards appearing above such standard in the above order of precedence, and, in addition, (ii) provided that this such application does not cause a breach of Performance Standards or the Parties shall discuss and agree upon the manner in which such conflict shall be resolved.

3.3 Notwithstanding any other provision in the contract, the Contractor shall have no responsibility or obligation, save and to the extent that the Contractor is required to do so pursuant to the provisions of Additional Services, to ensure that the Plant complies with the requirements of Applicable Law, Permits, if and to the extent that the same are introduced or amended following the Commencement Date;

3.4 The Contractor shall not do or omit to do anything in the performance or discharge of its obligations or the exercise of its rights under the contract or in breach of the contract, which would cause any breach of any of the terms of the Supply Contract, Works Contract, the Applicable Law, the Permits or the terms of any Permits or the Direct Contract, and should the Contractor be in breach of the Performance Standards, it shall, on demand of the Employer, indemnify the Employer against any direct Losses arising from a breach of this Clause by the Contractor, always subject to the aggregate liability cap of the Contractor (except as otherwise agreed herein).

3.5 If the Contractor is aware of a conflict between any of the above requirements, it shall inform the Employer accordingly and the Parties shall discuss and agree upon the manner in which such conflict shall be resolved.

4. EXCLUSIONS

4.1. General

(a) Force Majeure events as per GCC

4.2. The rights of the Contractor under Exclusions shall only apply to the extent that the Excluded Risk Event has caused actual delays or substantial interference to the performance of the Contractor's obligations under his Contract, which could not have been mitigated by the Contractor's best efforts, and to such portions of Contractor's obligations directly affected by such delays or interference.

4.3. Notification of Excluded Risk Event

To the extent Contractor has actual knowledge of any loss or damage to the Plant caused by or arising from an Excluded Risk Event, it shall give Employer immediate notice of the same and provide a written report to Employer within five (5) Business Days; and the employer and Contractor shall be mutually agreed upon within (30) business day. However, that any failure of Contractor to provide such notice shall not waive, prejudice or otherwise affect the other provisions in Exclusions, except to the extent that the failure to timely notify Employer results in any additional damage or loss to the Plant. Notwithstanding the foregoing, in case of delay to provide the aforementioned notice, the Contractor shall be liable towards the Employer for any additional damage or loss caused by the delay to notify the Employer.

5. ADDITIONAL SERVICES

5.1. Employer may, with respect to the Plant, request that Contractor perform work, provide services, or supply other equipment or parts, not included within Services for the successful operation of the plant for the duration of this O&M Agreement. Any such requested service or supply that the Parties mutually agree to in writing shall, subject to any specific terms and conditions agreed with respect to such service or supply, be an "**Additional Service**".

6. SERVICE PERSONNEL

6.1. Contractor shall provide the Services and any Additional Services to be performed on Site using a sufficient number of suitably skilled, qualified and experienced (including any licensing, certifications or training required by Applicable Laws or the local transmission system operator) and adequately equipped and properly trained Personnel and/or Subcontractors, all appropriately skilled and experienced in their respective trades or occupations as may be reasonably necessary to fulfil its obligations hereunder in relation to the Services and Additional Services

6.2. The Employer may request the Contractor to remove (or cause to be removed) any Person or Subcontractor employed on the operation of the Plant, including the Contractor's Representative if applicable, who:

(i) engages in material or persistent misconduct or lack of reasonable care;
(ii) carries out duties incompetently or negligently;
(iii) fails materially to conform with any provisions of the Contract;
(iv) engages in conduct which is prejudicial to safety, health or the protection of the environment or in violation of any related Performance Standards or Applicable Laws;
(v) engages in conduct which might reasonably result in a breach of any provision of the contract and threaten public health, safety or security.

6.3. The Employer shall give notice to the Contractor of the same giving reasons and request the Contractor to replace such Personnel with a suitable candidate. The Contractor shall then as soon as reasonably possible but no later than seven (7) days upon receiving such notice from the Employer, Contractor will look in to the facts and claims of the case in all sincerity and deploy the required actions with the notice to the Employer.

6.4. Contractor shall have full supervision and control over its Personnel at the Site and shall maintain appropriate order and discipline among such personnel and shall cause any Subcontractor to maintain similar standards with respect to such Subcontractor's personnel at the Site.

6.5. The Contractor shall be responsible for all matters relating to labour relations, working conditions, training, employee benefits, employee drug testing in accordance with the Contractor's standard drug testing policy, safety programs and related matters pertaining to its employees and other Personnel engaged by the Contractor. The Contractor shall at all times have full supervision and control over its employees and other personnel engaged by it and shall at all times maintain appropriate order and discipline among its Personnel and shall cause any Subcontractor (or any subcontractor appointed by such Subcontractor) to maintain similar standards with respect to such Subcontractor's or any subcontractor appointed by such Subcontractor) employees and Personnel.

6.6. The Employer shall have the right, acting reasonably and following prior notification, to require the Contractor to remove from the Site any employee or Personnel of the Contractor or any of its Subcontractors (or any subcontractor appointed by such Subcontractor) engaged in activity which presents a risk of injury to persons or property at the Site.

7. SAFETY PRECAUTION

7.1 During performance of the Services, Contractor shall:

7.1.1 comply with the safety standards and any safety procedures established by Contractor and same shall be approved by employer after the Commencement Date;

7.1.2 take all precautions required by Applicable Laws or Site Regulations, or otherwise according to the Performance Standards, for the health and safety of Contractor, its Affiliates and Subcontractors in the performance of the Services and any other Persons with temporary or perpetual access to the Site; [provided that the foregoing shall not limit Employer's responsibility for the safety of the Site as provided in Safety Precautions.

8. CONSUMABLES, SPARE PARTS, TOOLS AND EQUIPMENT

8.1 During the Term, Contractor shall provide equipment Spare Parts and Consumables and Tools, all as part of the Services and without Additional Cost to the Employer in accordance with the contract. Unless otherwise specified in the contract, the Contractor shall provide the Employer with an initial Spare Parts inventory. At the end of the Term or upon termination of the contract, the Supplier will replenish the equal quantity of the Spare Parts and Consumables and Tools as provided during the start of Contract.

8.2 <u>Consumables and Tools</u>

Contractor shall supply Consumables and Tools to the extent required for performance of the Services. All Consumables provided by Contractor in the performance of its Services, shall be compatible with the applicable requirements of the Reference Documents and Applicable Laws.

8.3 Equipment and Spare Parts

Contractor shall supply Equipment and Spare Parts to the extent required for its performance of the Services and to maintain its obligations thereunder. The Contractor has the right to use renovated Equipment and Spare Parts. If the Contractor intends to use any refurbished Major Components, it will seek prior written approval from the Employer. Contractor's right to procure and use renovated / refurbished Spare Parts is subject to: (i) standards of good workmanship and Good Industry Practice; (ii) compliance with the applicable requirements of the Reference Documents; (iii) the Spare Part(s) are of the type being replaced or of another type insofar as same does not invalidate any applicable Type Certification of the Equipment (iv) the same warranty as equivalent new parts in terms of scope, nature and duration, (v) being renovated in conformity with the original equipment manufacturer's standards, and (v) being listed in the monthly maintenance report when used (track record of the Part).All such renovated/refurbished parts will be allowed by Employer only for any long lead items and also considering uninterrupted generation from the Project. However, the contractor shall immediately reinstate and order new items in order to replace the refurbished items provided for emergency purposes.

8.4 Inspection of Replaced Parts

Contractor shall give to the Employer seven (7) days' notice of the time when the Replaced Part is being transported to the Site. Contractor shall permit Employer to inspect, at Employer's sole cost and expense, any Part which is removed and replaced by a Spare Part pursuant to Consumables, Spare Parts, Tools and Equipment (such Part, a "Replaced Part"); provided however, any such inspection:

(i) must not include physical alteration or disassembly of such Replaced Part; and

(ii) must not result in any material increased costs to Contractor or delay Contractor in the performance of its obligations under the contract or any Contract with, or warranty from, its Subcontractors, unless Employer agrees to cover such material increased cost.

