

TECHNICAL SPECIFICATIONS

SECTION – VI: TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

INDEX

PART-A	3
A-1: PROJECT INFORMATION	4
APPENDIX – 1	8
APPENDIX – 2	11
APPENDIX – 3	12
APPENDIX – 4	13
A-2: INTENT OF SPECIFICATION	15
A-3: PROVENESS	18
A-4: Electrical Scope of Supply & Services	22
A-5: CIVIL SCOPE OF SUPPLY & SERVICES	29
APPENDIX - 5	32
APPENDIX – 6	33
A-6: MISCELLANEOUS	36
A-7: TERMINAL POINT AND EXCLUSIONS	42
PART: B	43
DC SYSTEMS	44
B-1: SOLAR PHOTOVOLTAIC (SPV) MODULES	45
B-2: TRACKER SYSTEM	46
B-3: DC CABLES	53
B-4: STRING COMBINER BOX	55
B-5: POWER CONDITIONING UNIT	61
AC SYSTEMS	69
B-6: LT SWITCHGEAR	70
B-7: HT SWITCHGEAR	84
B-7(A): INVERTER TRANSFORMER	115
B-8: AC CABLES	126
B-9 CABLE INSTALLATION METHODOLOGY	136
B-10 SCADA	149
B-11 INSTRUMENTATION AND COMMUNICATION CABLE	170
B-12 EARTHING SYSTEM	176
B-13 PLANT ILLUMINATION SYSTEM	186
B-14 AUXILIARY POWER SUPPLY SYSTEM	193
B-15 LIGHTNING PROTECTION SYSTEM	209
PART-C : CIVIL WORKS	213
C-1 TOPOGRAPHY SURVEY AND SOIL INVESTIGATION	214
C-2 SITE LEVELLING AND GRADING	219
C-3 BOUNDARY WALL, FENCING AND GATE	221
C-4 DESIGN OF MODULE MOUNTING STRUCTURE & CIVIL WORKS	226
C-5 CIVIL & STRUCTURE WORKS - GENERAL DESIGN CRITERIA	232
PART-D: GENERAL SYSTEMS	246
D-1 WEATHER MONITORING STATION	247
D-2 FIRE FIGHTING AND ALARM SYSTEM	252
D-3 MODULE CLEANING SYSTEM	255

TECHNICAL SPECIFICATIONS

D-4 PROJECT COMMISSIONING AND OTHER GENERAL REQUIREMENTS	258
D-5 OPERATION AND MAINTENANCE.....	259
D-7 SAFETY MANAGEMENT	263
PART-E QUALITY ASSURANCE	264
E-1 QUALITY ASSURANCE ELECTRICAL.....	265
PART-F GENERAL TECHNICAL REQUIREMENTS	318
F-1 GENERAL TECHNICAL REQUIREMENTS.....	319
PART-G ERECTION CONDITIONS OF CONTRACT	345
G-1 ERECTION CONDITIONS OF CONTRACT.....	346
PART-H MANDATORY SPARES.....	361
H-1 MANDATORY SPARES.....	362
PART-I – TENDER DRAWINGS & ATTACHMENTS	363
I-1 : TENDER DRAWINGS & ATTACHMENTS	364

TECHNICAL SPECIFICATIONS

PART-A

TECHNICAL SPECIFICATIONS

A-1: PROJECT INFORMATION

1. ABOUT PROJECT:

Name of the Project	Development of Grid Connected 875 MW Ground Mounted Solar PV Plant At RVUNL's Solar Park Pugal, Bikaner, Rajasthan, India.
Solar Park	RVUNL's 2000 MW Solar Power Park, Pugal, Bikaner, Rajasthan, India
Plant Capacity	875 MW (AC) at Grid Connection Points.
Delivery Point/ Grid connection points	33kV/400 kV Park Pooling Substation.

2. LOCATION AND APPROACH:

Location of site	Ramsar Chotta & Barala, Puagal Tehsil of Bikaner District, Rajasthan.
Latitude	28.29 & 28.31
Longitude	72.94 & 73.13
Nearest Town	Pugal
Nearest Railways Station	Bikaner (50 kms)
Nearest Commercial Airport	Jodhpur (Approx. 300 KM) Jaipur (Approx. 398 KM)
Port	Deendayal Port Trust (Kandla) 903 KM Mundra 957 KM

3. AREA AVAILABILITY:

Land availability: Total 1576 Ha in Ramsar Chotta & Barala, in RVUNL's Solar Park.

Ramsar Chotta: 6A,6B,6C,7A,7B,9A,9B,10A,10B,11A,11B

Barala : 2A&2B,2C,3A,3B,3C

(Out of the total 1576 Ha land, acquisition of 196 Ha statuof private land between Solar Park area or connecting parcels is in progress.)

Bidder is required to refer plots map for detail regarding land.

4. TECHNOLOGY:

In Solar Photo Voltaic Power Generation, the direct conversion of solar radiation into electricity is achieved by using semiconductor devices "Solar Cells", which work on the principles of photo electric effect.

TECHNICAL SPECIFICATIONS

5. SITE SPECIFIC TECHNICAL:

Refer **Appendix– 1**

6. STATUTORY COMPLIANCE, GRID CONNECTIVITY AND POWER EVACUATION:

The scope of power evacuation system in the scope of the bidder is up to the terminal point/ Interconnection Point as indicated in the tender SLD. The Bidder shall be responsible for terminating their 33kV evacuation feeder as per Special Conditions of Contract.

Bidder shall comply all provisions and amendments thereafter of

- i. Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022
 - ii. CERC 'Detailed Procedure for Connectivity and GNA under the Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter- State Transmission System) Regulations, 2022'.
 - iii. CEA (Technical Standards for Connectivity to Grid) Regulation, 2007.
 - iv. CEA (Technical Standards for construction of Electrical Plants and Electrical Lines) Regulation, 2010.
 - v. CEA (Grid Standard) Regulation, 2010.
 - vi. CEA (safety requirements for construction, operation and maintenance of Electrical Plants and Electrical Lines) Regulations, 2011.
 - vii. CEA (Measures relating to Safety and Electrical Supply) Regulations, 2010.
 - viii. CEA (Installation and Operation of Meters) Regulations 2006.
 - ix. Indian Electricity Grid code Regulation, 2010
 - x. CEA (Technical standards for communication system in Power system operations) Regulation 2020
 - xi. CERC (Communication System for Inter State Transmission of Electricity) Regulations 2017
 - xii. MNRE guidelines/OM/Advisory/Clarifications
 - xiii. And any other applicable standard/regulations
- a) Bidder may conduct detailed Grid compliance study with Power Plant Controller for solar project as per CEA technical standard for grid connectivity and latest guideline of RLDC first charging clearance. In this regard, bidder should ready all technical details including Inverter bench marking report, Generic model data of Inverters, suitable for use in PSS/E and PSCAD software available at RLDC and Encrypted user-defined model (UDM)/generic model of Inverter in PSS/E software (*.dll files) as applicable. Provision of PSCAD model of inverter shall also be in bidder's scope. In case any site testing required for grid compliance as per RLDC, it shall also be conducted.

TECHNICAL SPECIFICATIONS

- b) Bidder should ready all required data to complete detailed consolidated Grid compliance study at least 6 months before the scheduled First Charging date of the plant and availability of PSSE and PSCAD model of Inverter and PPC shall be ensured by Bidder during selection of respective Manufacturer.
- c) Bidder should ready all data for performing applicable study/simulation reports as per 'Procedure for Integration of solar plant those are regional entities' for submission to RLDC for first time charging clearances (as required by regulatory/statutory body). Bidder may refer latest FTC (First Time Charging) clearance documents or RERC/CERC regulations with regards to same.
- d) Bidder shall update themselves latest requirement for technical data requirement/PSSE/PSCAD Model as per WRLDC/STU. The minimum data required is attached in Appendix-4 for IBR (Inverter Based Resources) to be ready for Grid study. Bidder should ready above documents within 3 months from LoA. However, the final requirement or any other requirement shall be intimated during detail engineering in due course of interaction with WRLDC/STU.
- e) EPC supplier has to apply on behalf of Solar Project Developer (SPD) has to apply for First Time Charging (FTC) approval for its installed capacity as per prescribed procedure by Western Region Load Dispatch Centre (WRLDC)/CEA/CERC/RERC. All the necessary compliance at 33 kV level, i.e. Study Reports/Models, additional equipment for reactive power support etc as required by the WRLDC shall be in the scope of Selected Bidder. First Time Charging obligation is to be solely fulfilled by Selected Bidder's and for any noncompliance of Selected Bidder and delay in FTC, SPPD/SPD will not be responsible.

Bidder shall facilitate Owner/ Company in addressing all the queries of CTU/RLDC with respect to reports and models are answered to their satisfaction.

All equipment, materials and services whether explicitly stated in Technical Specifications or otherwise and that are necessary for the successful commissioning of Solar Plant as per latest statutory regulations/procedures issued by bodies like CERC/SERC, CEA, RLDC/NLDC/SLDC, CTU/STU, MNRE, other Ministry etc. shall be deemed to be included in the scope of work of the Contractor.

Note: The bidder shall be responsible for obtaining all necessary statutory and regulatory compliances and approvals required for the successful construction, commissioning, and operation of the plant on behalf of company. However, all statutory fees will be borne by the company.

7. GENERATION GUARANTEE

- a) The Bidder shall give NEEGG per annum after considering proposed configuration and all local conditions, solar insolation, wind speed and direction, air temperature & relative humidity, barometric pressure, rainfall,

TECHNICAL SPECIFICATIONS

sunshine duration, grid availability and grid related all other factors and losses due to near shading, incidence angle modifier, irradiance level, temperature loss, array loss, module quality loss, module array mismatch loss, soiling loss and various inverter losses etc.

- b) Bidders are expected to undertake their own study of solar profile and other related parameters of the area and make sound commercial judgment about power output i.e. Net Electrical Energy Guaranteed Generation.
- c) The Bids should have the NEEGG equivalent to minimum CUF (as specified in NIT) at the Interconnection point for the first year. The degradation in NEEGG quoted for any year shall not be more than (as specified in the NIT) of that quoted for the previous year.

If the Bidder anticipates any degradation of the modules during the first year, it shall be taken care of by the Bidder to provide additional capacity of solar PV modules to meet guaranteed generation at the end of first year to avoid liquidated damages/compensation on account of guaranteed generation.

8. OTHER DETAILS:

Sl No.	Item	Details
1	Water Requirement during construction	To be arranged by bidder
2	Power Requirement during construction	To be arranged by bidder
3	MOEF Clearance	Shall be arranged by company, wherever applicable
4	SPCB Clearance	Application by Company. Inputs for application & processing to be facilitated by Bidder
5	MNRE Clearance	To be facilitated by bidder
6	Chief Electrical Inspector Clearance	To be facilitated by bidder
7	Tree Cutting Permission	NA

TECHNICAL SPECIFICATIONS

APPENDIX – 1

SITE SPECIFIC TECHNICAL DATA

A. Tentative Solar Insolation Data for Proposed Site:

Month	Solar Insolation (kWh/m ²)
January	116
February	134
March	187
April	201
May	206
June	182
July	170
August	177
September	177
October	165
November	124
December	112
Year	1951

B. MODULE MOUNTING – Single Axis E-W Tracker (Optional)/ Fixed tilt Technology

C. CABLE LAYING METHODOLOGY:

Bidder can propose suitable cable laying methodology for Project, keeping in view of the site-specific issues related to soil condition etc, which shall be reviewed during the detail design engineering.

D. PROJECT LOCATION CLASSIFICATION (CORROSION PROTECTION):

Parameter	Coastal/Non-Coastal	Corrosive Category (as per ISO12944-2)
For below Ground Structures (including up to 300mm above ground)	Coastal	C5-M
For Above Ground Structures	Non-Coastal	C4

TECHNICAL SPECIFICATIONS

(Beyond 300mm)		

Corrosive category (for Paints)

Classification of environments for Corrosive category shall be in accordance with ISO12944-2, the applicable atmospheric corrosivity categories C4 (high); C5-M (very high- marine).

ISO12944-5 shall be used related to paint systems in combination with guidance for the selection of different types of protective paint system. Wherever specification allows LT electrical panels, UPS, SCADA panel, Fire protection panel etc. associated with Inverter station to be placed outdoor, the enclosure of the same should be well engineered product having proper ventilation system and must be protected from harsh environment & direct sunlight/rainfall. Radiation and absorption effects of outdoor environment must be considered for temperature rise calculations. The temperature rise should not be more than working temperature of components. Requirement of suitable shed/canopy shall be reviewed based on the offered solution during detailed engineering stage.

For metal enclosed outdoor HT switchgear/RMU, pooling switchgear on the LT side (if applicable) from string inverter to inverter transformer, suitable shed shall be provided considering the O&M space.

Painting of outdoor metallic enclosed electrical panels including HT switchgear/RMU shall be as per ISO 12944-5, corresponding to corrosive category mentioned in the above table.

For outdoor inverter including containerized solution, painting corresponding to site condition shall be provided.

Unless noted otherwise, all steel structures exposed to environment would be painted to meet the requirements of C4 corrosion category or would be galvanized to minimum 90microns.

E. RAINFALL –

The average annual rainfall is 580 mm between driest and wettest months, the difference in precipitation is 223 mm. For Heaviest rainfall in one hour may be considered as per Nearest city / town (as mentioned in Appendix-A of IRC: SP:13-2004.)

F. SEISMIC DATA & DESIGN CRITERIA –

The site falls in **Seismic Zone III** of seismic zone map of india, which indicates Moderate Damage Risk Zone which is liable to MSK VII. Provisions of IS 1893 (Part 1) shall be followed.

G. WIND DATA & DESIGN CRITERIA

Basic wind speed shall be as per IS 875 (Part-3) (Based on survey of India Political map printed in 2002).

The minimum design wind pressure (Pd) to be considered for design of MMS, Equipment Fixing, Buildings, Rooms, etc. as below:

TECHNICAL SPECIFICATIONS

BASIC WIND SPEED, m/s	Design Wind Pressure, min, Pd (N/m ²)
47	1325.4

For Project site, the minimum design wind pressure (Pd) = 1325.4 N/m²

Area Drainage Study report carried out by Park developer is attached for reference purpose only.

TECHNICAL SPECIFICATIONS

APPENDIX – 2

LIABILITY DURING AMC

A. CONTRACTORS LIABILITY DURING AMC PERIOD.

Contractor shall carry out regular predictive maintenance during entire AMC period through OEM or OEM authorized service provider.

The requirement of Comprehensive AMC of Critical Equipment is revised as follows:

Equipment/System	Comprehensive AMC*
Inverter	10 Years
SCADA	10 Years
Tracker (If considered)	10 Years

* Starts from date of commissioning of full capacity.

Bidder will be required to submit the AMC documents for the above equipment in the name of owner for the period beyond O&M Period.

TECHNICAL SPECIFICATIONS

APPENDIX – 3

FACILITIES FROM COMPANY FOR SOLAR PROJECT

- a) Allocation of land of total area as mentioned.
- b) Availability of connectivity at 33/ 400kV Park Pooling Substation of Solar Park. Power from Solar Park pooling station will be transmitted to 400 KV RVPN GSS.
- c) Right of Way for installation of underground cable from project to Pooling Station.
- d) Water Supply during operation period in the ratio of capacity installed with metering at actual.
- e) Water Drainage System up to allotted plots as decided by Solar Park developer.
- f) Outer fencing of Solar Park as decided by Solar Park Developer.

Note - All temporary arrangements w.r.t approach roads, drainage, office set up etc. as necessary to take up the project construction work, would be in bidder's scope.

* Supply of 33kV Cable interconnecting Inverter Duty Transformer and ICOG, inter-pooling cable between 2 plots (if proposed), cable joining and termination kits including laying of 33kV Cable shall be in the scope of bidder.

TECHNICAL SPECIFICATIONS

APPENDIX – 4

Requirement of Single IBR unit Simulation model & Benchmarking report

Requirement of Single IBR unit Simulation model & Benchmarking report-

Single SoC (Statement of Conformity) and Evaluation Report for Type test report as per CEA Connectivity standard mentioning all Hardware/software/Firmware version

- Fault current characteristics (voltage -current) of Inverter during fault condition.
- Current and voltage Waveform capture facility during LVRT/HVRT at Inverter output terminal during event and accessible to Owner/ Company in PPC.
- Inverter controller Setting facility from local as per CEA Regulation.
- Time synchronization facility of Inverter with PPC/SCADA
- Single IBR Controller Setting in compliance with CEA grid connectivity regulation.
- Single IBR model shall be prepared or get from OEM (for PSS/E and PSCAD) and benchmark it with the lab/factory/field test measurements taken during certification process. Benchmarking report shall include model validation against all the clauses mentioned in B1 & B2 of CEA Technical Standards for Connectivity to the Grid (Amendment) Regulation, 2019.
- A separate benchmarking report /simulation comparison is required for SCR=5 and 3 for PSS/E and PSCAD software and furnishing the Parameters for the same. Provision to change setting in inverter according to various operating condition at site is to be provided.

Following shall be part of submission-

1. Comparison of field test measurement with simulation results numerical values & as well as graphical values for following points.
 - a) Power Quality (only in EMT).
 - b) Active power set change (RMS & EMT)
 - c) Reactive power control- V control, pf & Q control (RMS & EMT)
 - d) IBR capability demonstration (RMS & EMT)
 - e) LVRT (RMS & EMT)
 - f) HVRT (RMS & EMT)
 - g) Frequency response (RMS & EMT)
2. Final simulation model parameters like Generator model, Electrical control model, drive train model etc. shall be included in benchmarking report. (RMS & EMT)
3. Firmware version of IBR unit controller for which IBR unit got certified shall also be included in this report.
4. Field test report documents shall be referenced in the bench-marking report.