8.5 Tools and Equipment

Contractor shall furnish its service personnel with such tools, instruments, or materials tools and equipment and equipment as are necessary to perform the Services (the "**Contractor's Equipment**").

8.6 Prices of Consumables, Spare Parts and Contractor's Equipment

Subject to GST, Taxation & Import Duties, the O&M Price payable to Contractor under the contract shall include (in addition to other components included in such Price) the Costs of any and all Equipment, Consumables, Spare Parts and Contractor's Equipment required in connection with the performance of the Services.

Note: The List of Mandatory Spare Parts to be maintained under the Contract shall be as provided in the Appendix to this document.

8.7 Risk of Loss or Damage to Consumables, Spare Parts and Contractor's Equipment

Contractor shall:

(i) be responsible at its own cost for the safe transportation and delivery to Site and adequate storage; of all Consumables, Spare Parts, and Contractor's Equipment, in each case, required for the carrying out of the Services;

(ii) bear the risk of loss and damage to all such Consumables and Spare Parts during transportation to the Site and, thereafter up to the date of their incorporation by Contractor into the Plant; and

(iii) at all material times bear all risk in any and all Contractor's Equipment on or off the Site and whether remaining separate or temporarily attached to the Plant.

9. **COMMUNICATION AND REPORTING**

During the Term, Contractor shall exchange information and reports on daily, weekly, monthly, quarterly and annual basis:

9.1 Monthly Reports

Contractor shall provide Employer with the Monthly Performance Report by no later than the fifth (5th) day from the end of each month.

9.2 Emergency Notices

Upon obtaining actual knowledge thereof, Contractor shall promptly notify Employer verbally (with written notice to follow within three (3) Days) of any emergency or other hazardous condition or occurrence that Contractor reasonable believes could cause an immediate threat to the safe operation of the Plant and/or the safety of Persons.

If, by reason of an emergency arising in the course of, as a result of or otherwise in connection with and during the performance of the Services, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Plant, the Contractor must immediately perform that work, provided that, Contractor shall have no obligation to perform such portions of the protective or remedial work which would be in violation with the Performance Standards, be a material breach of the contract or would cause a threat to the safety of Persons or property or would otherwise not be reasonably practicable or possible; and provided further, that Contractor shall have no obligation to retrofit or upgrade the Plant except if otherwise agreed.

Without prejudicing the liability attributable to the Contractor for failure to comply with the provisions of the paragraph above, it is clarified that if the Contractor does not perform the protective or remedial works referred to above immediately, the Employer may appoint a Replacement Contractor to perform such works. If the work (or parts thereof) which were performed or caused to be performed by the Employer is work which the Contractor was liable to do at its own expense under the contract, the costs incurred by the Employer as a result of appointing a Replacement Contractor shall be [substantiated to the Contractor on an open book basis and be] considered due and payable to the Employer and Invoices and Payment and Set Off shall apply. It is further clarified that the impact of Replacement Contractor's actions shall not be considered as an Excluded Risk Event.

9.3 Meetings

A representative of each of Contractor and Employer (the "**Representatives**") shall meet (either at the Site or alternatively at such other location as may be agreed between the Parties) at quarterly intervals or such other period as is agreed especially for the purposes set forth below:

(i) to discuss projected dates for performance of the Services and the Additional Services in the following quarter;

(ii) to discuss, the calculated Measured Average Availability of the Plant Facility for the past quarter under Annexure 2 [Functional Guarantees]; and

(iii) to review the Services and Additional Services performed in the past quarter.

9.4 Visitors Log Book

Contractor shall provide Employer with a log book for the Plant to record the identity and activity of all visitors to site. Such log book will be kept at the entry Gate location of Plant. The Contractor shall cause that all personnel and representatives of each Party or any third parties visiting the [site] shall be required to record their identity, the date, time and purpose of any visit to site, the nature of any work performed thereon and such other details for which log books may reasonably be used. It is clarified that the Contractor shall not permit unauthorised third party access to the Site unless such third parties have been authorised by the Employer, are required to inspect or access the Site in accordance with Applicable Law or for performance of Services. Copies of these logs shall be provided to the Employer within ten (10) Business Days following its written request. Contractor shall create a digital back up of such logs at least every month. The log book shall be in English only.

9.5 Annual Calendaring of Maintenance Services.

At the latest two (2) months after the beginning of commencement date, each year during the Term thereafter, the Contractor shall send to the Employer the projected dates and times for the immediately following period during which the Contractor shall perform the Maintenance/Preventive Services on the Plant, with the parties using reasonable efforts to minimize any Plant downtime during Operational Sunny periods (the "**Maintenance Services Calendar**". Such Maintenance Services Calendar may be postponed by the Employer for 5 business days); provided, that the Maintenance Services Calendar shall be developed in accordance with the Operating Manual and the terms of the contract. The dates and times in the Maintenance Services Calendar may be amended thereafter by mutual Contract of the Parties. For clarity, the Maintenance Service Calendar shall include a maintenance plan established in accordance with the Maintenance Manual.

9.6 Status Reviews

As reasonably required, or requested by the Employer, the Representatives shall meet to discuss and review (i) the information contained in the Monthly Performance Reports, (ii) the availability of the Plant, (iii) any technical issues which may have arisen with respect to the performance, availability or maintenance and servicing of the Plant Equipment, (iv) Maintenance Services and Repair Services performed during the preceding calendar month, (v) any and all failures by a Plant equipment, and (vi) Maintenance Services to occur during the next following a calendar month.

10. **Contractor's Permits**

Prior to the time in which such Permits are required in order to perform when the relevant Services and/or Additional Services, as applicable, are to be performed, Contractor shall obtain and maintain, as applicable, throughout the Term of the Contract all Permits (the "Contractor Permits") required by the Applicable Law, Good Solar Industry Practices, Performance Standards and Technical Specifications which should be issued in the name of Contractor or are otherwise attributable or necessary to the provision of the Services and/or Additional Services, other than such Permits as are required to be obtained by Employer pursuant to *Employer Permits*.

11. **Contractor's Manager**

On or prior to the commencement of the Term, Contractor shall designate a duly qualified and experienced person to manage and administer the Contractor's activities and shall provide notice thereof to the Employer, to act as its manager and coordinator of the contract on Contractor's behalf (the "**Contractor's Manager**"). The Contractor's Manager shall not have authority to amend or modify the contract or accept any commitment which would have an effect on the contract. In case the manager is on leave with prior intimation to employer, the deputy manager with equivalent qualification shall be provided at site by the Contractor

12. **Cooperation with other Subcontractors**

Contractor acknowledges and agrees that the Employer or Other Subcontractors of Employer may be present at the Site and agrees, at no cost or expense to the Employer, to reasonably cooperate with such Other Subcontractors to allow the performance of its and their respective obligations to occur concurrently. Employer shall inform the Other Subcontractors of the clear demarcation of Contractor's scope of work so as to ensure non-interference in such work and operations by Employer's Other Subcontractors.

13. **Reserved Rights**

13.1 Plant

To the extent Contractor believes, in its reasonable discretion, that it is necessary to enhance the overall performance or safety of the Plant, Contractor may propose to Employer changes and improvements to the Plant (including the software included with respect thereto) and implement such changes or improvements proposed after obtaining the prior written consent of the Employer; provided that such changes and/or improvements shall not (i) be in conflict with the Performance Standards**;** (ii) adversely impact the technical performance of the Plant or the safety of the Plant**;** (iii) adversely impact the Availability Warranty in Annexure 2 [Functional Guarantees] (iv) increase the cost of operating the Plant; (v) place the Employer in breach of the technical requirements of the Power Purchase Contract; (vi) impair or vitiate any obligations of the Contractor under the contract; (vii) adversely affect the Supply Contract Warranties and the Works Contract Warranties; or (viii) result in non-compliance with the Type Certificate**.**

13.2 The Contractor shall only have the right to implement such changes or improvements if it has received the prior written consent of the Employer and such changes and improvements are carried out at no cost to the Employer and in accordance with Reserved Rights.