TECHNICAL SPECIFICATIONS

5. Ensure the setting kept in IBR while field testing & actual IBR installed at site are same, if any alteration kindly include justification for the same.
6. IBR simulation model flat run results for 100 seconds with simulation time step of 1ms shall be included for electrical parameters (P, Q, V, f) and speed to be included (RMS).
7. EMT model of IBR unit- flat run results for 100 seconds with simulation time step of 10us or greater shall be included for electrical parameters (P, Q, V, f) and speed. Further, model shall get initialised within 3 seconds & shall have snapshot capability.
8. Model compatibility: EMT models provided to shall be compatible with PSCAD version 4.6 and above and Intel Visual FORTRAN version 15 or higher and RMS model for PSS/E version 34.4 and above. Same shall be included in the report. The models which is compatible with PSCAD V5 (latest version) with GNU Fortran compiler and with intel Fortran compiler need to be provided. If the model compiled in one compiler is not compatible with other compiler, it is requested to provide both models
9. Include a table having IBR controller setting, RMS & EMT model parameter for different control parameters as specified. (RMS & EMT)
10. IBR unit model for PSS/E shall include .sav, .dyr, .py, .idv, .sld, .out files and PSCAD pscx and other supporting files.
11. Conclusion part include table for which models are benchmarked & whether the model replicates the actual. Error in simulation vs. actual shall be minimum to the extent possible, however it shall not be more than 5%.

TECHNICAL SPECIFICATIONS

A-2: INTENT OF SPECIFICATION

1. INTENT OF SPECIFICATION

- A. The scope of the proposal shall be Design, Engineering, Supply, Construction, Erection, Testing, and Commissioning of Solar PV plant along with power evacuation system Including supply of PV modules. The scope also includes (Two (02) years Operation and Maintenance O&M) of the solar PV plant as well as Annual Maintenance Contract (AMC) of critical equipment for a period of ten (10) years as mentioned in **Appendix 2, Chapter A-1 Part A**.

The scope of work covers the following activities and services in respect of all the equipment & works specified and covered under the specifications and read in conjunction with “Scope of Supply & services” elaborated elsewhere.

All equipment, materials and services whether explicitly stated or otherwise and that are necessary for the satisfactory operation of the Solar PV system and its integration with the existing AC Systems as described in the specification shall be deemed to be included in the scope of work of the Contractor and shall not be limited to the following:

- a) Basic Engineering of the plant and systems.
- b) Detailed design of all the equipment and equipment system(s) including civil works.
- c) Providing, Review and approval of engineering drawings, data, process
- d) Calculations, test procedures, Structural Design Calculations, Equipment Layout, Drawings / Data sheets of bought out items, Civil Structural / Architectural Drawings, etc.
- e) Providing Operation & Maintenance/ instruction manuals, as built drawings and other information
- f) Providing training of Employer’s personnel
- g) Finalization of sub-vendors, manufacturing quality plans and Field quality plans.
- h) Complete manufacturing including conducting all type, routine and acceptance tests; Civil, Structural and Architectural works to the extent applicable, including construction facilities and construction power distribution.
- i) Packing and transportation from the manufacturer’s works to the site including customs clearance & port clearance, port charges, (if any).
- j) Receipt, storage, preservation and conservation of equipment at the site; Fabrication, pre-assembly, (if any), erection, testing, pre-commissioning and commissioning and putting into satisfactory operation all the equipment including successful completion of initial operation
- k) Reliability and Functional guarantee tests after successful commissioning of full capacity

TECHNICAL SPECIFICATIONS

- l) Supply of Spares.
 - m) Satisfactory completion of the contract.
 - n) Special tools and tackles if any required for maintenance of the plant.
 - o) Installation and commissioning of SCADA, OWS at Solar plant CMCS with supply and laying of OFC and associated hardware and software.
- B. The work to be carried out as per the above scope shall be all in accordance with the requirements, conditions, appendices etc. given in Technical Specifications (Section-VI) together with those stated in other Sections / Sub-sections of Bid Documents which shall be considered as a part of this volumes completely as if bound herewith. It is not the intent to specify herein all aspects of design and construction nevertheless, the equipment and civil works shall conforming all aspects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Employer, who will interpret the meaning of the specification and drawings and shall have a right to reject or accept any work or material which in his assessment is not complete to meet the requirements of this specification and/or applicable Indian / International standards mentioned elsewhere in this specification.
- C. Bidders are requested to carefully examine and understand the specifications and seek clarifications, if required, to ensure that they have understood the specifications. Such clarifications should be sought within the time period as stipulated in section NIT. Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. However, if the bidder feels that, in his opinion, certain features brought out in his offer are superior to what has been specified, these may be highlighted separately.
- D. The Bidder shall be responsible for providing all material, equipment and services, specified or otherwise which are required to fulfil the intent of specification and ensuring operability, maintainability and the reliability of the complete work covered under this specification.
- E. Failure of any equipment to meet the specified requirements of tests carried out at works or at site shall be sufficient cause for rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in completion of the works as per schedule. Contractor shall be responsible for removing all deficiencies and supplying the equipment that meet the requirement.
- F. Before submitting his bid, the bidder should inspect and examine the site and its surroundings and should satisfy himself as to the nature of the ground and subsoil, the quantities and nature of work, materials necessary for completion of the work and their availability, means of access to site and in general shall himself obtain all necessary information as to risks, contingencies and other circumstances which may influence or affect his offer. No consequent extra claims on any misunderstanding or otherwise shall be allowed by the Employer.

TECHNICAL SPECIFICATIONS

2. SCOPE OF WORK (full scope of work or reference to NIT)

- A. Detailed design of Grid Interactive Solar PV Plant, civil, electrical & mechanical auxiliary systems including preparation of foundation drawings, single line diagrams, installation drawings, electrical layouts, design calculations etc. Design memorandum and other relevant drawings and documents required for engineering of all facilities within the scope to be provided under this contract, are covered under contractor's scope of work.
- B. Bidder shall monitor the PV module performance data before the PV Module becomes operational using PV Analyzer of reputed make. This data has to be stored at site and shared with Owner/Company during commissioning period. Bidder shall also carry out PV Module performance data review and storage using PV analyser during O&M period.
- C. Works related to site clearance including removal of bushes, trees, levelling, grading, finishing and other additional works in the scope of bidders. Mandatory permission/ licenses/ statutory clearances from Competent Authorities for undertaking blasting related works, disposal of cutting material, etc. shall be carried out by the Bidder.
- D. Detailed system wise scope is elaborated in A-4 (Electrical Scope of supply & Works), A-5 (Civil scope of supply Works) & A-6 (Miscellaneous Works) of Part-A, Section-VI.
- E. Detailed system wise Technical Specification is elaborated in Part-B, Section-VI.
- F. The evaluation criteria along with methodology & the requirements shall be as per NIT.

TECHNICAL SPECIFICATIONS

A-3: PROVENESS

PROVENESS CRITERIA

The bidder/his sub-vendor(s) is required to meet the Proveness criteria and/or qualification requirement for critical component and bought out item as per the criteria stipulated below:

1. Solar Engineering Firm

If the bidder himself does not fulfil the Technical Eligibility Criteria as per Section I Notice Inviting Tender, the bidder shall employ an Engineering Firm who has engineered and fulfils the criteria prior to the following reference date.

Date of submission of proveness documents to Owner/Company or (LOA date + 1 month), whichever is earlier.

The scope of work of engineering for the above project by the Firm shall necessarily include the following:

- a. Selection and Sizing of:
 - i. Inverter
 - ii. PV Modules
 - iii. DC Cables
 - iv. AC Cables
- b. Finalization of Plant Layout with shadow analysis
- c. Energy Estimation

The Firm shall undertake at least the above scope of engineering for the proposed Solar PV Power Plant.

Date of submission of proveness documents to Owner/Company or (LOA date + 1 month), whichever is earlier.

And

The proposed Tracker design/type (if considered) shall be of proven technology with Independent Engineers Bankability review report from reputable agencies like Black and Veatch, DNV, IITs or other premier institutions/agencies.

2. Solar Inverter Transformers

- a. The Bidder/its Sub-vendor should have designed, manufactured and supplied transformers of 33kV or higher voltage class of cumulative capacity of 40 MVA or above, out of which at least one such supply order for a single plant should be of 10 MVA or above capacity. The reference plant in which transformers of 10 MVA or above capacity (consisting of one or more) were supplied, must have been in successful operation for at least six (6) months prior to the following reference date:

TECHNICAL SPECIFICATIONS

Date of submission of proveness documents to Company/Owner or (LOA date + 6 months), whichever is earlier.

And

- b. Bidder/its sub-vendor should have its own facilities for conducting all routine tests for transformers as per IS: 2026/IEC 60076.

And

- c. 2.5 MVA, 33kV or higher rated inverter transformer manufactured by Bidder/ its sub-vendor should have been successfully short circuit tested.

3. Solar Inverter

- a. The Bidder/its Sub-vendor should have designed, manufactured and supplied grid connected solar Inverters of cumulative capacity of 40 MW or above, out of which at least one such supply order for a single plant should be of 10 MW or above capacity. The reference plant in which 10 MW or above capacity solar Inverters (consisting of one or more) were supplied, must have been in successful operation for at least six (6) months prior to the following reference date:

Date of submission of proveness documents to Owner/Company or (LOA date + 6 months), whichever is earlier.

And

- b. The Bidder/sub-vendor should have in-house solar Inverters routine testing facility as per relevant standard of solar Inverter.

And

- c. The offered solar Inverter model or any of its product family Inverter model or similar Inverter topology model must have been in successful operation for at least six (6) months the reference date mentioned above. The Inverter product family model or similar Inverter topology model power rating should not be less than 50% of the offered Inverter model rating. The similar Inverter topology model must have identical power circuit configuration and same maximum DC input voltage rating as compared with the offered Inverter model. The Inverter product family model or similar Inverter topology model shall be further technically assessed to establish the similarity with the offered Inverter model and same shall be subjected to Owner/Company acceptance.

Note: -

- i. The individual Inverter capacity of one (1) MW or above (for central Inverter) and 40kW or above (for string Inverter) shall only be considered for capacity determination.
- ii. In case the inverter manufacturer is not meeting the requirement as mentioned in Clause 3.0 (a) & (c) above, they can utilize the credentials of its principal/ holding or subsidiary company/ associate/ collaborator (a solar inverter manufacturer) through technology tie-up for meeting the criteria as stipulated in clauses 3.0(a) & (c).

TECHNICAL SPECIFICATIONS

4. HT Power cables (3.3kV or above but below 33kV)

The Bidder/ Sub Vendor should have manufactured and supplied following cables, prior to the following reference date:

Date of submission of proveness documents to Owner/Company or (LOA date + 6 months), whichever is earlier.

- a. At least 100kms of XLPE insulated power cables of 1.9/3.3 kV or higher voltage grade, executed in one or more limited to maximum of three orders.
- b. At least one (1) km of flame-retardant low smoke cables of any voltage level.
- c. The plant for which cable have been supplied should have completed at least six months of successful operation prior to the date the reference date mentioned above.

5. HT Power cables (33kV)

The Bidder/ Sub Vendor should have manufactured and supplied following cables, prior to the following reference date:

Date of submission of proveness documents to Owner/ Company or (LOA date + 6 months), whichever is earlier.

- a. At least 20kms of XLPE insulated power cables of 19/33 kV or higher voltage grade, executed in one or more limited to maximum of three orders.
- b. At least one (1) km of flame-retardant low smoke cables of any voltage level.
- c. The plant for which cable have been supplied should have completed at least six months of successful operation prior to the reference date mentioned above.

6. DC Solar cables

The Bidder/ Sub Vendor should have manufactured and supplied following cables, prior to the following reference date:

Date of submission of proveness documents to Owner/ Company or (LOA date + 6 months), whichever is earlier.

- a. At least 150 kms of XLPO insulated DC Solar cables of 0.63/1.1 kV or higher voltage grade of minimum 4 sq mm size executed in one or more limited to maximum of three orders.
- b. The plant for which cable have been supplied should have completed at least six months of successful operation prior to the reference date mentioned above.

Note: In case the DC solar cable manufacturer is not meeting the requirement as mentioned in Clause 6.0 (a) and/or 6.0(b) above, they can utilize the credentials of its principal/ holding or subsidiary company/ associate/ collaborator (a solar DC cable manufacturer) through technology tie-up for meeting these criteria as stipulated in clauses 6.0(a) and (b) below.

7. Cable Laying Agency

TECHNICAL SPECIFICATIONS

The bidder/ Subcontractor should have executed cabling works in which it has installed Power cables of 1.1 kV or higher-grade cables along with associated accessories for an industrial installation which should have been in successful operation for a period of at least two (2) years prior to the following reference date. The total quantity of Power cables (HT cables, LT cables, DC cables etc.) laid should be 100 kms or more in maximum two contracts/works

Date of submission of proveness documents to Owner/ Company or (LOA date + 6 months), whichever is earlier.

TECHNICAL SPECIFICATIONS

A-4: Electrical Scope of Supply & Services

1. BASIC ENGINEERING DESIGN PARAMETER OF SOLAR PV PLANT

a. Plant Capacity:

AC Capacity – 875 MW

DC Capacity – 1182 MWp (Minimum)

(Supply, Packing, Forwarding, Transportation, Unloading and Storage at Site is in the EPC Bidder Scope)

b. Designed System Voltage: 1500 V DC

c. Design Philosophy:

Bidder is free to propose his design of the solar plant including solar plant layout, solar block sizing, inverter sizing, inverter-transformer sizing etc. subject to meeting the boundary conditions/design parameters as specified in the table below. Bidder would be required to submit design details for actual Module Rating (in Wp) that would be supplied by the Bidder (minimum 540Wp), during detailed engineering.

The Bidder need to supply additional 0.5% of the mentioned DC Capacity as per clause 1.a of Chapter A – 4. as mandatory spares.

S. No.	Description	Details
1.	Annual Radiation (Global Horizontal)	1951 kWh/m ²
2.	Type of SPV Module	Thin film/ Mono Crystalline Silicon/TOP CON-Bifacial
3.	Peak Power rating of Module	540 Wp or above
4.	PV Module Dimensions	As per module selection
5.	PV Module Mounting Hole – Longer edge	As per detail engineering
6.	PV Module Mounting Hole – Shorter edge	As per detail engineering
7.	Module Efficiency	Minimum 19% at Standard Test Conditions (STC)
8.	Fill Factor	0.75 (Minimum)
9.	Bi-facility (If applicable)	Minimum 70%

TECHNICAL SPECIFICATIONS

10.	Module back	Glass or Transparent Back sheet
11.	Design Mechanical load	Minimum 1600Pa Downward and Upward when fixed at 400mm Hole Distance
12.	Min Pitch*	5.5m for 540 Wp
13.	Thermal Loss Factor (Uc, Uv)	Uc-29 Watts/m ² -K Uv-0.0 Watts/m ² -K
14.	DC Cabling loss at STC + AC Cabling loss at STC	2.5 % (Individual DC and AC Cabling loss shall be as per system design chosen by bidder)
15.	Transformer Loss (for MV transformer, i.e. for IDT)	As per Transformer data sheet (Maximum 1.5%)
16.	Module Quality Loss	0.0%
17.	Modules Mismatch Loss	1.2%
18.	LID Loss	2.0%
19.	Soiling Loss	1.5%
20.	IAM Losses	As per PV Module Characteristic
21.	Auxiliary Energy Loss	5 Watts/kW
22.	Unavailability of the system	2%
23.	Unavailability time fraction	1.0%
24.	Number of periods	3
25.	Auxiliary Power Loss at per Pooling Substation	As per Actual outside PVSYST
26.	Power Transformer Loss	As per Actual data sheet, as per CERC or input by Owner/ Company during detailed Engg. Stage.

TECHNICAL SPECIFICATIONS

Qualification of Sub-Vendor of Solar PV -Modules

- The Sub-vendor should be listed in the Approved List of Module Manufactures as per MNRE.
- The Sub-vendor should have supplied a PV Module of cumulative capacity of More than 500 MW in last 5 years from the date of publication of the tender.
- The Sub-vendor should have an annual manufacturing capacity of more than 500 MW per annum.

* Based on the actual Module panel size, the parameters may be modified suitably as per site conditions.

Bidder to mandatorily LIMIT the output of the Solar PV Plant at the Injection Point in PV Syst so that the Power injected into the grid NEVER exceeds the threshold of plot capacity.

Bidder shall submit PV Syst report complying with the design parameters specified above and the actual Module PAN file to arrive at the Target Generation for first year O&M at Metering Point.

d. Inverter Capacity:

The continuous combined rating of all PCUs shall not be less than Plant capacity at unity power factor at ambient temperature of 50 deg C and 0.95 p.f. at 45 deg. C. Provided further that each Inverter shall be able to maintain its performance specified above even with voltage variation of up to $\pm 5\%$ at Inverter terminal.

Same size of Inverter is recommended for the whole plant and same size of Inverter Transformer is also preferred considering Mandatory spare management. Foundation design of Inverter and Inverter transformer shall be of one type as per highest size.

e. 33 kV Local Pooling Switchgear

- i. Bus Bar rating of HT Switchgear: As per Single Line Diagram.
- ii. System Fault Current Rating: As per Single Line Diagram.
- iii. Dynamic withstand Current rating: 2.5 times of system fault current.
- iv. DC Supply shall be used for control and protection system of switchgear. In case UPS AC supply is considered for auxiliary control and protection supply for switchgear (except CMCS), then suitably rated AC/DC converter/power pack shall be used to meet the DC control supply requirement of switchgear panels.
- v. The 33kV switchgears (both indoor and outdoor type where allowed as per TS) shall have an internal Arc Classification corresponding to system fault current

TECHNICAL SPECIFICATIONS

- vi. The switchgear shall be cooled by natural air flow. Forced cooling shall be considered in case current rating is 2000 A or above
- f. **Construction of Store Room** – As per requirement per block/plot –
- g. **Outdoor containerized solution/compact** substation with inverter, inverter transformer & HT switchgear as inverter station are acceptable. However, technical specification of inverter, HT switchgear and inverter transformer as per technical specification shall be applicable.
- h. **Earth Pit for DC System:** 1 Nos. per 1.50 MWp.
Nos. of earth pit indicated is valid if all the earth pits are interconnected in single mesh of earth pits
- i. **Metering:** As per SLD
- j. **Module Cleaning System:**
Provision for module cleaning shall be as mentioned in chapter D-3, Part -D of Technical specification (Section VI).
- k. **Cable sizing criteria:**
The minimum size of cable based on 33kV voltage level power application shall be as per protection time grading requirement subject to min. of 0.3 sec. For any cable feeder the minimum time for cable size calculation shall be the immediate one upstream breaker (towards grid) relay time setting plus 100 msec. For final power evacuation to Power Transformer the time for cable size calculation shall be minimum 1.0 sec.
- l. **SCADA:**
Licenses for Remote Monitoring of SCADA - 2 Nos with provision of Concurrent viewing for all users. Solar Plant SCADA shall also communicate with the Owner's SCADA, placed in Switchyard Control Room, in a server client methodology on Modbus TCP/IP or any industry standard communication protocol for full monitoring and control of entire plant from CCR (Central control room) SCADA situated at substation.
- m. **DC and LT Power cable voltage drop criteria:**
From Module to Inverter Transformer shall be limited to 2.5% of rated voltage. For all other LT cables, Maximum Voltage drop shall be limited to 2.5% of rated voltage. 1.9/3.3kV grade LT cable shall be used for connection between Inverter and Inverter Transformer.
- n. **DC system voltage** of 125V/250V shall be considered for design of equipment rating, which has auxiliary voltage fed from 110V/220V battery.
The detailed scope of work in accordance with this specification is elaborated below. The scope of the contractor shall be deemed to include all such items which although are not specifically mentioned in the bid documents and/or in contractor's proposal but are needed to make the system complete in all respects for its safe, reliable, efficient and trouble-free operation and the same shall be

TECHNICAL SPECIFICATIONS

furnished and erected unless otherwise specifically excluded as per Section Terminal Points & Exclusions.

2. SUPPLIES & ASSOCIATED WORKS:

DC SIDE	
	Unloading, receipt, storage, erection and installation of Solar PV Modules
	HT Cables
	DC Cables including field connectors and DWC pipes
	String Combiner Box (if applicable)
	Power Conditioning unit
AC SIDE	
	LT Switchgear track
	HT Switchgear
	Inverter Transformer& Auxiliary Transformer
	LT Cables
	HT Cables – 1.9/3.3 kV and 19/33kV Cable between Inverter Duty Transformer and ICOG & inter-pooling 33kV cable (if applicable)
	Cable Laying – DC,LT & HT cables
	SCADA & Time Synchronization Equipment
	Instrumentation and Communication cable
	Lightning Protection System
	Plant Illumination system
	Auxiliary Power Supply System
	Battery and Battery Charger
	UPS
	Grid interfacing so as to meet statutory requirements and comply with CERC code.
GENERAL SYSTEMS	
	Fire Detection and protection system
	Module Cleaning system (Wet/ Dry robotic)

3. POWER EVACUATION SYSTEM, TELEMETRY & SCADA.

a. Power Evacuation System:

The Bidder shall terminate each 33kV export feeder at 33/400kV internal pooling substation of Solar Park as per Plot Single Line Diagram (SLD).Further it will

2

TECHNICAL SPECIFICATIONS

evacuated by RVUNL PPS through 400 kV transmission line to RVPNL Grid Sub Station (GSS) by Solar Power Park Developer. All hardware required for 33kV cable termination at 33/400kV switchyard, including supply of outgoing 33 kV AC cables, support structure and civil works required for the same, shall be under scope of bidder.

Also, supply of 33kV Cable interconnecting Inverter Duty Transformer and ICOG, inter-pooling cable between 2 blocks (if proposed), cable joining and termination kits including laying of 33kV Cable shall be in the scope of bidder.

b. Telemetry System:

The arrangement to transmit data required by the Load Dispatch Centre (LDC) from Solar plant to NLDC/RLDC/SLDC as per extant regulations and procedures for grid management upto 33 kV/400kV Park Pooling substation is in contractor's scope.

The required hardware and software, including laying of Communication/Fibre Optic cable to Owners' FOTE panel at 33/400kV GIS Substation required for communication of Solar plant data is included in the contractor's scope. Communication link and communication controller/Gateway used for data communication to FOTE panel/LDC shall be redundant (one for normal operation and other as hot standby). If any upgradation / modification required at FOTE, it shall be done by the bidder.

Bidders are advised to update themselves with LDC requirement for compliance related to Automatic Meter Reading (AMR), telemetry data, channel and procedures for engineering of telemetry solution accordingly.

The above real time data communication facility with REMC/RLDC shall comply CERC (Communication System for Interstate Transmission of electricity) Regulation 2017, Procedure for Implementation of the Framework on Forecasting and Scheduling for Renewable Energy (RE) Generating Stations, CEA (Technical Standards for Communication System in Power Systems Operations) Regulations, 2020 and amendments thereof.

c. Provision of SCADA HMIS/SERVER Operator Work-Station (OWS) at SCADA Room.

SCADA, & other associated electrical system shall be placed at the identified location inside SCADA Room.

Sl No	Description	Quantity
1	Engineering cum Operator work station (EWS+OWS) (Desktop & Monitor)	01 Set
2	Operator work station (OWS) (Desktop & Monitor)	01 Set
3	Portable (laptop based) EWS	01 No
4	Historian (Desktop)	01 No
5	50 Inch LED display	01 No

TECHNICAL SPECIFICATIONS

6	Control Desk	01 Set
7	Chairs for Control Desk	02 No
8	Laser Printer	01 No

*The SCADA/ all other related system supplied for EPC shall have facility to synchronize time on Network Time Protocol with Main SCADA Time Synchronization Equipment (supplied by Owner) at Switchyard Control Room.

4. OPERATION AND MAINTENANCE (O&M) Target Generation test:

The supply of PV modules is in the scope of EPC vendor, therefore Pre-dispatch inspection should be carried out at the presence of Owner or Owner's engineer before the dispatch of the module to the project location. Also, to ensure proper O&M during O&M Period, there shall be an O&M Target Generation Test for THREE months. During O&M Target Generation Test, bidder shall be responsible for operation and maintenance of the plant so that the plant is running in the most optimum operation and generating in line with the designed parameters. Details of this test are mentioned elsewhere in the Specification.

The supplier should furnish Test Certificates (in six copies), if applicable along with original documents to GM (Solar) Corporate Office Owner/ Company. Otherwise, the supplier's bill remain unpaid and the consequent demurrage/losses etc., will be to the supplier's account.

5. SOLAR PV MODULE – Performance Determination Methodology

- a. The procurement of Solar PV modules is in the Scope of the EPC Bidder. Any shortfall in generation during O&M Period resulting from the non-performance of the PV Modules (Defective Modules*) is the Liability of the Bidder and shall be intimated by the EPC Bidder to the Owner at the earliest.
- b. The determination of Defective Modules, for initial troubleshooting and preliminary assessment at site, shall be done jointly by the Engineer in-charge and the bidder. In such a scenario, the Defective Modules shall be replaced with the healthy ones from Mandatory Spares by the contractor to reduce the downtime of the Solar PV Plant.

* Defective Module is one whose either Isc (Short Circuit Current) or Voc (Open Circuit Voltage) or their combination thereof is less than 10% of average of 5-7 healthy modules of identical rating. The selection of healthy modules shall be done by Engineer Incharge (in consultation with the Module Manufacturer and as per the Approved Technical Documents) and bidder. Module shall also be declared as defective, if its output power is derated more than it's deemed Wp capacity taking consideration of yearly degradation. However, the responsibility for measuring the PV module performance output through the use of reputed make PV Analyzer etc, shall lie with the bidder.

TECHNICAL SPECIFICATIONS

A-5: CIVIL SCOPE OF SUPPLY & SERVICES

1. SCOPE

The broad scope of work under this package shall include Civil, Structural and Architectural Works related to but not limited to the following areas, System, Structures/ Substructures, Buildings and Facilities:

A. Design & Construction of Permanent Facilities:

S.No.	Facility/ Building	Quantity
1.	Site investigation-Topography survey & Geotechnical investigation	As required.
2	Mounting structure (E-W Single axis tracker).	As required
3	Central Monitoring and Control Station (CMCS) building with parking shed.	2
4.	Inverter Room(s) Pre- Engineered Building (PEB)/ Containerized System	As required.
5.	Permanent Store-Room / Ware House	1 No per 250 MW
6.	Cable Trenches / Trestle including any Cable Tray supporting facility	As required.
7.	Security Room & Toilet	As required (Min. 1 in each Block)
8.	All Equipment Supporting Foundation and Structures	As per Detailed Engineering Geotech Investigation including Reference to Flood Levels.
9.	Sewage disposal system such as Septic Tank & Soak pit for all toilets.	As per actual.
10.	Internal Roads	As per bidder's proposal and Tender Drawing (Refer Vicinity Map / Layout and Road Section Drawings)
11.	Drainage system including Recharge Pits	As per bidder's proposal, Tender Drawing and Park developers Recommendations / Report
12.	Permanent Project Boundary Fencing with Gate(s)	As per requirement
13.	Any internal Fencing and Gates, e.g. for Yards (Transformer, inverter, etc.)	As per Tender Drawing / System Requirement

TECHNICAL SPECIFICATIONS

14.	Owner/ Company Site Office:	As required.

Any other misc. requirement necessary for completion of commissioning & operation in line with Bidder's technical proposal/ detailed Engineering.

B. Site Preparation (as required for installation of panels / equipment etc. during construction, erection and commissioning activities).

- i. Cutting, Clearing, transporting and disposal of plants, bushes, other vegetation, roots, stubs etc.
- ii. Site grading including slope protection, ground preparation/ filling/ levelling (if required) of the identified area for solar plant.
- iii. Any temporary drainage including any dewatering, site approach & service roads.
- iv. All temporary work in bidder scope i.e. Fencing, Parking Shed, Road, Porta cabin and other infrastructures etc.
- v. Flood level calculation with 25 Years Return Period – For maintaining Plinth level of the building and equipment foundation level.
- vi. Swatch Bharat Yojana policy for cleaning and deposal of sewage.

Note – Bidders are also advised to visit site location to appraise themselves with local conditions.

C. O&M Related Facilities to be developed by EPC Contractor

- i. Rainwater Harvesting for RCC Buildings - If RCC Buildings are provided.
 - ii. Design, Supply & Installation of a Module cleaning system including any requisite Construction works.
 - iii. Design & Construction of Permanent water Supply / Network system for cleaning / washing.
 - iv. Additional scope as per facilities required for proper operation of Solar Park Project:
- Owner/ Company intends to provide water supply during plant operation for module cleaning through RE Park. Accordingly, the bidder shall connect the pipeline from the nearest source / tapping point (Likely to be near PSS location - Tentative) to the solar plant washing system and other O&M Facilities.
 - Water may or may not be continuously available from Owner/ Company water pipeline due to limited supply, infrastructure maintenance etc. at a given point in time. Thus, water storage tanks shall be designed and installed / constructed by the bidder for their respective projects for water storage purpose to ensure continuous water supply for plant facilities during O&M
 - The bidder has to provide Wet/Dry robotic based Cleaning System for Solar PV Project

TECHNICAL SPECIFICATIONS

- During O&M period, Optimum utilization of wet (by water) cleaning system shall be used as per requirement of cleaning cycle for Solar PV Modules and water may be used as less as possible for cleaning of solar panels as per the direction of owners Engineer In-charge. Owner/ Company shall provide water for minimum 10 cleaning cycle/year @2.5L per module/Cycle on best endeavour basis.
- Any fencing (if required) shall be in bidder scope for protection of their offices, labour camps (as per LMA permission), equipment etc. against theft or otherwise.

D. Other Site-Specific Activities

Array Layout for Robotic cleaning system: Array layout shall be designed considering future provision for operating Robotic cleaning system from reputed manufacturers/suppliers. The continuous length of solar array table (or MMS) for using Robotic cleaning system, the distance between two modules of two different Array tables, required levelling and grading shall be done by the bidder. The bidder shall provide the details of compatible models of Robotic cleaning system from a different manufacturers/supplier and same shall be used in detail engineering of array layout design.

E. Site Investigations

- a. Topographical survey
- b. Geo-Technical investigation

F. Bidder to refer Sub part -I 1 of PART I List of Attachments

NOTES

In case, any study / investigation report / design carried out by Owner/ Company, has been shared with bidder, then it is solely for the purpose of guidance of the bidder. Bidder may cross verify the data / design system on its own without any financial / time implications to Owner/ Company.

TECHNICAL SPECIFICATIONS

APPENDIX - 5

Survey, Investigation report & Recommendations (if any)

A. SURVEY & INVESTIGATION REPORTS:

- i. Topography survey of the sites is enclosed with this document for reference only. However, bidder would carry out topographical survey on his own. No time extension would be admissible on account of this.
- ii. Geotechnical studies** of the sites is enclosed with this document for reference only. However, bidder shall carryout detailed Geotechnical Investigation, as per the requirements of Technical Specification provided at **Cl. 2.0, Chapter C-1/ Section-VI**. No time extension would be admissible on account of this.

** Owner/ Company to provide geotechnical investigation report in the proposed area. The geotechnical investigation report comprising of Boreholes, Laboratory tests, Chemical analysis, etc. in respect of the sub-strata prevailing at site is available for the Bidder's study. The representative are enclosed at Appendix-I for Bidder's reference. These are solely for the purpose of guidance of the Bidder.

The onus of correct assessment/interpretation and understanding of the existing sub soil conditions/data, including ground water table, permeability, expansiveness of soil etc. is on the Bidder.

Reports on Area Drainage Study and Foundation System prepared by Park Developer, are available for the Bidder's study at Owner's office. These are solely for the purpose of guidance of the Bidder. The onus of correct assessment/ interpretation and understanding, is on the Bidder.

B. Geotechnical investigation work shall preferably be got executed by the Contractor through any reputed government of private organization having valid ISO/IEC 17025:2017 accreditation from NABL.

*Refer detailed technical specification in Part-B (Civil Work).

TECHNICAL SPECIFICATIONS

APPENDIX – 6

Central Monitoring and Control Stations (CMCS) with parking Shed

Contractor shall construct Central Monitoring and Control Stations (CMCS) as per detail engineering;

Contractor shall construct the same of min 300 sqm.

- The dimensions of the CMCS Building may be modified to comply with the statutory requirement suitable to accommodate Switchgear, SCADA, UPS etc. and Prudent Utility Practice. The contractor shall submit the drawing of the CMCS Building and the Administration Building for approval to the Employer.
- EPC contractor also need to construct fully furnished Guest House of minimum 1000 sqft (Carpet Area).
- Main Control Buildings shall be an integrated building comprising the following as a minimum:
 - Control and Relay panel Room
 - SCADA Room
 - Battery Room
 - O&M Staff Room
 - Storeroom
 - Conference Room
 - Manager Room-02 Nos
 - Pantry – 1 no.
 - Water Closets: 2 Nos.
 - Bathrooms: 2 No

Staircase (Concrete Staircase with handrail)

This shall also include 2 nos. overhead water tanks, each of 1000 liters capacity, adequately sized septic tank and required wash basins.

SCADA, Meeting, manager and Staff Rooms along with the guest house shall be provided with Energy Efficient industrial grade 5-star Comfort Air Conditioning System with a nominal operating temperature of 23-degree C and shall comply with all ASHRAE standards. Switchgear room shall accommodate LV Service switchboard, DCDB, LDB etc. Capacity of AC shall be decided as per room size.

The Substation Control and relay room shall accommodate Relay panels, Tariff metering panels, network communication panels, UPS, 415V AC service switch boards, Lighting DB & panels, etc.

TECHNICAL SPECIFICATIONS

The Substation control room shall accommodate SCADA system servers and operator workstation and operator workstation for tariff meters, Workstation for Disturbance recorder & Printers.

Control room, Relay room, SCADA, Meeting, manager and Staff Rooms shall have false floor for cabling and false ceiling.

Substation and Control room shall have RCC cable trench for cabling.

Although the actual layout and size of the Main Control Building and the Administration Building shall be finalized during detailed engineering subject to approval of the Purchaser, the Contractor has to meet the above minimum requirements without any deviation.