14. CERTAIN NOTIFICATIONS BY CONTRACTOR

14.1 Contractor shall, upon obtaining actual knowledge thereof, promptly give the Employer notice of:

(i) any events or facts or observations that the Contractor believes could be reasonably likely:

(a) to have a material adverse effect on the operation of any of the Plant or the performance of the Employer's obligations under the contract; or

(b) to cause an immediate threat to the safe operation of the Plant (or any Plant therein) and/or the safety of Persons; provided that, in the case of this Clause, the Contractor shall provide immediate verbal notice of such event, fact or observation to the Employer with notice to follow within three (3) Business Days);

(ii) any actual or proposed event that the Contractor believes would be reasonably likely to have a material adverse effect on the operation of any of the Plant or the performance of either Party's obligations under the contract;

(iii) any (a) violation of Applicable Laws, or Permit, by the Contractor's agents, officers, directors, employees, representatives and Subcontractors, Employer or any Other Subcontractor; or (b) any notices of Liens (or claims of Liens) or investigations by Governmental Authorities related to the Plant;

(iv) any actual or contemplated change in Law that Contractor believes would be reasonably likely to have a material adverse effect on the operation of any of the Plant or the performance of either Party's obligations under the contract.

14.2 If the Contractor does not comply with its obligations under Certain Notifications by Employer, the Contractor shall, subject to Limitations of Remedies and Liability, indemnify the Employer for any loss the Employer may suffer as a consequence, including, without limitation, compensation pursuant to Employer's Obligations.

15. ASSIGNMENT AND SUBCONTRACTING

15.1 In any event, the Contractor shall not subcontract all, or materially all of the Operation and Maintenance Services or the ultimate supervision of the performance of services under this Agreement.

15.2 The Contractor agrees and acknowledges that any review, by approval of, or failure to approve, or rejection by the Employer as to any Subcontractor shall not relieve the Contractor of any of its obligations under the contract, and the Contractor shall be liable hereunder to the same extent as if any such Subcontract had not been entered into. The Contractor shall at all times ensure and cause the Subcontractors not to commit any act or omission which could release, void, impair or waive any guarantee or warranty on the Plant or any part thereof.

15.3 The Contractor shall supervise and direct the work of all Subcontractors and be fully responsible for the performance of the Subcontractors and to the methods, techniques, sequences and procedures of, and for coordinating the work of the Subcontractors and to the acts and omissions of all Subcontractors and their employees, directors, officers, advisors, agents and representatives, and those of their subcontractors ("Subcontractors' Parties). With regard to any Subcontract and Subcontractor's Parties, in particular, Contractor shall ensure that all wages, labor, health and safety and social related obligations are duly performed and timely discharged in accordance with Applicable Laws. It is agreed that if the responsibility of any such payments is transferred to the Employer pursuant to Applicable Law, the Employer shall have the right to adjust all such payments against the dues to the Contractor under the contract or otherwise recover the same from the Contractor under any other Contract. It shall be at Contractor's sole responsibility to ensure the payment and discharge of all its obligations with regard to the Subcontracts and shall indemnify the Employer and any Employer Indemnified Parties for any losses incurred by such parties in relation to the Subcontracts or to Subcontractor's Parties.

16. Inspection and Testing

16.1 The Contractor must provide the Employer, independent engineer, Grid Operator, Grid Administrator, and any other Contractor or Contractors employed by the Employer and their respective nominees, or other inspectors where required under the Applicable Law, the Permits, the Finance Documents and/or the Grid documents (collectively hereinafter referred to as the "**Project Parties**"), with access at any time to any place where the Services are being performed in order to inspect the progress and the manner of the Services, provided that the Employer (or its designated representatives) gives the Contractor twenty four (24) hours prior written notice.

16.2 The Project Parties and their respective nominees will have the right to examine and have access to documents relating to the Services.

16.3 The Contractor must carry out all tests and/or inspections of the Plant or Spare Parts in a lawful, professional, timely, safe and environmentally responsible manner as may be necessary to ensure the safe, reliable, efficient, and optimal operation of the Plant and in accordance with the Performance Standards, Applicable Laws and Good Solar Industry Practice. All these tests and inspections are to be carried out at the Contractor’s expense, as part of Services.

16.4 The Project Parties and their respective nominees are entitled to attend any test and/or inspection.

16.5 Whenever the Contractor is ready to carry out any test and/or inspection, the Contractor must give at least ten (10) days’ advance notice to Employer of such test and/or inspection and of the place and time. The Contractor shall make its best efforts to obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Project Parties to attend the test and/or inspection.

16.6 The Contractor must provide the Employer with a report of the results of such test and/or inspection within five (5) days or any other time period, as agreed, after the completion of that test or inspection in question.

16.7 If the Employer and/or any of the Project Parties fail to attend the test and/or inspection, or if it is agreed between the Parties that the Employer and/or any of the Project Parties will not attend, then the Contractor may proceed with the test and/or inspection in the absence of the Employer’s and/or any of the Project Parties’ inspector and provide the Employer with a report in the approved form of the results.

16.8 If any Spare Parts or the Plant fails to pass any test and/or inspection, the Contractor must either rectify or replace those Spare Parts or repair the Plant and promptly repeat the test and/or inspection upon giving notice.

16.9 The Contractor agrees that neither the performance of a test and/or inspection of Spare Parts or the Plant, nor the attendance by the Employer’s and/or any of the Parties’ inspector nor the issue of any test report will release the Contractor from any of its obligations under the contract.

16.10 Inspection during the Term and at the End of the Term:

During the Term, the Plant may be submitted to a general inspection performed by a Contractor selected by Employer:

16.10.1. Inspection during the Term

From time to time during the Term, but not more than once every year (being specified that any additional tests and inspections instructed by the Employer under this Clause will be for the Employer's account unless the tests or inspections were necessary as a result of the failure of the Contractor to fulfil its obligations under the contract);

16.10.2. End of Contract inspection: six (6) to twelve (12) months before the end of the Term, at the convenience of the Employer.

Subject to the Employer's reasonable advance notice as to the date of such inspection, Contractor is required to attend and assist the Employer and the designated inspector in performing such tests, without additional cost.

16.10.3. The final report shall be sent to the Contractor by the Employer and if any defect or damage found, same shall be rectified/replaced.

16.10.4. Without relieving Contractor from its obligations and without limiting Employer's ability to reasonably pursue the reliefs available to it, if applicable:

a) Contractor shall, promptly following receipt of the report, submit to the Employer (a) a recovery plan to remedy all breaches, defects and malfunctions detected in the report for which the Contractor is liable and shall perform such remedial actions without delay, and (b) provide detailed measures to be put in place to prevent such defaults from recurring;

(b) if the Contractor fails to timely complete all remedial actions before the end of the Term, the Employer shall be entitled, at Contractor's cost and risk, to employ a Replacement Contractor to perform the works.

16.11 Employer Site Visit

16.11.1. If Employer decides to visit the Plant, Contractor shall provide personnel on the Site for mutual inspection with no additional cost to Employer. If the Contractor is reasonably unable to attend such visit for unexpected reasons and/or safety reasons, Contractor shall immediately inform the Employer. As the case may be, the Contractor shall reschedule a new visit within the next seven (7) days. Rescheduling of the visits thereof shall no occur more than once per year the Employer shall adhere to the HSE practices of the Contractor.

16.11.2. If, upon request of the Employer made in accordance with Employer Site Visit, the Contractor does not provide dedicated personnel for such visits, subject to the aforementioned rescheduling allowance, any downtime of Plant Equipment(s) to perform the inspections thereof shall be considered as unavailable for the purpose of availability calculation described in Annexure 2 [Functional Guarantees] [(however never exceeding eight (8) hours per given visit)]. Notwithstanding the foregoing, Employer may request that Contractor provide personnel on the Site for additional inspections as an Additional Service.

16.11.3. If, upon request of the Employer made in accordance with Inspection and Testing, for inspection of the Plant, the Contractor provides access to have services in the Plant Equipment examined available for inspection and Employer does not carry out such inspection, then any downtime of Plant Equipment(s) to perform the inspections thereof shall be considered as available for the purpose of availability calculation described in Annexure 2 [Functional Guarantees]

17. HAZARDOUS SUBSTANCES AND HAZARDOUS SITE CONDITIONS

17.1 Contractor shall not, nor shall it permit any other Person to bring any Hazardous Substances on the Site, other than Hazardous Substances to be used by Contractor or any Subcontractor in a manner that:

(i) does not violate any Applicable Laws, or Permits; and

(ii) is consistent in quantity and with Good Solar Industry Practices for operating and maintaining solar energy conversion plants, such as motor fuels, solvents and lubricants (collectively, "**Permissible Materials**").