- Contractor to consider RCC building for CMCS building.
- Parapet wall of CMCS Building shall be 850mm high
- RCC work shall be as per IS 456 and shall essentially involve appropriate mix and cement reinforcement in accordance with relevant standards. High strength reinforcement shall be used. Industrial best practices shall be followed for bending and fixing of bars for concrete reinforcement.
- All brick works shall be made, using 1st class bricks of approved quality as per IS 3102. Masonry work shall be performed using appropriate class of bricks. Bricks shall be soaked in fresh water for a minimum of two (2) hours. Masonry works shall have suitably mixed cement mortar. After completion, masonry work shall be kept moist for a minimum of week.
- Ramp with platform shall be provided with anti-skid tiles for CMCS Building.
- The main door shall be of mild steel, single leaf type.
- Plastering in cement mortar 1:6 and 1:4 shall be applied to all internal, external walls and ceiling of slab respectively as per IS 1542.
- Flooring for stores shall be made of concrete, with mix 1:2:4 using 10 mm aggregates as per IS 2571. Flooring for control building, equipment room etc., shall be of industrial grade vitrified tiles 12 mm.
- Roof shall be smoothened and built for efficient rainwater disposal. The roof of the building shall be properly insulated from heat and waterproofing shall be done as per IS standard.
- Anti-termite treatment shall be got done through approved specialist agency which is a member of Indian pest Control Association holding valid license the defects liability period of anti-termite treatment shall be 10 years and the contractor shall be responsible to keep the entire buildings free from termite infestation for a period of 10 years after the certified date of completion. The contractor may obtain a similar guarantee from the specialist firm engaged by him for the purpose.
- White washing and color washing work shall be conforming to IS 6278.

TECHNICAL SPECIFICATIONS

- Internal walls - Acrylic distempering as per IS 427.
- External walls - Heat reflective synthetic enamel as per IS 428.
- For painting of steel doors, wooden doors, ventilators - IS 2338, IS 1477 (Part I & II) shall be followed.
- Rainwater harvesting only for the CMCS Building with 2 No of sock pit rainwater shall be collected from the roof through down pipe and finally connected to 2 no of 4 feet diameter and 5 feet depth soak pit. 50 feet perforated pipe need to provide with each soak pit.
- GI/MS pipes (Medium Class B) shall be used for water supply and plumbing works. Piping shall include all the required valves, stop cocks etc.
- Sample of cement from each lot should be collected by the Engineer-in-Charge and AMP in accordance with IS 3535-1986, for independent or additional tests. The cement shall be tested within 1-3 weeks on supply but before incorporation of the same in works. The cost of testing, transportation and of material used in testing etc. shall be borne by the contractor irrespective of the results of testing and no extra claim whatsoever shall be admissible. The record of such samples selected by the AMP for testing shall be properly maintained in the 'Cement Testing Register' giving cross reference to relevant consignment of cement and quantity received etc. Cost of transportation of samples to the approved laboratory/test house and all testing charges including cost of sample shall be borne by the contractor.

TECHNICAL SPECIFICATIONS

A-6: MISCELLANEOUS

1. CODES AND STANDARDS:

All works shall be carried out as per the latest standards/codes (IEC, IS etc.) referred in the specification. All standards, specifications and codes of practice referred to shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those codes/standards referred the former shall prevail.

Equipment complying with other internationally accepted standards such as BS, UL, DIN, VDE etc. will also be considered, if they ensure performance and constructional features equivalent or superior to standards listed in the specification. In such case the Bidder shall clearly indicate the standards adopted, furnish a copy in the English of the latest revisions in force as on date of opening of bid and shall clearly bring out salient features for comparison.

2. APPROVALS:

The scope of the bidder includes complete design and engineering, technical coordination (including participation and arranging technical co-ordination meetings), finalization of drawings/ documents, submission of engineering drawing / documents and processing of their approvals by the Employer as per relevant clauses of Section VI (Technical Specifications) and other relevant clauses given elsewhere in the Technical Specifications. Further, the scope shall also include submission, in proper shape & format, of all types of manuals, handbooks & documents in requisite numbers to the Employer at different phases of the project as per the requirement of Employer. The contractor shall have to arrange technical coordination meetings and ensure participation.

3. PAINTING:

The bidder's scope of work includes painting of all equipment and structures as per the Employer's standard color-coding scheme. The painting shall include required application of finish paint indicated elsewhere in the Technical Specification. The quality and finish of paints shall be as per standards of BIS or approved equivalent, suitable for coastal (corrosive) conditions of site. Employer's Color-Coding scheme shall be furnished during detailed engineering stage.

4. TESTING

During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification. Unless specified, the type test should have conducted within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However, if the contractor is not able to submit report of the type test(s) conducted within applicable period or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests

TECHNICAL SPECIFICATIONS

under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

5. SPARES

The Bidder shall include in his scope of supply all the necessary Mandatory spares as described elsewhere in the Bid documents.

6. TRAINING OF EMPLOYERS PERSONNEL:

The bidder shall provide training (free of cost) to the personnel of Owner/ Company for 60 man- days at his works and at site for erection, testing, commissioning and O&M. Expenses towards travel, lodging, and boarding and other expenses for the personnel shall be borne by Owner/ Company.

7. PG Test Procedure: refer Appendix 7

TECHNICAL SPECIFICATIONS

Appendix 7

PERFORMANCE GUARANTEE (PG) TEST

The final acceptance test as to prove the Performance Guarantee shall be conducted at site by the contractor in presence of the Employer. The PG test shall be conducted based on PG test procedure to be submitted by the contractor and approved by CIL. This test shall be binding on all the parties of the Contract to determine compliance of the equipment with the functional guarantee. All auxiliary systems shall be taken into service before commencement of PG Test of the plant. Any special equipment, instrumentation tools and tackles and manpower, required for the successful completion of the Performance Guarantee Test shall be provided by the Contractor free of cost. The accuracy class of the instrumentation shall be as per the relevant clause of documents. PG test shall be started immediately after commissioning of entire project capacity so that PG test can be concluded within a year.

The procedure for PG demonstration test shall be as follows:

One-month (minimum 30 days) period, preferably during clear sky season, shall be chosen on the discretion of Company/ Owner for conducting the Performance Guarantee (PG) test.

1. Bidder is required to quote the annual energy target generation in the techno commercial bid as per the scope.
2. The month wise energy generation target for the bidder shall be as per the PVsyst report finalized during detailed engineering stage.
3. If the Project is not able to achieve the target generation as per the approved PG procedure during the test period, then contractor shall compensate Company/ Owner with an amount equivalent to the loss of generation based on tariff as per SCC
4. Global solar insolation, albedo and Generation for tender purpose shall be calculated as mentioned in Appendix-1, Part-A of Technical Specifications.
5. There shall be three Net Energy values, and these can be defined annually, monthly or for any specific period. These energy values shall be Net energy values calculated after excluding the import energy from export energy, i.e. Export-Import.

TECHNICAL SPECIFICATIONS

- i. **Quoted Net Energy (QNE)**- This is the Generation (in kWhr/MWhr/MU) quoted by the Bidder in the techno-commercial bid based on the design parameters and values considered for the plant in Pvsyst
- ii. **Actual Plant Net Energy (APNE)** – This is the actual plant generation (in kWhr/MWhr/MU) as per the readings recorded at the Metering Station at the Delivery point.
- iii. **Expected Net Energy (ENE)**- This energy (in kWhr/MWhr/MU) shall be calculated using the actual measured GHI, and Average Ambient Temperature and importing these site-measured values in the PVSYST software, keeping all the other Parameters fixed as per the approved design values to meet the Quoted Net Energy.

Note: The Expected Net Energy (ENE) shall be used for reference only and shall not form the basis for any correction, adjustment, or penalty. The Owner shall not be held accountable for deviations in actual irradiance or temperature. Only Expected Net Energy (APNE) vs Quoted Net Energy (QNE) will be considered for evaluating PG Test compliance.

6. The Pvsyst report and project files used for calculating Quoted Net Energy (QNE) shall be submitted during detailed engineering. The same shall be reviewed by Company/ Owner and then finalised. It is highly recommended that bidder may consider suitable PV syst values which are as close as possible to the actual plant details for fair assessment. Bidder to provide all relevant input files used to run the PVsyst simulation for the project. This final simulation version shall be used to simulate for Expected Net energy (ENE) by importing site measured GHI and Temperature values and keeping all other parameters unchanged.
7. While measuring the Actual Plant Net energy (APNE), the corresponding actual GHI values in kWh/m² and actual Ambient Temperature in Degree Celsius shall also be recorded. These readings shall be noted by the Contractor and shall be monitored & Certified by the Engineer-in-charge or his authorized representative on daily basis for entire PG test period.
8. The Actual plant net energy (APNE) shall be compared with the Expected Net Energy (ENE) considering Actual measured site GHI and Average ambient temperature and importing these site-measured values in the PVSYST software, keeping all the other Parameters fixed as per the approved design values excluding the periods of grid outage or any backdown situation not in control of the contractor.
9. Effect of any other meteorological parameters shall not be considered except for the above two mentioned meteorological parameter, i.e., GHI and Average Ambient Temperature.
10. Accounting of Generation loss due to grid outage (or outage of power evacuation system which is not in the scope of the Bidder) or any backdown situation not in control of the contractor: The measured global solar radiation of the period of the outage of the power evacuation system or for a period of backdown situation ordered by relevant authorities for any suitable reason not

TECHNICAL SPECIFICATIONS

attributable to the contractor shall be excluded/suitably adjusted to calculate the cumulative global Insolation for the month. Under such situation, the radiation corresponding to the warm-up time of inverter as per data sheet shall also be adjusted to arrive at the cumulative global insolation for the month.

11. In addition to the pyranometers and ambient air temperature sensors supplied and installed under the scope of work, contractor shall install same number of additional pyranometers and ambient air temperature sensors so that each location of measurement of GHI and Temperature shall have two pyranometers for radiation measurement and two ambient air temperature sensors for temperature measurement. The additional sensors/ pyranometers shall be complying with the technical specification and shall be free of cost on returnable basis. Valid test reports for the installed pyranometers shall be submitted by the Contractor for approval to Company/Owner. Average per minute values of all pyranometers (in W/sq. M) and ambient temperature sensors shall be considered in the PVsyst.
12. Contractor shall also install data logger to store all the pyranometers data during test period. All Pyranometer stations shall be provided with data loggers and the data logger shall capture all the raw data coming from the sensors and all processed data as per requirements of specification.
13. Before start of the PG test, Company's / Owner's team and EPC contractor shall check the integrity/protection and accuracy of the data logger and sensors. Further the data integrity and accuracy of measurements can be checked by Company/ Owner at any time during the PG test. The output of all the pyranometers mounted on horizontal plane shall be made available at SCADA during the complete PG test duration.
14. Radiation/temperature data from the datalogger and SCADA shall be downloaded weekly or earlier, jointly by Company/Owner and contractor and shall be jointly verified.
15. During the PG test period, the module tilt shall be kept as per approved schedule.
16. Actual net energy generated from the plant shall be noted for 30 consecutive days, i.e. PG test period. For this purpose, the net energy exported at the metering point and pyranometers reading shall be noted at agreed frequency on daily basis for entire PG test period.
17. If the difference of readings (in kWh/sqM or Temperature on any whole day) between the two horizontally mounted pyranometers and/or temperature sensors at the same location exceeds 2% then readings of that location shall be discarded and readings of other locations shall only be considered. If the variation exceeds 2% at all pyranometer locations, then the day shall be discarded. Maximum 02 such days shall be discarded due to any abnormality/malfunctioning of instrumentation (hardware or software) of ambient temperature and radiation measurement. In case the instrumentation issues occur for more than 02 days, then Company /Owner shall have the discretion to repeat or continue the test.
18. Contractor may opt to repeat the PG test in case of outage of any of the following equipment for more than 2 cumulative days.
 - i. Inverter transformer

TECHNICAL SPECIFICATIONS

- ii. Power Conditioning Unit
- iii. Inverter Duty Transformer (IDT)
- iv. HT Switchgear and/ or ICOG
- v. Power and/or Tie transformer

If bidder is not able to demonstrate PG test during the one-month period they shall be given one more chance to demonstrate the PG test after establishing the reasons of shortfall in generation and rectifying them. In that case, the steps for PG test shall be repeated as above after carrying out necessary modification/replacement/rectification.

In case of any practical difficulty encountered during the PG test, then EPC contractor and Company/ Owner shall mutually resolve it for concluding the test in the spirit of contractual provisions.

TECHNICAL SPECIFICATIONS

A-7: TERMINAL POINT AND EXCLUSIONS

1. ELECTRICAL INTERFACES

A. TERMINAL POINT:

The Bidder shall terminate each export feeder of 33 KV side of 400/33 KV Internal Pooling Sub-station where power from the Solar Power Project is injected for measuring export / import from each project. All hardware required for 33kV cable termination at 33kV Main Pooling Switchgear shall be under scope of bidder.

B. EXCLUSION:

The following are excluded from the scope of Contractor under this contract:

- a. Main Pooling 33kV Switchgear incoming for PPS and associated equipment.
- b. 400/33 KV Internal Pooling Switch yard including Power Transformers and Substation Automation System.
- c. Space for accommodating Solar SCADA and other equipment at GIS Switchyard Control Room.
- d. DC & AC source of supply required for above equipment at GIS Switchyard Control Room.
- e. 400kV Transmission line from 33/400kV Park Pooling substation to RVPN GSS 400kV.

2. CIVIL INTERFACES

A. TERMINAL POINT:

All Internal Project Roads and all Drainage are in Bidder Scope and shall be constructed and connected suitably with the Main Road at Park periphery/ PSS location etc. by the Bidder. Permanent Park peripheral fencing of the is in Solar Park Developer scope, but internal park plotting fencing is in Bidders scope. Also, any temporary arrangement for safety and security of project, Manpower as well as any storage arrangement (Equipment or otherwise) etc. during construction would be in Bidder Scope. All temporary arrangements w.r.t approach roads, drainage, office set up, labour management etc. as necessary to take up the project construction work, would be in bidder's scope.

B. EXCLUSION:

The following Civil works are excluded from the scope of Contractor under this contract:

Peripheral Road & road joining plots to PSS & Main Approach Road (Refer Vicinity Map / Layout).

TECHNICAL SPECIFICATIONS

PART: B

TECHNICAL SPECIFICATIONS

DC SYSTEMS

TECHNICAL SPECIFICATIONS

B-1: SOLAR PHOTOVOLTAIC (SPV) MODULES

GENERAL

Under 'Make in India' policy of Government of India, Purchase Preference will be given to eligible bidders as per Public Procurement (Preference to Make in India), Order 2017 issued vide order No. P-45021/2/2017-B.E.-II dated 15th June 2017 (subsequently revised vide orders dated 28.05.2018, 29.05.2019, 04.06.2020, 16.09.2020 and 04.03.2021) of Department for Promotion of Industry and Trade, Ministry of Commerce and Industry.

The modules to be procured by the Contractor as per provision as contained in the O.M. dated 10.03.2021 issued by MNRE on the subject "Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirement of Compulsory Registration) Order, 2019-Implementation-Reg." and its subsequent amendments and clarifications (including MNRE's clarification ref. no. F. No. 283/54/2018- GRID SOLAR-Part (1) dated 11.05.2021 and Amendment to ALMM order OM No. 283/59/2024-GRID SOLAR dated 09.12.2024), shall be applicable for this Tender.

In line with provisions already specified in ALMM Order dated 02.01.2019, and subsequent clarifications and amendments thereto, all projects falling under the purview of ALMM shall have to mandatorily source their solar PV modules from models and manufacturers included in ALMM List-1 for solar PV modules and such solar PV modules in turn shall have to use solar PV cells from amongst the models and manufacturers enlisted in ALMM List-II for solar PV cells, as specified in OM No. 283/59/2024-GRID SOLAR dated 09.12.2024 and subsequent amendments, if any.

The Module specifications should be as per parameters mentioned in clause 1, Chapter A-4, Part A.

TECHNICAL SPECIFICATIONS

B-2: TRACKER SYSTEM (Optional)

1. GENERAL

The PV modules shall be mounted on metallic structures called Module Mounting Structures (MMS) having adequate strength and appropriate design, to withstand various loads on the MMS including design wind pressures. Modules shall be mounted on non- corrosive support structures with Automatic motor powered Realtime East-West tracking.

2. TRACKER SYSTEM

The Tracker System shall be of proven design capable of tracking Sun's path actively, intended to maximize the energy output from PV Module. Design shall be based in accordance with the site climatic conditions and seismic loads, soil characteristics, thermal loads caused by expected fluctuations of materials and ambient temperatures and the minimum required design wind speed.

A. STANDARDS

- a) UL 2703: Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels or equivalent
- b) UL 3703: Standard for Solar Trackers or equivalent
- c) IEC TS 62727: Photovoltaic systems - Specification for solar trackers
- d) IEC 62817:2014+AMD1:2017 CSV: Photovoltaic systems – Design qualification of solar trackers

B. DESIGN

- a) Only single axis East-West real time tracking
- b) Configuration - Both, single and multi-rows options are accepted.
- c) Tracker Range of Movement (ROM): +/- 60 degrees or better
- d) DC/AC Self-powered drive system with battery backup of 3 days autonomy.
- e) Individual row-level bi-directional control
- f) Redundant communication (wireless) for individual Trackers
- g) Stow configuration: optimal Angle, as per aero elastic instability analysis.
- h) Design wind speed as per site condition, basic wind speed as per wind map of India from IS 875 Part 3: 2015.
- i) Suitable material for corrosion category compliance as per Corrosion map of India, EN ISO 14713, EN ISO 1461, EN ISO 12944-5 or ASTM 123.
- j) Operational temp: -10 to 50 degree Celsius.
- k) Integration to Plant SCADA
- l) Cleaning - Compliant with robotic module cleaning

TECHNICAL SPECIFICATIONS

- m) Minimum 400mm clearance to be maintain at module edge with maximum angle.

C. REQUIREMENTS:

- a) Tracking system shall be followed by either means of sun's positioning algorithm or optimization algorithm with a minimum tracking accuracy of $\pm 2^\circ$ between the pointing vector of the sun and the pointing vector of the modules.
- b) The tracking system shall have back tracking algorithm to avoid inter-row shading and optimizing irradiance collection for both row avoidance shading and diffuse light optimization.
- c) All local tracking controls shall be mounted on the tracking structure. A suitable arrangement/bellows shall be provisioned to protect actuator assembly from extreme outdoor harsh condition, dust and UV rays.
- d) In case of failure of supply, the arrays should return to the stow position. Bidder shall supply a tracking mechanism with an inbuilt feature for meeting the requirement.
- e) All modules associated with a specific tracking system should be connected to a common inverter.
- f) Suitable redundancy in sensing and auxiliary power supply shall be provided for fail-safe stowing of trackers. Redundancy in control is also desirable for the safe operation of trackers. Detail of the scheme for various redundancy shall be finalized at the time of detailed engineering.
- g) Safety measures such as stop devices shall be applied to ensure personal safety.
- h) Tracker shall be equipped with safety features like, auto high wind stow to the designed angular position and shall have uninterrupted communication with monitoring console/station. It should be capable of sending alarms to the monitoring station in case of failure or abnormal operations of the tracking systems.
- i) For each row an earthing cable shall be installed to interconnect all metallic parts of foundation, tracker structure and PV modules of each table.
- j) Tracker design shall also include a provision for fastening DC cables to the structure each 500mm without causing tearing or fluttering of cables.
- k) Tracker shall able to track as per proposed stow strategy supported by Wind Tunnel test.
- l) Tracker Torque Tubes should be galvanized in accordance with, ISO 1461, ISO 14713, ISO 9223, or relevant standard as per Corrosive Category of proposed Solar PV Site.

D. MODULE MOUNTING ARRANGEMENT:

- a) Module mounting structures shall be designed to withstand the extreme weather conditions in the area. The site design wind speed factors k1, k2, k3 and k4 and pressure coefficient shall conform to IS 875 (Part-3): 2015 or as per a Wind Tunnel Study from a reputed national/international

TECHNICAL SPECIFICATIONS

facility, for the design of MMS. However, design wind pressure to be considered for design, shall not be taken less than the minimum wind pressure “pd” as mentioned in the Technical Specification.

If the Bidder is going for wind tunnel test for the analysis & design of complete MMS and solar tracking system following shall be ensured.

- i. It must be done from an institute of repute (IITs / CSIR-SERC / CPP Wind Engineering / RWDI or equivalent) in Indian / international facility.
 - ii. Bidders must ensure that offered tracker has proven design with wind tunnel test simulating relevant site conditions. The analysis and design shall be completed within two months from the actual date of issue of LOA.
 - iii. Tests and design must comply with relevant Indian/ International codes.
 - iv. The design shall be shown in STAAD pro or similar commercially available software for further checking by CIL as and when required.
 - v. Refer Appendix-1 for site-specific design parameters.
- b) The structural material and design shall be as per Design Criteria for Module Mounting Structures (MMS). The structural Material Yield Strength and Minimum Design Thickness can be as per “Proprietary Design” of Tracker supplier, and It shall conform to relevant Indian / international codal design provisions. The Proposed Solar PV tracker system should be certified for successful performance of MMS and tracker system by designer for its design life of 25 Years after COD. The Solar PV tracker system shall also fulfil the requirements of proveness criteria as per Chapter A-3.
- c) The design and the calculations for the MMS and the foundation system shall be submitted for prior approval of CIL before the commencement of construction and shall be based on the soil Geotechnical Investigation report.
- d) Further details related to structures and foundations have been mentioned in the chapter on civil works of these specifications.
- e) The Structure shall be analysed and designed in accordance with finite element method and the fundamental principles of Engineering using commercially available software (such as STAAD pro or similar), with dead loads and imposed loads considered as per IS 875 (Part 1 & 2) respectively, and with wind loads considered as per IS 875 (Part 3) or as per Wind Tunnel study done from a reputed national/international facility (IITs / CSIR-SERC / CPP Wind Engineering / RWDI or equivalent). Analysis shall be done as per appropriate load combinations preferably as per IS codes.
- f) The Structure must be provided with limit switches to control the rotation

TECHNICAL SPECIFICATIONS

of the frame.

- g) All nuts & bolts or clamps shall be of Stainless steel, Aluminium or Metal Alloy type for a module to structure connection, and other structural bolts shall be of grade HDG5.6 or 8.8 or exclusively designed for solar tracker systems by manufacturers. Which should suffice the design life for 25 years and more for Corrosive Category proposed for Solar Park and confirm to Indian / international codal provision.
- h) Tracker Based MMS would be provided with Module Supporting Member(s) including the provision for fixing of modules, such that the maximum pressure in module frame is limited to +/-1600Pa (Design) / +/-2400Pa (Test) under Wind Load or any Combination. Higher permissible stress would be permitted based on actual inputs and module fixing location during post award Engg. subject to approval of EIC.

E. PROTECTION AGAINST CORROSION & UV

Appropriate measures shall be considered, as required, to protect the structure, foundation, and all components against corrosion during the expected lifetime of the Plant. Structural steel shall be hot dip galvanized as per ISO 1461 (or BS 729), EN 10346, ISO 14713, IS 4759, ISO 9223 and as per Corrosive Category of proposed Solar PV Site. However minimum galvanization to be provided would be as per details mentioned for conventional MMS structure.

Non-metallic materials placed outdoors shall be UV and sand resistant and withstand high ambient temperature operation regimes as per the climatic conditions over the whole Plant design lifetime, and where materials are specified in any part of this RFP, those characteristics are to be considered as a minimum requirement. Metallic materials are not explicitly required to be UV resistant but in case protective coating is required, this shall be UV and sand resistant.

All materials used for concrete, reinforced concrete structures, steel structures, aluminum structures or structural elements or any other building material shall be of high quality, free from defects likely to undermine the strength and duration of service of the Plant.

F. BEARING

- a) The bearing should be type tested for operation cycles which solar plant will go through in its life of 25 years.
- b) Preferably there should not be any lubrication in the bearing, but if there is any, then it should be maintenance free. No cleaning should be needed.
- c) The bearing should also be resistant to dust, water and any other external parameters. Test report to be submitted.

G. MOTOR AND ACTUATOR

TECHNICAL SPECIFICATIONS

- a) The motor should be IP 65 or better and it should be powered by reliable supply to drive the link through gear or hydraulic/electric actuator.
- b) The temperature rises in the motor during operation specified in IS12802: 1989 should not be more than approximately 10°C.
- c) The location and moisture or fumes shall not seriously interfere with the operation of the motor.
- d) The severity of vibration for the motors shall be within the limits specified in IS 12075: 1987.

H. CONTROLLERS

- a) Trackers should have an industrial grade system for its automatic control and operations. For all outdoor controllers, it should be housed in IP-65 enclosure.
- b) Battery back-up should be provided for Controller and motor for at least 15 minutes with power pack cum UPS. Alternatively, the bidder can provide backup power from the UPS of inverter room or CMCS room.
- c) The controller must be enabled with a feature of stowing during high-speed winds.
- d) The Real Time Clock (RTC) of the trackers shall have a facility to be time synchronized with SCADA on Network Time Protocol (NTP).
- e) A suitable communication link between the master controller of tracker and tracker SCADA system shall be arranged. The software for communication and analysis shall be provided by the tracker supplier. Tracker SCADA shall be interfaced with solar SCADA on an open protocol such as MODBUS.
- f) Battery back-up should be provided for Controller and motor as per design specified in Cl 2.2. Alternatively, the bidder can provide backup power from the UPS of inverter room or CMCS room.

I. STUDIES/REPORTS

The following studies, and reports shall be submitted by the Bidder for the offered solution. The studies and reports shall provide a positive outcome of the respective tests, designs, and concepts for the utilization of the proposed single axis tracking system in the Project:

- a) Stow strategy control system: The Tracker supplier is solely responsible for the definition and implementation of a proper stow strategy, which clearly demonstrates and guarantees the safe operation of the tracker during all wind events with speed up to and including the maximum one defined as per local structural code. The following points, including but not limited to, should be made available as part of the safety stow strategy

- Tracker inclination and orientation at safety stow position

TECHNICAL SPECIFICATIONS

- Maximum wind speed in [m/s] as [3-sec gust / 10min average] defined at 10m height which the tracker can withstand in working position
 - Stow alarm function and wind speed at which it is triggered
 - Safety strategy during installation / commissioning
In case that batteries are used, which is the minimum charge level required in order to reach safety stow position
 - Security of communication protocols required for the active stow
 - Time requirement to move the tracker from working position into stow position considering also safety factors
 - System redundancies that help to minimize risk of failure.
Emergency system in case of tracking or measurement defects
 - Dynamic analysis and tests along with static coefficients based on the actual tracker configuration, stiffnesses and geometry
 - Aeroelastic instability analysis for the proposed tracker structure to show that the stow angle will not result in aeroelastic instability
 - Definition of tolerances, maximum terrain inclinations North-South, East-West
-
- b) Wind tunnel tests from a recognized wind expert institute (IITs / CSIR-SERC / CPP Wind Engineering / RWDI or equivalent).
 - c) Independent Engineers Bankability review report from reputable agencies like Black and Veatch, DNV, IITs or other premier institutions/agencies.
 - d) Structure design review document from any IIT Civil/Structural certifying department, if required.

J. WARRANTY

- a) 25-year lifetime design (at least) considering local ambient conditions and in respect of all standards for the PV modules support structures and foundations
- b) 5-year warranty starting with the Project Commercial Operation Date (COD) for the complete mounting structure including but not limited to the design, material, and installation of the tracker, substructure, power unit, piles, and foundations
- c) 25 years for corrosion protection.

3. CODES AND STANDARDS

The applicable codes and standards $A = \pi r^2$ as mentioned below.

TECHNICAL SPECIFICATIONS

1	IS 875: Part 1 & 2	Code of practice for the design loads for buildings and structures
2	IS 875: Part 3	Code of practice for the design loads for buildings and structures-Wind Loads
3	IS 800: 2007	Code of practice for use of structural steel in general building construction
4	IS 4759	Hot-dip zinc coatings on structural steel and other allied products
5	IS 1868	Anodic Coatings on Aluminium and its Alloys

Equivalent National and International standard/code would also be acceptable
Module Mounting structures (MMS) with trackers.

TECHNICAL SPECIFICATIONS

B-3: DC CABLES

The DC Cables in a solar PV plant are used in the following areas

- i. Interconnecting SPV modules
- ii. From SPV Modules up to SCB
- iii. From SCB up to the Inverter.

1. DC CABLES (Interconnecting SPV MODULES and from SPV Modules TO SCB)

Each module, provided by Employer, shall have two 4 sq.mm stranded UV resistant cables and terminated with DC plug-in connector directly. The positive (+) terminal shall have a male connector while the negative (-) terminal a female connector. All the modules in the PV plant shall be arranged in a way so as to minimize the mismatch losses.

It is to be ensured by the contractor that the Modules installed on a MMS Table, in two rows, should be connected to each other so as to minimize the shading effect. The same is to be achieved by connecting the modules in the upper row of consecutive tables in series. Similarly, the modules in the lower row are to be connected in series and to be kept separate from the modules in the upper row. Bidder can also propose a different scheme during detailed engineering subject to engineering review and acceptance.

Cables used for inter-connecting SPV modules as well as Modules to SCB's shall conform to the requirements of EN 50619:2014/IS17293:2020 applicable for DC cable for photovoltaic system. The connectors used for interconnecting the modules and connectors used for connecting the strings and/or to the String combiner Box, i.e. field connectors to be mated shall be of same make and model otherwise they shall be tested for Inter-compatibility as per detailed Specification of Field Connectors given elsewhere in this specification).

These cables shall also meet the fire resistance requirement as per the above standard and shall be electron beam cured.

All cables except module cable used for (+) ve and (-)ve shall have distinct color identification.

In addition to manufacturer's identification on cables as per EN50618/IS 17293, following marking shall also be provided over outer sheath.

- a) Cable size, voltage grade and code designation "PV"
- b) Word 'HALOGAN FREE LOW SMOKE'
- c) Sequential marking of length of the cable

The distance between two consecutive printing, identification or embossing shall not be more than 550 mm. The Printing shall be progressive, automatic, in line and marking shall be legible and indelible.

TECHNICAL SPECIFICATIONS

Type test, routine, acceptance tests requirements for these cables shall be as per EN50618:2014/IS 17293:2020. All test charges shall be deemed to be included in the cable price. Sampling for acceptance tests will be as per IS 7098.

A maximum of 8 Cables (4 Circuits) shall be laid in one HDPE Pipe for DC Cable from Module to string monitoring box (if applicable). The fill factor of the pipe should not be more than 40%.

However, in case of necessity to lay more than 8 cables (4 circuits) in one pipe, the same shall be allowed during detailed engineering and as per the derating factors recommended by the cable manufacturer. Fill factor criterion is still to be maintained.

Bidder to ensure that there is no gap and proper packing at the junction of two pipes, in which DC cable is laid, using proper method and accessories, like bell mouth.

Bidder can propose DC Cables (Interconnecting SPV Modules and from SPV Modules to SCB) with Nylon 12 sheath/other suitable material between Insulation and outer sheath of the DC Cable. Such cables can be laid without DWC/HDPE pipes. Such cable should be type tested. The proposal to accept such cable and such laying methodology shall be reviewed during detailed engineering.

2. DC CABLES (STRING COMBINER BOX TO INVERTER)

Cables used between SCBs and Inverters shall be of 3.3kV (E) grade. These Power cables shall have compacted Aluminium / Copper conductor, XLPE insulated, PVC inner- sheathed (as applicable), Armoured / Unarmoured, FRLS PVC outer sheathed conforming to IS: 7098 (Part-II). These cables shall confirm to the requirements of the standards & codes specified in the relevant chapter.

For other details refer chapter –LT Cables

Bidder can propose DC Power Cables (SCB to Inverter) with armour of HDPE/other suitable material instead of Steel or Aluminium Armour. Such cable should be type tested. The proposal to accept such cable shall be reviewed during detailed engineering.

3. DC CABLES SIZING CRITERIA

As per relevant clause in Chapter A-4

4. CABLE DRUM

For details refer clause 8.0 of Chapter B-8 AC Cables

TECHNICAL SPECIFICATIONS

B-4: STRING COMBINER BOX

1. GENERAL

String Combiner Box (SCB) is used in multi-string photovoltaic systems to combine the individual strings electrically and connect them to the Inverters. It shall have protection devices to protect the PV modules from current/voltage surges. Nos. of input to each SCB shall be decided during detail engineering based on approved SLD and the temperature rise calculations.

Vendor to note that DC system 1500-Volt rating only is acceptable. Accordingly, component/assembly shall comply with 1500 V rating as applicable.

Voltage rating of the selected component shall be 1500V (Min.) as per system requirement during detail engineering. SCB offered for 1500V Application shall have already been type tested and in satisfactory operation in Solar plant with 1500 V DC system.

2. CODES AND STANDARDS

S NO.	CODES	DESCRIPTION
1	UL 94V	Fire Resistant/ flammability for Enclosure
2	UL 746C	UV Resistant for Enclosure
3	IEC 62262/EN 50102	Mechanical Impact Resistance for Enclosure
4	IS 2147/IEC 60529	Degrees of protection provided by enclosures (IP Code)
5	IEC 61643-31	Surge Protection
6	IEC 62208	Enclosure for low voltage Switchgear and control gear assemblies

Vendor shall submit the suitable Test Certificate/ Report from accredited lab(s) indicating compliance of mentioned codes and standard if asked for the offered component or assembly.

3. GENERAL REQUIREMENT

SCB shall be equipped (but not limited to) with the following.

- DC Disconnect/ Breaker to disconnect the PV strings from the Inverter for maintenance purpose as per specification mentioned in this chapter.
- All component in the SCB shall be suitable for operation within temperature range of 0-65 Deg C.
- Fuse in each SCB input (both positive and negative) shall be provided to prevent the reverse short circuit current flow. However, in case of negative

TECHNICAL SPECIFICATIONS

string fuse is not required as per recommendation of inverter manufacturer, string cable shall preferably be terminated with field connector with SCB.

- d. Surge Protection Devices for protection against surge currents and voltages as per specification given in separate clause. Other associated items like cable glands, lugs, vents and items required for the protection and completeness of the system shall be provided
- e. The common collection bus bars should be made up of zinc/ tin coated copper and shall be suitably sized to limit temperature rise within safe operating limits.
- f. Vendor shall ensure adequate clearance with suitable insulated separator between positive bus and negative bus if it is in same enclosure. Positive and Negative section shall be orientated horizontally (Landscape orientation) on the either side of separator. Separate compartment for negative section and positive section for termination of positive and negative string input shall be preferred.

4. DC SURGE PROTECTION DEVICES (SPD) for PV Solar Application:

DC output SPD shall consist of three Metal Oxide Varistors (MOV) type surge arrestors which shall be connected from positive and negative bus to earth. The discharge capability of the SPD shall be at least 12.5kA at 8/20 microsecond wave as per IEC 61643-12 and shall be rated for MCOV 1500 Volt DC. During fault and failure of MOV, the SPD shall safely disconnect the healthy system. SPD shall have thermal disconnecter to interrupt the surge current arising from internal and external faults. In order to avoid the fire hazard due to possible DC arcing in the SPD due to operation of thermal disconnecter, the SPD shall be able to extinguish the arc. SPD shall have local visual indication and potential free contact for remote indication.