17.2 Contractor shall bear all responsibility and liability for:

(i) any Hazardous Substances that are not Permissible Materials belonging to the Contractor or present on site; or

(ii) the handling of, or failure to handle, Permissible Materials in violation of Applicable Laws or otherwise in any manner that constitutes negligence or willful misconduct by Contractor or any Subcontractor.

17.3 Contractor shall use Hazardous Substances in performance of the Services in accordance with the Performance Standards, Applicable Laws and Good Solar Industry Practices and shall not:

(i) utilize, or permit or cause any Subcontractor to utilize, on the Site such Hazardous Substances as are prohibited under Applicable Law from being used in India; or

(ii) import or use at the Site such Hazardous Substances as are prohibited under Applicable Law.

17.4 Contractor shall maintain a regularly updated log of all material safety data sheets for all hazardous substances used in connection with performance of the Services at or near the Site, which shall be available for Employer to review upon reasonable request. Contractor shall maintain an accurate record and current inventory of all hazardous substances used in performance of the Services at or near the Site, which record shall identify quantities, location of storage, use and final disposition of such hazardous substances.

17.5 Contractor shall arrange and agree for the disposal, transportation, reporting and certification (including provision of waste disposal vouchers and other certificates as required by Applicable Law or Permits) of Hazardous Substances, including waste disposal vouchers, brought onto and released at the Site by Contractor or its Sub Contractors, which are expected to include but not be limited to used oil, grease and ethylene glycol, to the extent required by Laws, in each case, by licensed, insured, competent and professional Contractors in a safe manner and in accordance with Laws. As between the Parties, Contractor shall be solely liable for any response, removal, investigation, clean-up or other remedial action required by any Laws related to any Contractor, 17.6 In the event Contractor encounters any Hazardous Substance or other hazardous conditions at the Site that are inconsistent with the Performance Standard or would reasonably be expected to impact the performance of Contractor's obligations hereunder, Contractor shall promptly report the condition to Employer. In such event, Contractor shall stop work and remove, or take other actions necessary to remedy the hazards associated with, any Contractor Hazardous Substances such that Contractor can resume work.

17.7 The Contactor shall ensure compliance with the Battery Waste Management Rules, as notified by the Government of India, from time to time.

17.8 The Contractor shall indemnify and hold harmless the Employer against any fine, penalty or third-party Claim incurred as a result of non-compliance by the Contractor with the terms of the contract, Applicable Laws, Good Solar Industry Practice and more specifically, with its obligations under Hazardous Substances and Hazardous Site Conditions.

18. EMPLOYER'S OBLIGATIONS

During the Term, Employer shall perform the following obligations:

18.1 Access

18.1.1. On and from the Commencement Date, Employer shall provide the Contractor (and its Subcontractors) full, free and safe Access to the Plant for the purpose of enabling Contractor to fulfil its obligations under the contract.

Notwithstanding the foregoing, the Contractor shall be required to perform any works (including obtaining permits for such works) related to the Access to the Site required for the delivery of any Spare Parts, if so requested by the Employer in writing, on the Time to time Basis.

18.1.2. The Employer shall give to the Contractor and the Contractor's personnel unrestricted Access to the Site to enable Contractor and the Contractor's personnel to carry out all elements of the Services at any time from the Commencement Date until the end of the Term. Such Access shall include the provision by the Employer of:

(i) such keys or access codes as may be required by the Contractor to gain unhindered access to the Site (as the case may be);

(ii) Access to the access roads to and on the Site If there is any deviation, and such deviations are accepted by the transport contractor, then such deviations shall be accepted by the Contractor.

Notwithstanding anything else contained in the contract all Access to the Site and Plant is subject to the applicable site safety, security and environmental requirements and Applicable Law (and the Contractor should comply with the same). The Employer will have the right to limit Access or expel any Person off the Site in case of them not fulfilling the Emergency plan of the Site, the Emergency plan of the Plant Facility.

18.2 Employer's Permits

Contractor, on behalf of the Employer, shall obtain and maintain all Permits and any Permits required by Applicable Law to be obtained in the name of the Employer in order to (i) perform Employer's obligations under the contract and (ii) enable Contractor to lawfully access the Site at the point of entry to the Site and the Plant].

19. SITE REGULATIONS

Employer shall (directly or through a Subcontractor, advisor or agent) provide the Site Regulations and revisions thereof from time to time, and shall require the Other Subcontractors and their respective agents and employees to, (i) comply with the Site Regulations; and (ii) take all necessary precautions (as required by Applicable Law or otherwise) for the health and safety of all Persons (including Contractor's personnel) at the Site.

20. CERTAIN NOTIFICATIONS BY EMPLOYER

20.1 Employer shall, upon obtaining actual knowledge thereof, promptly give the Contractor, as soon as practicable, notice of:

20.1.1. any events or facts or observations that the Employer believes has determined that would:

(i) have a material adverse effect on the operation of any of the Plant or the performance of the Contractor's obligations under the contract; or

(ii) to cause an immediate threat to the safe operation of the Project (or any Plant therein) and/or the safety of Persons; provided that, in the case of this current Sub-Clause, the Employer shall provide as soon as possible verbal notice of such event, fact or observation to the other;

20.1.2. any (a) violation of Applicable Laws, including environmental Laws or the terms of any Permit, by Contractor or any Other Subcontractor or (ii) any notices of Liens (or claims of Liens) or investigations by Governmental Authorities related to the Project.

20.2 Failure to furnish notice pursuant to Certain Notifications by Employer shall not affect the Contractor's obligations to perform its obligations. Contractor.

21. EMPLOYER 'S OWNERSHIP OF ENERGY, EQUIPMENT, SPARES AND PROJECT BENEFITS

21.1 The Contractor acknowledges that ownership of the Energy or any benefits arising out of the operation of the Plant remains at all times, and in all circumstances with the Employer at all times and the Contractor has no legal or equitable title to or interest in the Energy or other benefit.

21.2 The ownership of all item supplied by the Contractor, including under Additional Services shall be transferred to the Employer at the end of the term of the contract:

(i) such items becoming a permanent part of the Plant against the mutually agreed payment by both the parties

21.3 The ownership of any item (not including Energy or benefits arising out of the operation of the Plant) supplied by the Contractor as part of the Services shall be transferred to the Employer upon such items becoming a permanent part of the Plant.

21.4 The Contractor agrees that any benefits, including any carbon credits, renewable energy certificates or similar royalty or credit that may arise as a result of having the Project undertaken belong to the Employer and the Contractor shall provide all reasonable assistance requested by the Employer in order to obtain such rights and benefits.

22. PRICE AND PAYMENT

22.1 Total Annual O&M Cost

Commencing on the Commencement Date and for the remainder of the Term, Employer shall, in consideration of the Contractor providing the Services and its prior receipt of an invoice with respect thereto, pay in accordance with Invoices and Payment to Contractor an annual O&M cost in INR in equal quarterly instalments at the end of every quarter for each year till Contract Period in the amounts set forth in and payable in accordance with Price Schedule No 5/SOR-5 [Schedule of Rates] of the bidding documents for the plant facilities. The yearly breakup of the Total O&M price shall be in line with the Price Schedule No 5/SOR-5.

Against the successful Operation and Maintenance of the entire Plant Facility payment will be released on quarterly basis at the end of every quarter for each year during the currency of the Contract Period.

The Contractor acknowledges that the Total Annual O&M cost forms the sole and exclusive consideration and reimbursement due to the Contractor for the performance of the services included under the Services and Spare Parts and that the Contractor shall not be entitled to any additional amount for their performance, for whatever reason, including, amount others due to increased costs, changes in applicable GST, customs or duties (including, without limitation those set forth in GST, Taxation and Import Duties below), and except as may be specifically provided in the contract.