5. STRING FUSES

In order to provide protection to all cables and modules, string fuses shall be provided with strings. String fuses shall be of gPV category and dedicated to solar applications and conform to IEC 60269-6 or UL-2579 standards and fuse base shall comply with IEC 60269-1. String fuses should be so designed that it should protect the modules from reverse current overload. Fuses or Isolation Link shall be mounted in pull out type fuse holders. Fuse holders shall be suitable for DIN rail mounting. PCB mounted fuses are not acceptable. Fuse rating for single and combined input (limited to two) shall be calculated and finalized as per the current rating (Isc) of the PV module installed and the same be finalized during detailed engineering which shall be suitable for 1500 Volt for crystalline module.

For Thin film modules, fuse rating shall be decided during detail engineering. In case of negative grounded system, requirement of string fuses as well as inverter input fuses on negative side shall be decided based on the recommendation of Inverter (PCU) manufacturer. There should be minimum 10 mm gap between two fuses (fuse holders).

TECHNICAL SPECIFICATIONS

6. SCB ENCLOSURE AND ASSEMBLY

SCB shall satisfy the following requirement.

- a. The enclosure shall be made of UV Protected, Halogen Free, and Fire-retardant GRP/FRP/Polycarbonate material with self-extinguishing property.
- b. Degree of protection for enclosure shall be at least IP 65. All the part shall be corrosion resistant and enclosure surface shall be free from crazing, blistering, wrinkling, color blots/striations. There should not be any mending or repair of surface.
- c. The mechanical impact resistance of enclosure shall be IK 10 or better.
- d. The size of the enclosure and general arrangement of the component shall be designed in such a way that the average temperature of enclosure shall not exceed 62-degree C and operating temperature of the components used in the enclosure shall not exceed 72 deg C or OEM recommended temperature limit at ambient temperature of 50 deg C for rated load conditions along with spare. The components mounted inside the SCB shall have higher temperature withstand capability and operation/performance of should not be affected due to derating by temperature.
- e. Complete assembled SCB shall be subject to heat run type test to be witnessed by owner after manufacturing. The heat run test to be carried out at 1.25 times the rated current i.e. $1.25 \times (\text{Imp of PV Modules}) \times (\text{no. of string inputs} + \text{spare})$. In case it is found that the temperature rise is beyond the acceptable limits, bidder shall redesign the assembly and perform the test free of cost to verify that temperature rise is within acceptable limit.
- f. In each SCB 5 % spare terminals along with cable glands and fuse rounded off to next higher integer shall be provided to connect the PV strings.
- g. All terminals' blocks shall be rated for min 1000V/1500 V and rated continuously to carry maximum expected current.
- h. SCB shall be mounted under the PV module or under proper shed with minimum 150mm extension at all sides of SCB for protection from direct radiation. Design and dimensions of SCB structure must be such that minimum 400 mm (bending of DC cable also to be considered) of ground clearance is available below SCB at site for repair and maintenance. All the erection hardware and mounting accessories shall be galvanized steel.
- i. All internal wiring shall be carried out with stranded copper wires with voltage rating mentioned elsewhere in the specification. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to component terminals and terminal blocks. Wire terminations shall be made with solder less crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations.
- j. Engraved core identification plastic ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit

TECHNICAL SPECIFICATIONS

tightly on wires and shall not fall off when the wire is disconnected from terminal blocks.

- k. If metallic hinge is being used with enclosure cover, it shall be made of SS 304 and shall be rust proof. Enclosure shall be provided with captive screws so that it screw don't fall off when cover is opened. Screw shall be made of corrosion free material. Suitable non-conducting protection cover shall be provided for any metallic hinge/screw/fastener to avoid contact with live part of the assembly.
- l. Mounting plate inside the SCB for mounting/fixing of devices shall be made of FRP/GRP.
- m. Offered enclosure shall have adequate space to fix one String Monitoring card, One Modbus SPD and One DC-DC converter for internal power supply with suitable terminal block for retrofitting of enclosure to convert the offered combiner box as String Monitoring Box in future by Owner/ Company. Vendor shall submit a sample Internal GA drawing with aforementioned components for future use of Owner/ Company in addition to the drawing/document(s) for inspection and dispatch of offered assembly for Owner/ Company approval.
- n. RF Communication should handle large amount of data and it should be secured using encryption and authentication protocols to protect data from unauthorized access. The receiver should be PLC based with built in 8 DI/4 DO, 512 Kb memory and removable storage of 2GB, it should have 2 built in Ethernet port for redundancy and RS 485 port should be extendable. Should support SNTP protocol for time synchronization.

7. DC On-load Isolator

Solar PV On-load Isolator shall be suitable for 1500Vdc operational voltage having minimum Insulation voltage of 1500 V dc, in true 2 pole or 3 pole construction with 500Vdc per pole breaking. Any multipolar device achieving this configuration with shorting link (with less than 500Vdc per pole), will not be acceptable. The Isolators shall be type tested to carry the nominal current at rated Voltage till ambient Temperature of 60 Deg C without any de-rating, inside the String Junction box. The Switching part shall necessarily contain reinforced break with an integrated magnetic arc-extinguishing system for the PV arc. The PV isolator need to positive break indication given through a position indication window. The PV Isolator terminals need to be silver plated, and shall comply with IEC 60947-3 and tested for PV application. These shall withstand any PV current and should have no critical current.

8. A- TYPE TEST

Vendor shall submit the following Type Test/ Product Certification from any National/International accredited lab for approval.

- a. Temperature rise test on complete assembled Box as per acceptable limit mentioned in relevant clause.

TECHNICAL SPECIFICATIONS

- b. Type test for enclosure as per code and standard mentioned in relevant clause.
- c. Thermal ageing at 70 Deg C for 96 hours as per IEC 60068-2
- d. HV Test.

B- Routine test :

All acceptance and routine tests as per the specification and relevant standards.

An indicative list of tests / checks is mentioned in QA chapter on String combiner box. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

9. DC PLUG-IN CONNECTORS FOR FIELD CABLING

A. GENERAL REQUIREMENT:

Field connectors are electrical connectors/coupler used for connecting solar panels and also strings of panels to String combiners box. Cable connector to be used for connecting SPV modules and String combiner boxes shall be in accordance with IEC 62852: 2014.

Connector shall be of plug and socket design to be plugged together by hand but can be separated again using a tool only. Contractor shall ensure that field connectors to be mated shall always be of same make and model or shall be tested Inter-compatible as per IEC 62852: 2014 for offered make(s).

Mating of connectors of different makes/model shall not be acceptable if not tested for inter-compatibility by any accredited lab.

Bidder can propose Y-connector type DC Field Connector for paralleling two DC strings from PV Module to SCB. However, bidder to provide fuse in positive side of Y-connector. Fuse shall be sized as suitably.

B. TECHNICAL REQUIREMENTS:

Rated Current, IEC (85°C)	30 A (4 mm ² , 6 mm ²), 40 A (10 mm ²)
Rated Voltage	Min 1500 Volts
Connector Design	Snap-In locking Type
Protection Degree	IP68 (Mated)
Ambient Temperature	(-) 40 ⁰ C to (+) 85 ⁰ C
Protection/Safety Class	Class II
Contact material	Cu
Contact surface material	Silver/Tin
Contact resistance for plug connector	≤ 0.5 milli-ohms

TECHNICAL SPECIFICATIONS

Stripping length	10 mm
In flammability class	UL 94-V0
Insulating Material	PPE / PPO/Polyamide
Pollution degree	3
Certification	UL/TUV/CSA/EAC or Equivalent

C. TYPE TEST FOR DC PLUG-IN CONNECTORS:

- a. Protection Degree (IP)
- b. Operating Temperature
- c. In flammability
- d. Pollution Degree
- e. Voltage Withstand (Rated Voltage/Test Voltage)
- f. Salt mist, cyclic (sodium chloride solution) as per IEC 60068-2-52
- g. Product Certification

TECHNICAL SPECIFICATIONS

B-5: POWER CONDITIONING UNIT

1. The Power Conditioning Unit (PCU) is Solar Inverter designed to convert solar PV DC power to 3-phase AC power and fed into utility grid. The PCU shall consist of solid-state electronic switch along with all associated control & protection, filtering, measuring instruments and data logging devices. The PCU shall have suitable maximum power point tracker (MPPT) for operating the input PV Array at its maximum power point. The PCU output shall always follow the grid voltage & frequency by sensing the grid voltage and phase and the PCU shall always remain synchronized with the grid. The PCU shall use only self-commutated device which shall be adequately rated. The continuous combined rating of all PCUs shall be as per **Chapter A-4**.

1. CODES AND STANDARDS

The PCU shall conform to all applicable IEC standard. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice.

IEC-61683	Energy efficiency requirements
IEC 61000	Emission/ Immunity requirement
IEEE 519	Recommended practices and requirements for harmonic control in electrical power systems.
IEC 60068	Environmental testing
IEC 62116	Testing procedure—Islanding prevention measures for power conditioners used in grid-connected photovoltaic (PV) power generation systems
IEC 62109-1 & 2	Safety of power converters for use in photovoltaic power systems.
EN 50530	Overall efficiency of grid connected photovoltaic inverters.
IEEE 1547/IEC 61727/ BDEW	Standard for interfacing solar PV plant with utility grid.
IEC 60529	Ingress protection test
Grid Connectivity	Relevant CEA regulations and Indian grid code as amended and revised from time to time.

2. GENERAL REQUIREMENTS

A. Applicable both for Central and String Inverter

PCU shall meet the following technical parameter

TECHNICAL SPECIFICATIONS

1.	Maximum Input voltage DC	1500V
2.	Nominal output voltage frequency	50Hz
3.	Continuous operating frequency range	47.5 Hz to 52 Hz
4.	AC Voltage Range	± 10% of rated AC voltage
5.	Euro efficiency	Minimum 97% (as per IEC 61683)
6.	Number of MPPT	Single MPPT or Multi-MPPT
7.	Surge Protection Device (SPD)	Type-I & II DC side
		Type-II AC side
8.	Euro efficiency	Minimum 97% (as per IEC 61683)
9.	Operating power factor range	0.8 Lead to 0.8 Lag (adjustable)
10.	Night SVG (Q at Night)	Required.
11.	Current harmonics	As per CEA regulation requirement
12.	Current THD value	< 3% at nominal power
13.	DC Injection	<0.5 % at rated current
14.	Operating ambient temperature	0 to 60 ° C
15.	Humidity	95 % non-condensing
16.	Maximum Noise level	75 dBA (for indoor application)
17.	Flicker	As per CEA regulation requirement
18.	Remote start and stop facility from SCADA	Required.
19.	Active power limit control, reactive power, power factor and power factor control features.	Required. Possible both from PPC and SCADA.

TECHNICAL SPECIFICATIONS

20.	PCU designed DC fault current level	Maximum short circuit current of PV array connected to PCU and duration continuous.
21.	PCU designed AC fault current level	Maximum short circuit current of LV side of Inverter Duty transformer and duration one sec.
22.	AC & DC overcurrent protection. Synchronization loss protection. Over temperature protection. DC & AC under and over voltage protection. Under & over frequency protection. Cooling system failure protection PV array ground fault monitoring & detection PV array insulation monitoring LVRT protection Anti-islanding protection Grid monitoring	Required.

- B. The PCU shall comply with the Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments.
- C. The PCU shall be capable of supplying reactive power as per grid requirement during solar and non-solar hours. PCU shall have Static Var Generation (SVG) function.
- D. The PCU shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.
- E. The Contractor shall ensure by carrying out all necessary studies that the PCU will not excite any resonant conditions in the system that may result in the islanded operation of PV plant and loss of generation. In case there is excitation of any resonant condition in the system during PV plant operation that may result in the islanding/tripping of the PV plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.
- F. The PCU must be self-managing and stable in operation.
- G. In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized after restoration of grid supply during detailed engineering.

TECHNICAL SPECIFICATIONS

- H. 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.
- I. PCU shall have necessary limiters in build in the controller so as to ensure safe operation of the PCU within the designed operational parameters.
- J. PCU shall have thermal overloading protection to prevent failure of switching devices (i.e. IGBT) and other components of Inverter. PCU controller shall automatically regulate/limit the power output to reduce the PCU cabinet and switching devices temperature. Bidder to submit the PCU power vs ambient temperature curve during details engineering stage. PCU shall be able to provide inverter inside cabinet (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.
- K. PCU shall be provided with Mobile user interface facility for monitoring of inverter by plant O&M personal for better O&M and highest yield from the PV plant. In case PCU does not have this facility, then Bidder can provide the same facility through plant SCADA system.
- L. PCU shall have AC and DC side monitoring capability and reporting to SCADA system (measured analog and digital value measured within PCU). Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.
- M. All-important alarm and trip signals shall be configured in the PCU and their corresponding modbus address shall be provided for SCADA configuration. Signal shall necessarily be included such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, Inverter cabinet temperature high alarm and all other important signals. Details shall be finalized during details engineering stage.
- N. **DC Overloading:** - Maximum PCU DC overload loading shall be limited to its design PV Array Power to PCU nominal AC power ratio. Bidder needs to submit all the relevant technical document/test report from PCU manufacturer (OEM) during details engineering stage in support of declared PCU design DC overloading capacity.
- O. **EARTHING OF INVERTERS:** - The PCU shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details earthing arrangement of PCU and system earth pit requirement during detail engineering stage. The detail specification for panel earthing for safety has been mentioned elsewhere in this specification.
- P. **OPERATING MODES OF PCU**
 - a) **Low Power Mode:** - The PCU shall be able to wake-up automatically when PV array open circuit voltage value is equal/more than preset value in the PCU

TECHNICAL SPECIFICATIONS

program. Once its start generation the PCU shall automatically enter maximum power mode.

- b) **Maximum Power Point Tracking (MPPT):** - In order to maximize the energy collection from solar PV array, the PCU shall have inbuilt MPPT controller and same shall be able operate the PV array at its maximum power point by adjusting output voltage of PV array system according to atmospheric condition. PCU MPPT controller shall ensure that it operate the PV array system at its global maximum power point under all operating conditions of PV array including cloudy atmospheric condition.
- c) **Sleep Mode:** - PCU shall automatically go into sleep mode when the output voltage of PV array and/or output power of the inverter falls below a specified limit. During sleep mode the inverter shall disconnect from grid. Inverter shall continuously monitor the output of the PV array and automatically start when the DC voltage rises above a pre- defined level. The above clause is applicable for unity power factor operation/no reactive power support to grid. In case reactive power is required to be supplied to grid, in that case the PCU shall remain connected to grid and supply reactive power as per grid requirement. Inverter shall continuously monitor the output of the PV array and automatically start active power generation when the DC voltage rises above a pre- defined level.
- d) **Standby Mode:** - In standby mode the PCU DC & AC contactor are open, inverter is powered on condition and waiting for start command.
- Q. In case auxiliary supply of PCU is met internally, then it should have sufficient power backup to meet the LVRT requirement.
- R. Bidder to submit third-party verified OND files of the inverter during detail engineering.

3. CENTRAL INVERTER

- A. PCS must have provision to be isolated from grid through Air Circuit Breaker/MCCB. The ACB/MCCB as required can be provided as a part of PCS/its Modules or separately based on standard design and configuration of PCS manufacturer. The ACB and MCCB shall be able to withstand the maximum fault current for minimum one sec duration. ACB/MCCB shall be able to isolate PCU from AC grid under all fault current condition. Any alternate provision other than ACB/MCCB which is recommended by OEM and meeting the requirement, shall be considered on case-to-case basis during detailed engineering stage.
- B. Suitable rated fuse shall be provided (at inverter end) in incoming DC cable from each string combiner box (SCB). One set spare terminal with fuse (as applicable) and holder shall be provided for the future use. In addition, the PCU shall have suitable rated DC motorized isolator/MCCB or contactor for isolation of PV array from inverter.
- C. String Monitoring facility: - PCU shall be provided with current monitoring transducer at incoming DC cables from each string combiner box (SCB) for PV array zone monitoring purpose. The current transducers used for this purpose shall have accuracy of 1.0 class or better.

TECHNICAL SPECIFICATIONS

- D. The PCU should be designed for parallel operation through galvanic isolation. Solid state electronic devices shall be protected to ensure smooth functioning as well as ensure long life of the inverter. Parallel operated PCU system are also accepted subjected to recommendation of PCU manufacturer. In such case, PCU design shall also ensure that no abnormal interaction shall take place among the PCU unit during any grid operating condition which may result in outages.
- E. PCU shall have suitable communication card (Modbus TCP/IP) for networking and SCADA integration and same shall support dual master communication. PCU shall include all important measured & internal calculated analog values and alarm & trip signals for remote monitoring, storing and report generation purpose in SCADA system. Details list of above such parameters shall be provided along with their Modbus address during detail engineering stage.
- F. In case of modular design of PCU is offered, the Contractor shall ensure that no abnormal interaction shall take place among the various PCU modules during any grid operating condition which may result in outages. The PCU controller offered by the Contractor shall be such as to ensure stability, reliability, and a good dynamic performance. The Bidder shall indicate the control scheme adopted for modular PCU and its merits and the test which will check its performance.
- G. Bidder may offer liquid cooling system subject to Owner/ Company approval. In case Liquid cooled inverters are offered, Bidder to ensure that coolant is used in closed cycle. Complete inverter along with cooling system shall be of proven design.
- H. The Inverter shall have suitable arrangement for negative grounding of solar PV array system and the ground current shall be limited to safe limit. Ground current shall be measured continuously, and alarm shall be generated in case ground current reaches to predefined set value. Inverter shall trip in case ground current more than safe operating limit.
- I. Inverter shall have emergency stop push button for tripping of inverter with complete DC & AC electric isolation.

A. INDOOR CENTRL INVERTER

- a) **The PCU enclosure protection class shall be IP 20 or better protection.**
- b) **COOLING AND VENTILATION: -**

To prevent the maximum permissible temperature in the inverter room from being exceeded because of internal heat emission of inverters and other auxiliaries in the inverter room, the inverter room in the PV plant shall be adequately ventilated. The Ventilation plant capacity and air quality of inverter room shall be as per inverter and other auxiliary's system manufacturer's recommendations. Filter banks at the air inlet of the inverter room shall be provided to prevent dust ingress. Bidder shall furnish peak power consumption of cooling system (cooling fans, pumps etc.) of the PCU along with the data sheet.

Ventilation shall be designed in such a way that the temperature rise of the inverter rooms does not exceed the maximum designed temperature of

TECHNICAL SPECIFICATIONS

Inverters and other auxiliary equipment's placed inside the inverter room. Accordingly, the air velocity through the filter shall be suitably chosen to remove the heat from the inverter room. All exhaust and fresh air fans shall be provided with thermostat control.

B. OUTDOOR CENTRL INVERTER

- a) Outdoor PCU enclosure must be suitable to withstand the harsh environmental conditions for complete life of plant.
- b) The PCU enclosure protection class shall be IP 54 or better protection. For outdoor solution (Other than containerized), the electronic card compartment shall have IP 65 or better protection.
- c) Bidder to submit temperature endurance test report of complete assembly during detail engineering stage.
- d) For Outdoor PCU (without containerized solution) the complete assembly should be placed inside a shed made of structural steel section preferably tubular/hollow section and color coated metal sheets for roof with BMT 0.5 mm and at least 60cm projection in all side. For containerized solution separate shed is not required, however, the container shall have projection of at least 60cm wherever an opening in the inverter door exposes the inverter component to outside environment. Structural steel and paints for shed shall be as per ISO 12944-5.
- e) Outdoor inverter (including containerized solution) platform shall be raised Min 1250 mm from NGL. Cable bending radius and other relevant factors to be considered during platform design. This shall be reviewed during detailed engineering.

4. STRING INVERTER

- A. The string inverter enclosure protection class shall be IP 65 or better protection.
- B. The string inverter should be placed inside a canopy shed with at least 15 cm in all direction, if installed in open. Alternatively, the Bidder can also install the inverter on the column post of the module mounting structure, below the modules. In such case, the canopy is not required, and the column and foundation shall be designed accordingly.
- C. String inverter shall have suitable communication port (TCP-IP/PLC) for SCADA integration. All necessary hardware, software and accessories used for communication with SCADA (including smart logger Data logger) at both the ends shall be provided by the bidder. String Inverters system shall support dual master communication.
- D. String inverter shall have string monitoring (MPPT level) capability and reporting to SCADA system. Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.

TECHNICAL SPECIFICATIONS

- E. Anti-PID device along with all hardware and communication cable/device shall be provided in case negative grounding of PV string provision is not available in string inverter.
- F. DC fuse requirement for PV string at string inverter end shall be as per string manufacturer/system requirement and same shall be finalized during detail engineering stage.
- G. Provision for AC and DC electrical isolation device (such as MCB/MCCB/Isolator) inside string shall be as per string inverter manufacturer practice.
- H. Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided as per string inverter manufacture practice. In case standard design of string inverter does not include display, then string inverter shall be provided with required software along with accessories (2 sets for complete plant) for interface with inverter or facility for mobile viewing and configuration with laptop.
- I. LT Junction box, switchboard, and switchgear requirement for string inverter system as per chapter B-6, Part B (LT Switchgear).

5. TYPE TESTING

Applicable both for Central and String Inverter

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

ROUTINE TESTING:

All acceptance and routine tests as per the specification and relevant standards. Charges for these shall be deemed to be included in the equipment price.

An indicative list of tests/ checks is mentioned in QA chapter on PCU (Inverter). However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

TECHNICAL SPECIFICATIONS

AC SYSTEMS

TECHNICAL SPECIFICATIONS

B-6: LT SWITCHGEAR

1. CODES AND STANDARDS

The design, materials, and method of LT switchgear shall conform to the applicable IEC standard. All equipment shall be installed, and all work shall be carried out in accordance with relevant IEC standards. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice. All standards, specifications and codes of practice shall be the latest editions including all applicable official amendments and revisions.

As a minimum requirement, the following standards shall be complied with:

IS	Details
IEC 60947/ IS13947	Low-voltage switchgear and control gear
IS 2705	Current Transformers
IS 3043	Code of practice for earthing.
IS 3072	Code of practice for installation and maintenance of Switchgear
IS 3156	Voltage Transformers
IS 3202	Code of practice for climate proofing of electrical equipment.
IS 3231	Electrical relays for power system protection.
IS 13703/ IEC 60269	HRC Cartridge fuses
IS 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear.
IEC 60255	Electrical Relays

2. TECHNICAL PARAMETERS:

A. POWER SUPPLY (AC SYSTEM)		
(i)	Voltage	415V + 10%, 3 Phase, 4 wire, Neutral Solidly Earthed
(ii)	Frequency	50 Hz +/- 5%
(iii)	Minimum system fault level	As per system fault current (for 1 sec)

TECHNICAL SPECIFICATIONS

(iv)	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	As per system fault current (for 1 sec)
(v)	Maximum ambient air Temperature	50 deg. C
BUS BARS		
(vi)	Continuous current rating at 50°C ambient:	As Per Requirement
(vii)	Temperature Rise allowed above ambient	400C for plain joints 550C for Silver plated joints
B. MCCB		
(i)	Rated voltage	415V
(ii)	Rated Insulation Level	690V
(iii)	Rated ultimate and service SC breaking capacity (As per system requirement)	As per system fault current (for 1 sec)
(iv)	Rated making capacity	2.1 times of System fault current
(v)	Utilization category	A
C. DIGITAL MFM		
(i)	Accuracy class	0.5
(ii)	MFM shall be provided at LT incomer feeder. MFM shall have suitable communication port for integration with SCADA system.	
D. CURRENT TRANSFORMERS		
(i)	Type	Cast Resin Bar Primary
(ii)	Voltage class and frequency	650V, 50HZ
(iii)	CT Secondary Current	1 A
(iv)	Class of insulation	E or better
(v)	Accuracy class & burden	
	a) For Protection	5P20, 5VA
	b) For Metering	Class 1.0, 5VA (min)
(vi)	Instrument Security Factor for metering CT	5
E. VOLTAGE TRANSFORMERS		

TECHNICAL SPECIFICATIONS

(i)	Type	Cast Resin
(ii)	Voltage Ratio	415 / 110V for line PT 415/ $\sqrt{3}$ / 110/ $\sqrt{3}$ V for Bus PT
(iii)	Method of Construction	Vee Vee
(iv)	Accuracy Class	0.5
(v)	Rated Voltage factor	1.1 continuous, 1.5 for 30 sec.
(vi)	Class of insulation	E or better
(vii)	One minute power frequency withstand voltage	2.5 KV

F. HRC FUSES

(i)	Voltage Class	650 Volts
(ii)	Rupturing capacity	80kA (RMS) for AC circuits

G. CONTACTORS

(i)	Type	Air break electro magnetic
(ii)	Utilising Category	AC3 of IS/IEC 60947 for non-reversible AC4 of IS/IEC 60947 for reversible drives

H. SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS

(i)	Colour finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers) The paint thickness shall not be less than 50 microns
	Cable entry	
(ii)	Power Cables	Bottom
	Control Cables	Bottom

The quantities/Nos. of the Feeders /MCCB shall be so as to meet the system requirements. 5% spare with minimum 01 No. to be provided on each board/switchgear having more than 5 MCCB. However, no spare Air circuit breaker panels are required.

3. DETAILS OF INDOOR DISTRIBUTION BOARDS

Applicable for Auxiliary Power Supply system and String Inverter distribution board of rating up to & including 400A.

TECHNICAL SPECIFICATIONS

- A. Switchboards shall be of metal enclosed, indoor, floor-mounted, free-standing type.
- B. All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold- rolled sheet steel and 4.0 mm for non-magnetic material.
- C. All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.
- D. The switchboards shall be of bolted design. The complete structures shall be rigid, self- supporting, and free from flaws, twists and bends. All cut outs shall be true in shape and devoid of sharp edges.
- E. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 4X as per IS/IEC 60947. All cutouts shall be provided with EPDM / Neoprene gaskets. However, the control / relay compartments shall have degree of protection not less than IP 5X.
- F. All switchboards shall be of uniform height not exceeding 2450 mm.
- G. Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates.
- H. All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/ component shall be possible without switching off or isolating the other equipment's/components.
- I. Each switchboard shall be provided with undrilled, removable type gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.
- J. The minimum clearance in air between phases and between phases and earth for the entire busbars shall be 25mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be at least ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / fuses/MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminium alloy / copper of adequate size.

TECHNICAL SPECIFICATIONS

- K. All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- L. The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.
- M. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track- resistant and high strength sheet molded compound or equivalent type polyester fiber glass molded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.
- N. All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All copper to aluminium joints shall be provided with suitable bimetallic washers.
- O. All busbars shall be colour coded as per IS: 375.
- P. Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.
- Q. The Bidder shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.
- R. Panel space heaters shall be provided and the supply for this shall be tapped from incomer, before the isolating switch/circuit breaker. Incoming circuit to space-heater shall have an isolating switch, HRC fuse and neutral link of suitable rating. Panel illumination and plug-socket shall also be tapped from the space heater supply.
- S. A galvanized steel / Copper / Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.
- T. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth without exceeding the allowable temperature rise.

TECHNICAL SPECIFICATIONS

- U. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.
- V. All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq.
- W. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable. However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.
- X. VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.
- Y. All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also be acceptable. The Contractor shall establish earth continuity at site also.
- Z. All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.
- AA. All auxiliary wiring shall be carried out with 650V grade, single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm² (min.) for control circuit wiring and 2.5 mm² (min) for CT and space heater circuits.
- BB. Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.
- CC. All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.
- DD. All internal wiring terminations shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component-to-component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.
- EE. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring.
- FF. Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC/ XLPE insulated, armoured /

TECHNICAL SPECIFICATIONS

unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the contractor, to suit the final cable sizes.

- GG. All power cable terminals shall be of stud type and the power cable lugs shall be solder-less crimping ring type conforming to IS: 8309. All lugs shall be insulated/sleeved.
- HH. All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local push-button stations etc. shall be provided with prominent, engraved identification plates.
- II. All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Employer's approval.
- JJ. Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.
- KK. The gaskets, wherever specified, shall be of good quality EPDM / neoprene with good ageing, compression and oil resistance characteristics suitable for panel applications.
- LL. The bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per Indian standards / specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.
- MM. ON/OFF status and protection trip status of incomers and bus coupler (if applicable as per SLD) be provided for SCADA system.
- NN. Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler (if applicable as per SLD).
- OO. It shall be the responsibility of the contractor to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type ii class of co-ordination as per IS: 8544.
- PP. All sheet steel work shall be pre-treated, in tanks, in accordance with is: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "class-c" as specified in is: 6005. The phosphate surfaces shall be rinsed and passivated. After passivation, electrostatic powder coating shall be used. Powder should meet requirements of is 13871 (powder costing specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the employer. The paint thickness shall not be less than 50 microns.

QQ.

TECHNICAL SPECIFICATIONS

4. MCCB

- A. MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.
- B. MCCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc).
- C. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked. The MCCBs being offered shall have common/interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

5. FUSES

- A. All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be rated for 80kA rms (prospective) breaking capacity at 415V AC and for DC circuits, 20kA rms breaking capacity at 240V DC.
- B. Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.
- C. Fuse shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchboard.
- D. The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

6. INDOOR LT SWITCHGEAR FOR STRING INVERTER

In addition to the above clauses (relevant), the following shall also be applicable for switchgear ratings more than 400A.

- A. All switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments.

- a) **BUSBAR COMPARTMENT:** - A completely enclosed bus bar compartment shall be provided for the horizontal and vertical busbars. Bolted covers shall

TECHNICAL SPECIFICATIONS

be provided for access to horizontal and vertical busbars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. Auxiliary and power busbars shall be in separate compartments.

- b) SWITCHGEAR / FEEDER COMPARTMENT:** - All equipment associated with a feeder of rating above 400A shall be housed in a separate compartment of the vertical section. ACB shall be provided for feeders of rating 1000A and above. The design of the vertical section for such an arrangement shall ensure ease of termination of power cables of size & quantity as per system requirement. The compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. Insulating sheet at rear of the compartment is also acceptable. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure.
- c) CABLE COMPARTMENT/CABLE ALLEY:** - A full-height vertical cable alley of minimum 250mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations located in cable alley of capacity more than 400 A shall be designed to meet the Form IVb and for less than 400A A shall be designed to meet the Form 3b (as per IEC 61439) for safety purpose. Wherever cable alleys are not provided for distribution boards, segregated cable boxes for individual feeders shall be provided at the rear for direct termination of cables. For circuit breaker external cable connections, a separately enclosed cable compartment shall also be acceptable. The contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged.
- d) CONTROL COMPARTMENT:** -
- A. Separate compartment shall be provided for relays and other control devices associated with a circuit breaker.
 - B. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 4X as per IS/IEC 60947 (for indoor panels). All cut-outs shall be provided with EPDM / Neoprene gaskets. However, the control / relay compartments shall have degree of protection not less than IP 5X.
 - C. Provision of louvers on switchboards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating is 1600 A and above.
 - D. Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. EPDM / Neoprene gasket shall be provided between the panel sections to avoid ingress of dust into panels.
 - E. The minimum clearance in air between phases and between phases and earth for the entire busbars. and bus-link connections at circuit-breaker shall be

TECHNICAL SPECIFICATIONS

25mm. All busbars and jumper connections shall be of high conductivity aluminium alloy / copper of adequate size.

- F. After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.
- G. All switchgear (circuit-breaker) panels shall be of single-front type. The covers shall be provided with "DANGER" labels. All panel doors shall open by 90 deg or more.
- H. All circuit-breaker modules shall be of fully draw out type having distinct 'Service' and 'Test' positions. Suitable arrangement with cradle / rollers, guides along with tool / lever operated racking in / out mechanism shall be provided for smooth and effortless movement of the chassis.
- I. All switchboards shall be provided with three phase and neutral busbars. Two separate sets of vertical busbars shall be provided in each panel of double front DBs. Interleaving arrangement for busbars shall be adopted for switchboards with a rating of more than 1600A. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- J. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked.
- K. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear switchgear also.
- L. Temperature raise test of LT switchgear of rating more than 400A: - The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not exceed 10deg. C for metallic & 15 deg. C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.

TECHNICAL SPECIFICATIONS

- M. The carriage and breaker frame shall get earthed while being inserted in the panel and positive earthing of the breaker frame shall be maintained in all positions, i.e. SERVICE & ISOLATED, as well as throughout the intermediate travel.
- N. Electrically controlled circuit breaker boards shall be provided with DC control supply.

7. CIRCUIT BREAKERS

- A. Circuit breakers shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameters of continuous current rating and fault making / breaking capacity only after provision of cooling fans or special device shall not be acceptable.
- B. Circuit breakers along with its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.
- C. There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "Test" position the circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLLY WITHDRAWN" position. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition.
- D. Separate limit switches, each having required numbers of contacts shall be provided in both "SERVICE" and "TEST" position of the breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240 V AC and 1 Amp (Inductive) at 240 V DC respectively.
- E. Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.
- F. Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half a cycle of rated frequency.
- G. Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed-circuit breaker shall preferably not trip the circuit breaker. In case the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exists between the fixed and draw out contact at the time of breaker trip so that no arcing takes place even with the breaker carrying its full rated current.
- H. Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.

TECHNICAL SPECIFICATIONS

- I. Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.
- J. Breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.
- K. Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.
- L. Circuit breaker shall be provided with anti-pumping feature and trip free feature, even if mechanical anti-pumping feature is provided.
- M. Mechanical tripping shall be possible by means of front mounted Red "trip" push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

- N. Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels, the busbar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live. Dummy panels if required to achieve the above feature shall be included in the Bidder's scope of supply.
- O. Circuit breaker open/close shall be possible from SCADA and open/close status and all other important signal status shall be provided for SCADA monitoring.
- P. Power operated mechanism shall be provided with a Universal motor suitable for operation on DC Control supply. In case of DC supply motor should satisfactorily operate with voltage variation between 85% to 110% nominal control supply voltage. Motor insulation shall be class "E" or better.
- Q. The motor shall be such that it requires not more than 30 Seconds for fully charging the closing spring at minimum available control voltage.
- R. Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.
- S. The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.
- T. Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.
- U. All circuit breakers shall be provided with closing and trip coils. The closing coil shall operate correctly at all values of voltage between 85% to 110% nominal control supply voltage. The trip coil shall operate satisfactorily at all values of voltage between 70% to 110% nominal control supply voltage.