22.2 Payment of amounts due to the Contractor:

Amount shall not be considered as due and payable and the period for the payment of any Price stipulated under the contract shall not commence until the Contractor has duly fulfilled and delivered all obligations and deliverables required from the Contractor until the date of submission of the invoice for the payment to the Employer with relation to such invoice and/or within the period for which the Price included in the invoice are due.

23. INVOICES AND PAYMENT

23.1 Contractor shall submit Goods & Service Tax (GST) compliant invoices to Employer for the amounts due under Total Annual O&M cost above and for any other amounts that may be due under the contract.

23.2 The Total Annual O&M Cost shall be invoiced by the Contractor quarterly against the completion of concerned quarter and each invoice may be submitted by Contractor no later than the day after the completion of the quarterly period in question and, subject to the terms of the contract, shall be paid by the Employer no later thirty (30) days from the date of submission of the invoice along with all other requisite documents (If so required). The Employer shall make payments by wire transfer to the bank account designated from time to time and owned by Contractor. The payment of any invoice shall be subject to the Contractor submitting to the Employer the Monthly Performance Reports.

23.3 Additional Services may, for purposes of this Invoices and Payment, be invoiced upon full and proper completion of each individual task and shall, subject to the terms of the contract be paid by the Employer within thirty (30) days from the date of submission of the invoice along with all other requisite documents (If so required).

23.4 VOID.

23.5 To the extent permitted by Applicable Laws, if the amount of an invoice is disputed by the Employer, the Employer shall be entitled to withhold payment of the disputed amount for the next invoice (or part thereof), until the dispute is resolved between the Parties under Law Dispute Resolution or otherwise. The Employer shall pay at the applicable time the undisputed amount of such invoice including any undisputed portion of the invoice item in dispute. Further, the Employer shall be entitled to withhold payment of any amount due to the Contractor, if, at the time, the Contractor is in breach of one or more of its material obligations in terms of the contract.

23.5.1. Subject to the provisions on the contract, the Contractor warrants that it has, and will be deemed to have, done everything that would be expected of a prudent, competent and experienced Contractor and in accordance with Good Solar Industry Practices in:

(i) assessing all risks which it is assuming under the Contract; and

(ii) ensuring that the **O&M Price** contain allowances to protect it against any of these risks eventuating,

and that it will not make a claim for an increase in the **O&M Price** if any of those risks eventuate.

23.5.2. Except for Liens arising out of a failure of the Employer to make any payment when due hereunder to Contractor or any other Person providing labour or services to the Project under Contract to the Employer, the Contractor acknowledges and agrees that it shall not file, claim or register any Liens and shall use its best efforts to prevent any Liens from being filed, claimed or registered by any Subcontractor or by any employee, or agent of the Contractor or Subcontractor, against the Services, Additional Services, the Plant as a whole or any part thereof, or any real or other property of the Employer, for any works done or any Services and/or Additional Services rendered under the Contract or any subcontract let by the Contractor and shall procure that all subcontracts contain undertakings to the like effect.

23.5.3. The Contractor shall indemnify the Employer against any loss, damage, cost or expense (including legal fees) of the Employer arising out of or in connection with any Lien being filed, claimed or registered as referred to Invoices and Payment.

23.5.4. The delay or failure of a party to pay any amounts due hereunder, or the withholding of any amounts which are claimed by a party to be due, shall not release the other Party from any of its obligations or liabilities under the contract.

24. INSURANCE

24.1 Contractor ‘s insurance

The Contractor, at his own cost and expense, shall take out and maintain in full force and effect and shall cause its Subcontractors to take out and maintain in full force and effect, throughout the Term of the Contract and any extensions thereof, the following insurance policies from reputable insurers and shall provide the Employer with copies of the corresponding insurance certificates:

a) Workers compensation insurance, as required by the Applicable Law and Contracts made with employees.

b) Group Medical Claim, Group Term Policy & Group Personal Accident Insurances covering the financial consequences cause by damage and loss arising from sickness, disease, injury or death of any person employed by the Contractor in respect of the services performed Automobile Public Liability insurance, as required by the Applicable Laws, for all vehicles and automotive equipment owned hired, rented, leased and non-owned by the Contractor and used in the performance of the Services.

c) Comprehensive General third-party liability insurance including product and contractual liability covering the financial consequences of the liability arising out loss or damage caused to third parties or to the employer as consequence of the performance of the services.

d) The Contractor shall also arrange suitable insurance to cover following during the O&M Period:

(i) **Machinery Breakdown**: Electrical & or machinery breakdown of any machinery or other equipment resulting in costly repairs or even replacement of the solar panel.

(ii) **Business Interruption**: Cover for period of operational downtime i.e., covering the cash flow of the solar business as a result of an insured peril, for example fire or storm damage, machinery breakdown or equipment failure.

(iii) **Property Damage**: The insurance should cover material damage due to external causes such as fire, theft, vandalism, sabotage, hail damage, snow load, lightning strike, overload, operational mistakes, clumsiness, negligence & theft.

(iv) **Employers Liability**: Provides cover against the risk of accident from usual workplace risks such as working at height & manual handling during construction & O&M period.

(v) **Environmental Risk Insurance**: Environmental damage coverage indemnifies solar system owners of the risk of either environmental damage done by their development or pre-existing damage on the development site.

The Contractor shall ensure that under the aforementioned insurance policies, each of the insured has the ability to claim thereunder for a minimum period of three (3) months from the date of expiry of the insurance policies for any claims that arose prior to the expiry date.

The Employer shall be named as co-insured under all insurance policies taken out by the Contractor, except for the Third-Party Liability and Workers' Compensation Insurances, and the Contractor's Subcontractors shall be named as co-insureds under all insurance policies taken out by the Contractor, except for the Cargo, Workers' Compensation. All insurer's rights of subrogation against such co-insureds for losses or claims arising out of the performance of the Contract shall be waived under such policies.

Annual Status Report of Insurance Claims: The Contractor shall include the status of Insurance Claims made or required to be made during the year as part of the Annual Reporting Requirements.

25.2 Contractor's Insurance for the Plant Facility

The Contractor shall take out and maintain an insurance policy, seamlessly with CAR policy taken earlier during construction phase, preferably from same insurance company for the plant facility during the entire term of the contract

In the event of any incident or damage or loss that would be reasonably expected to result in an insurance claim, the Contractor shall:

a) Notify without delay to the Employer
b) Prepare and conduct all and any claims made under the policies effected by it, and all monies payable by any insurers shall be paid to the Contractor take all reasonable measures to mitigate the loss, its effects and to protect salvage.
c) Collaborate with Employer and the insurer and provide them with all information and documents they may request.
d) Arrange immediate reinstatement of the damage to the employer's satisfaction, without waiting for the settlement for the corresponding insurance claim.
e) Claim in pursuant to the contract to the insurance agencies, if the claim is accepted or rejected or not accepted or partly accepted by the insurance agency then it will not limit the contractor obligation in any case and also if any losses on account of this shall be in the scope of contractor.

25.3 General Insurance Requirements

25.3.1 The Contractor shall, provide copies of the corresponding insurance policy document mentioned above.

25.3.2 If the Contractor fails to effect or maintain any insurance policy required hereunder, or fails to produce copy of the corresponding policy documents, the Employer may (but as no obligation), without prejudice to any other right or remedy available to it under the contract, procure the insurance for the relevant coverage and/or pay the premiums due. Such payments shall be recoverable and deducted from the payments to be made to the Contractor by the Employer under the Contract. In the event if Contractor does not pay the premium, then the Employer may pay the premium however in such case the obligations of Contractor to undertake the coverage shall continue as envisaged, irrespective of premium being paid by Employer. The Premium if paid by the Employer shall be recovered from the Annual O&M Fees payable by the Employer to the Contractor.

25.3.3 The Contractor shall comply with the conditions stipulated in each of the insurance policies to be affected under the Contract and shall not make any alteration to the terms of any policy subscribed by it so it deviates from the requirements herein.

25.3.4 The Contractor must promptly notify to the Employer any notification received from an insurance company regarding any actual alteration to one of their policies.

25.3.5 On occurrence of any loss covered by an insurance policy contemplated under Insurance, the Contractor shall, as soon as reasonably possible, notify to insurance companies for the policy subscribed by it. The Contractor shall also take any appropriate measure to mitigate the effects to the loss to the maximum extent possible. The Contractor shall assist any assessment mandated by the insurance companies.

25.3.6 The required coverages referred to and set forth in this Article shall in no way affect or limit the Contractor's liability with respect to its obligations under the Contract.

26 Completion of the Contract Period

1.1 Prior to the completion of the term of this agreement (including extension thereof), either through expiry of the Contract Period or through Termination, the Contractor shall, jointly with the Employer and/or its assignee, identify any pendency of deliverables under this Contract, including but not limited to, breakdown of any part of the Plant Facilities, if any, payments to sub-Contractors etc.

ANNEXURE-1

Scope of Work for Operation and Maintenance

i) The Contractor shall prepare the initial Annual Operating Plan for the Plant Facility and shall also indicate the proposed resources (manpower, material & machinery) that would be deployed for O&M.

ii) The Contractor shall be responsible for the smooth day-to-day operation of the Plant Facility.

iii) The Contractor shall provide necessary routine and preventive maintenance schedules of the plant for the Employer's approval and shall carry out all routine and preventive maintenance accordingly.

iv) The Contractor shall perform periodic overhauls and preventive maintenance required for the Plant in accordance with the recommendations of equipment manufacturers and as per the O&M manuals.

v) Contractor shall perform all break down maintenance and other maintenance in the Plant Facility. The Contractor shall be responsible for achieving the performance guarantee of the plant as indicated in the contract.

vi) The Contractor shall operate and maintain fire protection system and safety equipment for the plant.

vii) The Contractor shall do maintenance of electricity system including overhead lines in the Plant Facility area up to the Point of Interconnection. Necessary co-ordination shall be made by the Contractor with STU/CTU, SLDC/RLDC and other agencies as may be required during the Operation and Maintenance term for smooth operation of the plant.

viii) Contractor shall work in coordination with the Employer or any Employer's designated party to optimize the Plant production.

ix) The Contractor shall provide required spare plant Equipment, Spare Parts, tools and tackles, consumables required for comprehensive operation and maintenance of the plant facility as per prudent/ standard utility practices, OEM recommendations and warranty clauses for the entire O&M period. The Contractor shall make arrangement to procure required spare parts, or equipment/s as required, overhauling of parts, tools and equipment, required to operate and maintain the Plant in accordance with the recommendations of individual original equipment manufacturer at his own cost. Cost of Equipment & spare parts, if any, shall be included in the O&M quoted cost. The List of Consumables, Spare Parts, tools and equipment shall be finalised in consultation with the Employer or Employer's representative. List of recommended spare parts shall be submitted by the Contractor at the beginning of services; however, the complete recommended spares will be in the scope of contractor only. In case any equipment or spares is not listed in the mandatory spares list but is required vitally for the operation of the plant, then the same shall be procured and provided by the contractor without any additional cost.

x) It is the responsibility of the Service Provide to store the materials in appropriate stock yard or container at the site so as to ensure timely availability of the materials.

xi) The Contractor shall upkeep all administrative offices, roads, tool room, stores room, equipment in clean, green and workable conditions.

xii) The Contractor shall co-ordinate with PDD/CTU/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.

xiii) The Contractor shall employ only such personnel who are adequately qualified and experienced for operating and maintaining such power generating sets. The Contractor shall ensure that such personnel are on duty at the plant at all times, 24 (twenty-four) hours a day and 7 (seven) days a week commencing from the Date of Operational acceptance.

xiv) Contractor shall carry out all day-to-day operation and maintenance for the Plant Facility as set forth herein. Contractor shall perform the Work and supply all required spare parts in a prudent and efficient manner and in accordance with manufacturers and systems designers' specifications, the Annual Operating Plan for the Plant and all operation and maintenance manuals, all Indian applicable laws including environmental protection, pollution, sanitary, labour act, factory act, employment and safety laws, ("Government Rules") and Prudent Utility Practice. The contractor shall adhere to all labour laws which are applicable and as specified in the EPC contract document.

xv) Contractor shall arrange necessary security staff for watch and ward of the Plant Facility round the clock at his own cost, the details of which shall be furnished along with the bid.

xvi) Contractor shall be responsible for:

- Maximizing plant capacity utilization,
- Reducing plant downtime,
- Optimizing the useful life of the equipment of the power plant.

xvii) The Contractor shall maintain all accounting records regarding the facility in accordance with the generally acceptable accounting principles under the Laws of India.

xviii) The Contractor shall maintain accurate and up-to-date operating logs, records and monthly reports regarding operation and maintenance of the Plant facility (Such records shall be distinctly recorded for Plant Facilities, in order to have clear data for assessment of any individual component of the Plant Facility) which shall include details of power output, other operating data, repairs performed and status of equipment. All such records to be maintained for a minimum of 60 (sixty) months after the creation of such record or data and for any additional length of time required by regulatory agencies with jurisdiction over the Parties. Upon expiry of term, the Contractor shall hand over all such records to Employer . However, Employer shall have access to all such records at any time. Generation and O&M reports should be made available to Employer on daily and monthly basis in required formats as well as the Quarterly and Annual Performance Reports shall be provided. Contractor shall provide communications as well as daily, weekly, monthly, quarterly and annual reports to the employer in the desired format as per the Contract with the Employer or Employer's Engineer.

xix) The Contractor shall develop and implement plans and procedures including those for firefighting, maintenance planning, procuring and inventory control of stores and spares, plan to meet emergencies, plant safety and security; and such other facilities and systems as may be necessary to commence Contractor's ongoing responsibilities.

xx) The Contractor shall provide copies of all necessary documents including the following:

- Operation and maintenance manuals shall be prepared and approval shall be accorded from Employer within three months from the date of Operational acceptance.

- Failure Analysis/history/trouble shooting details of all the Equipment
- Identification of Equipment needing preventive maintenance
- List of Vendors indicating name and addresses during operation and maintenance with credentials
- root cause analysis report for any major failure.
- Record of consumables / spare parts

xxi) The Contractor shall be responsible for conveying following details to the Employer on daily basis as well as on monthly basis (by the end of 5th day of each month) by fax/ e-mail giving the detail of plant performance during previous month.

- Power generated at all Solar PV Plant
- Power fed to the grid
- Internal power loss and internal consumption
- Power consumption for captive use (if any)
- Reactive power consumption
- Downtime of Plant Facilities including Solar PV Plant and other infrastructure of the Plant facility.

xxii) The Contractor shall be responsible for liasioning with statutory authorities–and local authorities in order to ensure smooth operation of the Power Plant.

xxiii) Contractor shall provide constant remote surveillance to the Plant Facility

xxiv) Contractor shall provide updates and revisions to Reference Documents, as and when applicable.

xxv) Shall implement software updates to control and monitoring systems including BMS/EMS/SCADA in order to meet the plant facility operating requirement in consonance with the grid operations and in compliance with the grid codes as applicable during the operation.

xxvi) Duly and timely provide the Employer (or parties designated by the Employer) with all notifications required under the Contract including in particular such notifications set forth in Certain Notifications by Contractor;

xxvii) Contractor shall provide access to the Employer to all data for the Plant Facility from the EMS including the SCADA system.

xxviii) Provide training to the Employer's personnel in relation to the operation of the complete plant facility. Training shall be provided to the employer within 190 days before end of the contract period.

xxix) Contractor shall provide the insurances prescribed in insurance. The Contractor shall, with [prior intimation of 5 Business Days] at regular business hours, allow persons duly authorized by the Employer including but not limited to the officials of the insurance company of the Employer, to inspect the Project and provide to such personnel, access to all information which is necessary for their inspection, and is reasonably requested by the Employer. All representatives of the Employer shall strictly adhere to the Applicable Laws and the Health, Safety and Environmental (HSE) practices of the Contractor as provided in the Reference Documents;

xxx) Contractor shall provide for the watch and ward of the Plant at all times during the Term. The watch and ward deployment plan shall take care of comprehensive Project level security and the Contractor shall take necessary steps to prevent sabotage, theft, vandalism and malicious damage of the assets comprising the Plant, and shall also coordinate and liaison with law enforcement authorities. The Contractor shall take all possible measures to keep the plant operational and secure.

xxxi) Contractor shall Coordinate with SLDC/RLDC and other related entities/departments/local Panchayats as required for proper operation of the Plant Facilities. The Contractor shall Also coordinate with relevant agencies for monthly Joint Meter Readings, meter testing, and any other requirements such as any audit or inspection by the government agencies or authorities, financiers, any designated third-party agency etc. for the Project operations.

xxxii) Contractor shall be responsible for appointing a Qualified Coordinating Agency (QCA) at the Pooling Substation Level and shall be responsible for carrying out the forecasting and scheduling of the energy generation from the plant facility (In accordance with the Deviation Settlement Mechanism Regulations, as applicable). Scheduling given by the Contractor is such that no penalty is levied on the Employer due to any deviation of actual generation from scheduling beyond the allowed limit. If any penalty is imposed on the Employer due to such deviations beyond allowed limit the same shall be passed on to the Contractor and the recovery of the same will be done from the O&M Price payable to the

Contractor.

xxxiii) Water requirement for module cleaning arrangement, if required, and the cost for the same shall be borne by Contractor. The Contractor shall arrange for water on it's own, by ensuring ESIA norms.

xxxiv) Contractor shall be responsible to comply with all applicable National and International Standards as well as local statutory provisions related to Environmental Protection Regulations, Health and Safety requirement.

xxxv) Contractor will be responsible for coordinating with the OEMs for securing warrantee conditions and services from OEMs as per the warrantee of each equipment, as well also for the Project insurance claims.

xxxvi) Contractor shall carry out the performance monitoring for the Plant Facility on continuous basis and in case of any deviation, the Contractor shall perform the due diligence appropriately to find out the actual root cause of such deviation. Any test or inspection required such as thermal imaging, IV characteristics test etc. to analyse such deviation will be the responsibility of the Contractor. Thereafter the corrective action required to mitigate such deviation shall be undertaken by the Contractor without any additional cost.

xxxvii) Contractor shall be responsible for maintenance of all each and every civil infrastructure parts like Building, cable trench, fencing, drain, plumbing system fire-fighting system, CCTV system, security arrangement, road, earthing, any foundations, anti-weeding, clearing bushes in the solar field etc., as per the direction of Employer.

xxxviii) In the last quarter of the O&M Contract Period, the Contractor shall handover the Plant Facilities to the Employer along with 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 for the basis of replacement frequency and mean time between failures and mean time to restore.

ANNEXURE-2

Functional Guarantees

1. Annual CUF Guarantee

A. In consideration for the payment of the O&M Price , from the Commencement/Effective Date until the end of the Term, the Contractor grants to the Owner the CUF Guarantee on the terms and conditions set forth in the contract.

B. The Contractor guarantees the annual CUF committed herein over the O&M Period ("**Annual CUF Guarantee**"). In the event the CUF is less than the Guaranteed CUF, the Contractor shall immediately, upon demand, indemnify the Owner, as liquidated damages and not as penalty, amounts equivalent to remuneration of the equivalent shortfall Energy, subject to a maximum of hundred (100%) percent of the Total Annual O&M Price.

C. Capacity Utilization Factor (CUF) for Solar Plant shall be calculated as per the following formula.

$$\mathrm{CUF} = \frac{\mathrm{E_{ac}} + \mathrm{E_{outage}}}{8760 \times \mathrm{P_{ac}} \times [1 - \mathrm{DF} \times (\mathrm{N} - 1)] \times \mathrm{RCF}}$$

where,

E_{ac} , is the Net Energy Exported from the Plant, kWh

E_{ac} = (Energy export recorded in the ABT meter*) - (Energy import recorded in the ABT meter*), kWh

E_{outage} is the energy adjusted for grid outage hours, kWh

$E_{outage} = 2 \times (E_b + E_a) \times Q_{outage}$

E_b is the energy export recorded in the ABT meter* during complete 15-min period preceding the start of grid outage, kWh

E_a is the energy export recorded in the ABT meter* during complete 15-min period succeeding the end of grid outage, kWh

Q_{outage} is the number of grid outage hours

(The Contractor shall submit grid outage certification from competent authority of STU/DISCOM).

8760 refers to the number of hours in non-leap year. It shall be replaced by 8784 hours during leap year

P_{ac} is the plant AC capacity, kW

DF is module degradation factor, 0.5% per year

N is the number of years of operation after operational acceptance of the plant

*ABT Meter at the Metering Point specified in Section VII-A: Scope of Works.

RCF is the Radiation Correction Factor:

$$RCF = \frac{Measured\ Irradiation}{Reference\ Irradiation},$$

Reference Irradiation for the site = 1827 kWh/m^2/year

The Measured Irraditation (GHI_{mes}) shall be recorded from the Pyranometer installed in horizontal plane at the site location (average in case of multiple pyranometers). The radiation data of the Pyranometer shall be compared with the Reference Irradiation mentioned above. The radiation data from the Plant Pyranometer shall be used for computation of CUF, except in case of any discrepancy (i.e. more than ± 10% variation from the Reference Radiation, GHI_{ref}), in which case the radiation data from SolarGIS database for the said period will be used for computation of CUF. Missing data (GHI_{mes}) from the Plant Pyranometer shall be substituted by average of GHI measured for the same period in the past three (3) days. The plant Pyranometer has to be under CCTV coverage.

Note:

1. CUF shall be calculated on annual basis, from the Effective Date to the currency of the O&M Contract.
2. Module degradation factor will not be considered for first year CUF calculation. It is the Contactor's responsibility to envisage and install extra DC capacity to accommodate any degradation during first year.

D. Liquidated Damages for Shortfall in Annual CUF for Solar PV Plant

If the Contractor fails to achieve guaranteed annual CUF at the end of First Year, the Contractor shall be liable for payment of Liquidated damages to the Owner (amount to be deducted from the Final Payment at the end of 1 year), an amount equal to the NPV of the estimated shortfall in cash flow resulting over the period of 25 years due to reduced Plant CUF, calculated at a tariff of Rs. 2.22 per unit (kWh) and discount rate of 8.9%.

The Contractor may take corrective action during the ensuing year to demonstrate the guaranteed CUF at the end of the 2nd year. In such case, the part of the Final Payment withheld by the Owner on account of Liquidated Damages shall be released and the CUF shall remain unchanged from the tender specifications.

If the Contractor fails to demonstrate the guaranteed CUF at the end of 2nd Year as well, the CUF achieved at the end of First Year shall be fixed as the new Guaranteed CUF for the remaining period of this Contract.

Illustration:

Guaranteed Annual Energy (MWhs) after 1 Year (assuming RCF =1):

$$P_{ac} * 8760 * CUF_{e} * (1 - DF \times (N - 1))$$

= 25*8760*0.361*(1-0.0055*(1-1)) = 79059 MWh

If Actual Generation during First Year =76650 MWh i.e. CUF = 35.00%

Estimated Shortfall in Cash Flows over 25 years:

Year	Expected Energy as per Guaranteed CUF (MUs), **A**	Estimated Energy Based on First Year Performance (MUs), **B**	Estimated Shortfall in Revenue in Rs. Crores (A-B)*2.2/10, **C**
1	79.06	76.65	0.5300
2	78.66	76.27	0.5273
3	78.27	75.88	0.5247
4	77.87	75.50	0.5220
5	77.48	75.12	0.5194
6	77.08	74.73	0.5167
7	76.69	74.35	0.5141
8	76.29	73.97	0.5114
9	75.90	73.58	0.5088
10	75.50	73.20	0.5061
11	75.11	72.82	0.5035
12	74.71	72.43	0.5008
13	74.32	72.05	0.4982
14	73.92	71.67	0.4955
15	73.52	71.28	0.4929
16	73.13	70.90	0.4902
17	72.73	70.52	0.4876
18	72.34	70.13	0.4849
19	71.94	69.75	0.4823
20	71.55	69.37	0.4796
21	71.15	68.99	0.4770
22	70.76	68.60	0.4743
23	70.36	68.22	0.4717
24	69.97	67.84	0.4690
25	69.57	67.45	0.4664

LD applicable = NPV of Column C calculated at the Discount Rate specified above

= ₹ 5,04,17,135.32 (to be deducted from the final payment)

(i) In case the EPC Contractor takes corrective action and demonstrates guaranteed CUF at the end of 2nd Year:

LD Applicable = Shortfall in Generation in the First Year*Rs.2.2

= (79.06-76.65)*2.2/10 = Rs. 0.52998 Cr.

The Balance Final Payment Amount shall be released to the EPC Contractor.

(ii) In case the EPC Contractor fails to demonstrate the guaranteed CUF at the end of 2nd Year, Annual CUF guarantee for the remaining period of the Contract shall be fixed as the CUF demonstrated at the end of First Year, as revised CUF. Liquidated Damages applicable in subsequent years, on account of shortfall in generation, shall be determined with reference to this revised CUF.

E. Incentives for excess Generation

(i) Any excess generation over and above the minimum Expected energy in an year, calculated as per the formula below, shall be entitled to an incentive of 50% of PPA tariff per unit of energy:

Minimum Expected Energy (MWhs) in Nth Year:

$$P_{ac} * 8760 * CUF_e * (1 - DF \times (N - 1))$$

Pac, Plant AC capacity (MW)	25
DF, Module degradation factor (%/year)	As per OEM Datasheet
N, Number of years of operation after operational acceptance of the plant	N= 1,2,3,…..15
CUFe, Guaranteed Annual CUF at the end of First Year (%)	36.1%

(ii) The incentive under this Clause is subject to the upper limit of 110% of the Minimum Expected Energy in the Nth year (Refer (i) above).

Illustration:

The Minimum Expected Energy in 5th Year as per (i) = 25*8760*0.361*(1-0.005*(4))

= 77,477.82 MWh

PPA Tariff = Rs. 2.2/kWh

50% of PPA Tariff = 50% of Rs. 2.2/kWh = Rs. 1.1/kWh

Case I: Actual Energy generated in 5th Year = 80,000 MWh

110% of the Minimum Expected Energy in the 5th year = 110%* 77,477.82 = 85,225.602 MWh

Since 80,000 < 85,225.602

Generation Incentive = Rs. (80,000 - 77,477.82)*1000*1.1 = Rs. 27,74,398/-

Case II: Actual Energy generated in 5th Year = 85,800 MWh

Since 85,500 > 85,225.602,

Generation Incentive = Rs. (85,225.602- 77,477.82)*1000*1.1 = 85,22,560.200/-

Case III: Actual Energy generated in 5th Year = 76,500 MWh

Since 76,500 < 77,477.82

LD applicable as per Clause D

In case the Project fails to generate any power continuously for 1 month any time during the O&M period, apart from the force majeure and grid outages as certified by competent authority from DISCOM/Electricity Department/STU/ CTU, it shall be considered as "an event of default". In the case of default the entire Contract Performance Security will be forfeited.

F. Penalty during O&M period against breakdown of other Infrastructure of Plant Facilities that don 't affect the generation of power directly, such as but not limited to, civil infrastructure, water supply system/network, other Infrastructure developed by the Contractor as a Scope of Work for the Project (Section-VII: Scope of Works & Technical Specifications) shall be penalised @ Rs.1000/day, for non-compliance with PM Schedule (Initiation/Completion of Scheduled maintenance Activity as agreed under this Contract) beyond 48 hours. Cumulative value of such penalty shall be limited to 5% of yearly O&M cost.

For the purpose of this Clause, the PM shall be inclusive of, but not limited to the following PM activities:

Item	**Scope of Maintenance Activity**	**Periodicity**
PV Arrays	Cleaning of PV Modules	A least 2 cycles per month
PV Arrays, Battery Modules/Racks/PCUs, Transformers	Thermal Imaging	Half Yearly
Transformers	As per OEM Recommendation	As per OEM Recommendation
Environmental/Corrosive Protective Coatings	White-washing/Application/Re-application of Distemper, Epoxy coatings	Once in every 2 years under the O&M Contract period, in consultation with the Owner
Roads and Access paths	Repair and maintenance of all roads – Access, Internal and Periphery roads, walkways as well as fences, gates, cable-trenches and outdoor equipment platforms.	Once every year post Monsoon season, in Consultation with the Owner

Periphery Lighting	Repair and maintenance of Peripheral Lighting including replacement of non-functional lighting fixtures, Junction Boxes, Conduits etc.	Once every Six Months
Rodent Entry Points	Application/re-application of Anti-rodent protection measures like PUF filling, sealant etc. at Checker/Gland Plates, Cable Entry Points (in PCU/SMU, Switchgear Panels, Buildings, Enclosures)	Once every Six Months
All bolted/tightened structures	Tightening/fastening of bolts that are exposed to winds/vibrations like MMS members/foundation bolts	Once every Year before onset of Windy season, in consultation with the Owner.
Enclosures of Equipment requiring Temperature and Dust Controlled environment for Normal Operation	Application/re-application of insulation/Dust-Filters/Temperature-control equipment at Enclosures/Buildings housing PCU, Switchgear, BESS	Once every Year, consultation with the Owner.
Weather Monitoring System	Calibration of Sensors/Measuring Instruments	As per the requirement to maintain valid calibration certificate

Pyranometers in the WMS	Cleaning	Daily
ABT Meter	Callibration	Yearly
Entire Plant Facility	Oversight management of the hazardous/toxic materials including its handling and disposal as per Government of India Rules and environmental and safety assessments by a qualified Specialist	Once every Year, in consultation with the Owner.
Earthing System	Measurement of earth resistance of Plant as well as individual earth pit	Every Month

Note : *The Contractor shall ensure intimation and submission of requisite Reports to the owner at least 15 days prior to initiation of maintenance action for the activity.*

The Contractor shall submit the detailed PM Schedule for the approval of the Employer. The Preventive Maintenance Schedules will be drawn such that jobs other than breakdown, which may require comparatively long stoppage of the Power Plant, shall be carried out preferably during the non-sunny days or evenings. Prior information shall be provided to the Employer for such preventive maintenance prior to start.

G. The Penalty specified on account of delays, and Liquidated Damages and on account of deviations in Functional Guarantees as above shall be assessed independent of each other.

H. **Limitation of Contractor's Liability under O&M Contract**: Except for the Contractor's indemnity obligations under this Contract, and except for actions or claims arising from gross negligence or intentional or wilful misconduct, Contractor's total liability to Employer for a given year shall not exceed the corresponding year's Value of O&M Contract.

Scheduling and Forecasting:

1. The Contractor shall be responsible for appointing a Qualified Coordinating Agency if required by concerned authorities at the Pooling Substation Level for scheduling and forecasting activity. Also, the contractor shall be responsible for carrying out the forecasting and scheduling of the energy generation from the plant facility (In accordance with the Deviation Settlement Mechanism Regulations, as applicable). Scheduling given by the Contractors is such that no penalty is levied on the Employer due to any deviation of actual generation from scheduling beyond the allowed limit. If any penalty arises due to DSM after adjusting the payable and receivable imposed on the Employer due to such deviations beyond allowed limit, the same has to be paid by the contractor separately. If the contractor fails to pay such penalty, then it shall be recovered from the contractor's payment to be done by Employer.

2. The deviation charges, as per applicable regulations, for the difference in units between scheduled and actual generation shall be recovered from the contractor on following basis.

2.1 In case of any deviation due to forecasting and scheduling error, Contractor shall bear the cost/Penalty.

2.2 In case of localized thunderstorm/sand storm, the Employer shall bear the deviation charges till the time period before which the revision of scheduling is not allowed, as per applicable regulation.

2.3 In case if there is a component/Machine/Inverter failure, the Employer shall bear the deviation charges on account of such failure till the time period block before which the revision of scheduling is not allowed, affected as per applicable regulation. The contractor shall bear the deviation charges due to such failure beyond such time period.

Appendices

1. **O&M Manual**

2. **Annual Preventive Maintenance Schedule**

3. **Mandatory Spares (General Annexure: GA-C: Mandatory Spares of the RfS), Consumables, Spare Parts**

4. **Price Schedule No 5/SOR-5**