TECHNICAL SPECIFICATIONS

- V. Provision for mechanical closing of the breaker only in "Test" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.
- W. The ACB Panel door shall not be possible to open in breaker closed condition. Further, the racking mechanism shall be accessible only after opening the breaker panel door.
- X. Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit- breaker module in a cubicle at each location. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn /inserted of particular switchgear.
- Y. Electrical Parameter of Circuit Breaker

1)	Type	Air break spring charged stored energy type
2)	Operating duty	O-3 MIN-CO-3 MIN-OC
3)	Symmetrical interrupting	As per system fault current (for one sec)
4)	Short circuit rating	2.1 times of System fault current (peak)
5)	Short Circuit Breaking current	
	a) AC Component	As per system fault current (for one sec)
	b) DC Component	As per IS:13947
6)	Short time withstand	As per system fault current

8. AC JUNCTION BOXES (for use with string inverters)

- A. Separate AC Junction box shall be used for string inverters AC output connection. Protection class for AC junction box shall be IP 54 or better protection. All components of junction box shall be suitable for rated output voltage (with + 10% variation) of string inverter, grid frequency of 50 Hz +/- 5%, ambient temperature 50 deg. C and system fault current for 1 sec.
- B. AC junction box shall be of metal enclosed type. All frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material. The minimum clearance in air between phases and between phases and earth shall

TECHNICAL SPECIFICATIONS

be at least twenty-five (25) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers.

- C. All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.
- D. EPDM / Neoprene gasket shall be used to prevent ingress of dust into panels.
- E. All non-current carrying metal work of the junction box shall be effectively connected to the system earth bus.
- F. Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the Employer. The paint thickness shall not be less than 50 microns.

9. TEMPERATURE-RISE (For LT Switchgear having capacity more than 400A)

The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not exceed 10deg. C for metallic & 15 deg. C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.

10. DERATING OF COMPONENTS

The Bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per Indian Standards / Specification. Continuous current

rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.

The Bidder shall indicate clearly the derating factors if any employed for each component and furnish the basis for arriving at these derating factors duly considering the specified current ratings and amb. temperature of 50 deg C.

11. ROUTINE TESTS: -

All acceptance and routine tests as per the specification and relevant standards to be carried out. Charges for these shall be deemed to be included in the equipment price. An indicative list of tests / checks is mentioned in QA chapter as LT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

TECHNICAL SPECIFICATIONS

B-7: HT SWITCHGEAR

1. CODES AND STANDARDS

All standards, specification and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of Techno commercial bid. In case of conflict between this specification and those (IS Codes, Standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards and codes.

Sl No	IS Code	Name Of Equipment
a)	IS: 722	AC electricity meters.
b)	IS: 996	Single phase small AC and universal electrical motors.
c)	IS: 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories.
d)	IS/IEC: 60947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
e)	IS: 2544	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
f)	IS: 2705	Current transformers.
g)	IS: 3156	Voltage Transformers
h)	IS: 6005	Code of practice for phosphating of iron and steel.
i)	IS: 5082	Specification for wrought aluminium and aluminium alloy bars, rods, tubes and selections for electrical purposes.
j)	IEC: 61850	Communication Standard for Numerical relays
k)	IEC: 61131-3	Automation Standard for Numerical relays
l)	IS: 9046	AC contactors for voltages above 1000 volts and up to and including 11000 Volts.
m)	IS: 13703	Low voltage fuses
n)	IS: 9385	HV fuses
o)	IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts up to and including 300 kV
p)	IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages

TECHNICAL SPECIFICATIONS

		above 1000 V
q)	IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
r)	IS: 13118	Specification for high voltage AC circuit breakers.
s)	IEC: 60099-4	Metal oxide surge arrester without gap for AC system
t)	IS/IEC: 62271-100	High voltage alternating current circuit breakers.
u)	IS/IEC: 62271-200	High voltage metal enclosed switchgear and control gear.
v)	IEC: 60947-7-1	Terminal blocks for copper conductors
w)	IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

2. TECHNICAL PARAMETERS

A. SYSTEM PARAMETERS		
a)	Nominal System voltage	33kV
b)	Highest System voltage	36kV
c)	Rated Frequency	50Hz
d)	Number of phases/ poles	Three
e)	System neutral earthing	Solidly Earthed
f)	One-minute power frequency withstand voltage	
	- for Type tests	70kV
	- for Routine tests	70kV
g)	1.2/50 microsecond Impulse withstand voltage	170kV (peak)
h)	Minimum system fault level	
i)	Short time rating for bus bars, circuit breakers, current transformers and switchgear assembly.	As per System Fault current (Refer Cl. 1 of Chapter 2-A)
j)	Dynamic withstand rating	2.5 times of system
		fault current

TECHNICAL SPECIFICATIONS

k)	- Space heaters	240 V AC single phase with neutral solidly earthed
l)	Maximum ambient air temperature	50 deg. C
m)	Internal Arc testing	As per system fault current (for Min 1 sec)

B. BUS BARS

a)	Continuous current rating at 500C ambient:	As Per Requirement
b)	Temper Rise allowed above ambient	As per IEC 62271-1, 2017

C. SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS

a)	Colour finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers)
b)	Cable entry	
	Power Cables	Bottom
	Control Cables	Bottom
c)	Earthing conductor	Galvanized steel strip
d)	Service Continuity of swgrs (LSC2B-PM)	as per IS/IEC 62271-200

D. CIRCUIT BREAKERS

a)	The circuit breakers current rating shall be selected from the load current at an ambient of 50 deg. C.	
b)	Short circuit breaker Current	
	a) A.C. component	As per Clause 1.0 of Chapter 2-A (Part A)
	b) D.C. component	As per IS: 13118 or IEC-62271
c)	Short Circuit making current	2.5 times of system fault current (peak)

TECHNICAL SPECIFICATIONS

d)	Operating Duty	O-3 min-CO-3 min-CO
e)	Total break time	Not more than 4 cycles
f)	Total make time	Not more than 5 cycles
g)	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271

E. CURRENT TRANSFORMER		
a)	Secondary Current	1A
b)	Class of Insulation	Class E or better
c)	Rated output of each	Adequate for the relays and devices connected, but not less than five (5) VA.
d)	Accuracy class	
	Protection	5P20/PS as per requirement
	Measurement	0.5 class or better as per requirement
e)	Instrument Security Factor for Measurement CTs	5
f)	CT Ratio	CT ratio shall be finalized during details engineering stage. Minimum CT primary side current shall be 110% of rated current.

F. VOLTAGE TRANSFORMERS		
a)	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 8 Hours for star connected VTs.
b)	Class of insulation	Class E or better
		0.5 Class or better as per requirement. VA requirement shall be based on application/ requirement.
c)	Other parameters	Additional open delta core with damping resistor shall be provided in all VT's to prevent damage on account of Ferro-Resonance conditions

TECHNICAL SPECIFICATIONS

d)	At pooling switchgear, Bus VTs panels and line VTs in outgoing feeders shall be provided. All other switchgear location, at outgoing feeder cable charge indication shall be provided based on voltage sensing or use of voltage transformer.

G. DIGITAL MFM		
a)	Accuracy Class	0.5 or better
b)	Digital MFM shall be provided for VCB panels as per requirement/SLD.	

3. SWITCHGEAR PANEL

- A. The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with clause No. 3.102 of IEC 62271-200, comprising of a row of free-standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker truck, cable termination, main busbars and auxiliary control devices. The adjacent panels shall be completely separated by steel /Aluzinc sheets except in bus bar compartments where insulated barriers shall be provided to segregate adjacent panels. The Service Class Continuity of Switchgears shall be LSC2B-PM (as per IS/ IEC 622771-200). However, manufacturer's standard switchgear designs without inter panel barriers in busbar compartment may also be considered.
- B. The circuit breakers and bus VTs shall be mounted on withdrawable trucks which shall rollout horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trolley shall be provided by the Bidder for withdrawal and insertion of the truck from and into the panel. Testing of the breaker shall be possible in isolated position by keeping the control plug connected.
- C. The trucks shall have distinct SERVICE and ISOLATED positions. It shall be possible to close the breaker compartment door in isolated position also, so that the switchgear retains its specified degree of protection. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition. While switchboard designs with doors for breaker compartments would be preferred, standard designs of reputed switchgear manufacturers where the truck front serves as the compartment cover may also be considered provided the breaker compartment is completely sealed from all other compartments and retains the IP-4X degree of protection in the Isolated position. In case the latter arrangement is offered, the Bidder shall explain how this sealing is achieved and shall include blanking covers one for each size of panel per switchboard in his total Techno commercial bid price.
- D. The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED or removed, and all doors and

TECHNICAL SPECIFICATIONS

covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.

- E. The control / relay compartments shall have degree of protection not less than IP 5X in accordance with IS/IEC 60947. However, remaining compartments can have a degree of protection of IP 4X. All louvers, if provided, shall have very fine brass or GI mesh screen. Tight fitting gaskets are to be provided at all openings in relay compartment.

Numerical Relays shall be fully Flush mounted on the switchgear panels at a suitable height.

- F. The Switchgear shall have an internal Arc Classification of IAC FLR corresponding to system fault current. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. To demonstrate that the pressure relief device operates satisfactorily the Contractor shall submit a type test report in line with IEC 62271-200 Annex – A for each high voltage chamber. Wherever louvers are provided, the construction of louvers should be such that the IAC requirements are satisfied. Further, viewing glass windows shall have the same strength as the enclosure against Internal Arc.
- G. Enclosure shall be constructed with rolled steel / Aluzinc sections. The doors and covers shall be constructed from cold rolled steel sheets of 2.0 mm or higher thickness. Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for non-magnetic material it shall be 3.0 mm.
- H. The switchgear shall be cooled by natural air flow. Forced cooling shall be considered in case current rating is above 2000 A or above.
- I. The height of switches, pushbuttons and other hand operated devices shall not exceed 1800mm and shall not be less than 700mm.
- J. Necessary guide channels shall be provided in the breaker compartments for proper alignment of plug and socket contacts when truck is being moved to SERVICE position. A crank or lever arrangement shall preferably be provided for smooth and positive movement of truck between Service and Isolated positions.
- K. Safety shutters complying with IEC 62271-200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to ISOLATED position. The shutters shall move automatically, through a linkage with the movement of the truck. Preferably it shall however, be possible to open the shutters of busbar side and cable side individually against spring pressure for testing purpose after defeating the interlock with truck movement deliberately. In case, insulating shutters are provided, these shall meet the requirements of IEC 62271-200 and necessary tests as per IEC 62271-200 Clause 5.103.3.3 shall be carried out. A clearly visible warning label "Isolate elsewhere before earthing"

TECHNICAL SPECIFICATIONS

shall be provided on the shutters of incoming and tie connections which could be energized from another end.

- L. Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.
- M. The breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Standard and proven designs of switchgear manufacturers (other than above) shall be reviewed during detailed engineering stage. Busbar and cabling compartments provided on the rear side shall have separate bolted covers with self-retaining bolts for easy maintenance and safety. Breaker compartment doors shall be provided with single-shot latch type handle and shall have locking facility. Suitable interlock shall be provided, which will ensure that breaker is OFF before opening the backdoors. Suitable interlock shall be provided to prevent opening of any compartment doors which has any of the MV equipment, in case the supply is ON.
- N. In the Service position, the truck shall be so secured that it is not displaced by short circuit forces. Busbars, jumpers and other components of the switchgear shall also be properly supported to withstand all possible short circuit forces corresponding to the short circuit rating specified.
- O. Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and levelled when the flooring is being done, welding of base frame to the insert plates as per approved installation drawings shall be in Bidder's scope.
- P. Alternatively, Outdoor HT switchgear can be offered for ICOG configuration. The outdoor switchgear shall have minimum IP 55 or better protection with painting and shed requirement as mentioned in Appendix-1 of Part-A, Sub section-1. The bidder shall submit the relevant details of the switchgear including the datasheets, drawings and applicable type test reports during the detailed engineering for Employers approval. Internal Arc requirement for metal enclosed outdoor HT switchgear shall be same as indoor type switchgear. The main pooling/final pooling switchgear shall be indoor only.

4. CIRCUIT BREAKERS

- A. The circuit breakers shall be of Vacuum type.
- B. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.
- C. Circuit breaker shall be restriking free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable.

TECHNICAL SPECIFICATIONS

- D. During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke.
- E. Plug and socket isolating Contacts for main power circuit shall be silver plated, of self-aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self-aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.
- F. All working part of the mechanism shall be of corrosion resisting material. Bearings which require greasing shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately secured and locked to prevent loosening or change in adjustment due to repeated operation of the breaker and the mechanism.
- G. The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.
- H. Mechanical indicators shall be provided on the breaker trucks to indicate OPEN /CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring. An operation counter shall also be provided. These shall be visible without opening the breaker compartment door.
- I. The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 85% to 110% rated DC voltage. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker up to its rated short circuit breaking current at all values of control supply voltage between 70% to 110% of rated DC voltage. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by two indicating lamps (Red) and one trip coil supervision relay.
- J. The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation.

As long as power supply is available to the charging motor a continuous sequence of closing and opening operations shall be possible. One open-close- open operation of the circuit breaker shall be possible after failure of power supply to the motor. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is anywhere between 85% to 110% rated DC voltage. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 50 deg. C ambient air temperature. The motor shall be provided with short circuit protection.

TECHNICAL SPECIFICATIONS

- K. Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.
- L. Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.

5. CONTROLS AND INTERLOCKS

- A. Rotary type Control switches shall be provided in each switchgear panel. The circuit breaker will normally be controlled from remote control panels through closing and shunt trip coils. The control switch and local control console of the relay flush mounted on the switchgear would normally be used only for testing of circuit breaker in isolated position, and for tripping it in an emergency. The closing and opening of the breaker shall also be possible from the Laptop through front serial port of the relay to facilitate commissioning activities.
- B. The basic control scheme shall be developed in the numerical relay using programmable (soft) logics. Tripping of breaker shall be done either through numerical relay or Master Trip Relay.
- C. Facilities shall be provided for mechanical tripping of the breaker and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency.
- D. Each panel shall have two separate limit switches, one for the Service position and the other for isolated position.
- E. Auxiliary Contacts of breaker may be mounted in the fixed portion or in the withdrawable truck as per the standard practice of the manufacturer, and shall be directly operated by the breaker operating mechanism.
- F. Auxiliary contacts mounted in the fixed portion shall not be operable by the operating mechanism, once the truck is withdrawn from the service position, but remain in the position corresponding to breaker open position. Auxiliary contacts mounted on the truck portion, and dedicated for Employer's use shall be wired out in series with a contact denoting breaker service position. With truck withdrawn, the auxiliary contacts shall be operable by hand for testing. There shall be at least 2 NO and 2 NC breaker/contactors original Auxiliary contacts made available for the use of the Employer.
- G. The contacts of all limit switches and all breaker auxiliary contacts located on truck portion and fixed portion shall be silver plated, rated to make, carry and break 1.0A 240V DC (Inductive) / 10A 240V AC. Contacts of control plug and socket shall be capable of carrying the above current continuously.
- H. Movement of truck between SERVICE and ISOLATED positions shall be mechanically prevented when the breaker is closed. An attempt to withdraw a closed breaker shall not trip it.
- I. Closing of the breaker shall be possible only when truck is either in TEST/ISOLATED or in-service position and shall not be possible when truck is

TECHNICAL SPECIFICATIONS

in between. Further, closing shall be possible only when the auxiliary circuits to breaker truck have been connected up, and closing spring is fully charged.

- J. It shall be possible to easily insert breaker of one typical rating into any one of the panels meant for same rating but at the same time shall be prevented from inserting it into panels meant for a different type or rating.
- K. Indications shall be provided in the relay console flush mounted on the panel front as brought out in the specification elsewhere. It shall be possible to easily make out whether the truck in SERVICE OR ISOLATED POSITION even when the compartment door is closed.
- L. Reverse blocking and Inter tripping shall be implemented in switchgear boards level. Detailed scheme for the same shall be finalized during detailed engineering stage.
- M. All required interlock shall be provided for safe operation of switchgears. Capacitive voltage detection or other alternative suitable arrangement (VT shall not be used) shall be used for outgoing feeder backdoor (cable chamber) open interlock.

6. NUMERICAL RELAYS AND NETWORKING

- A. Circuit breaker feeders (with protection function as per requirement) shall be provided with communicable numerical relays (IED, i.e. Intelligent Electronic Device) complying with IEC-61850, having protection, control, and monitoring features. These relays shall be networked and suitably interfaced with the Solar SCADA system for dynamic SLD display, status monitoring, measurements, event / alarm displays, reports, etc. The relays shall be flush mounted on panel front with connections from the inside. These numerical relays shall be of types as proven for the application and shall be subject to Employer's approval.

Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity. All equipment's shall have necessary protections.

- B. The numerical relay shall be capable of measuring and storing values of a wide range of quantities, events, faults and disturbance recordings. The alarm / status of each of protection function and trip operation shall be communicated to Solar SCADA. The numerical relays shall have built in feature / hardware interface to provide such inputs to Solar SCADA / for analog / digital values.
- C. All relays shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker close and trip

commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.

TECHNICAL SPECIFICATIONS

- D. One-minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
- E. Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.
- F. Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.
- G. All numerical relays shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts as per the requirement of control schematics. The quantities of such input / outputs shall be finalized during detailed engineering.
- H. All the numerical relays shall have communications on two ports, local front port communication to laptop and rear port on IEC 61850 to communicate with the interface equipment for connectivity with the Solar SCADA. Laptop provided with PCU/SCADA shall be used to facilitate numerical relay configuration, DR and event/fault records downloading from relay locally. Latest version of hardware and Software for interfacing the numerical relays with laptop shall be provided. At least two sets of communication cable for Laptop to relay communication shall be provided.
- I. All the numerical relays shall have adequate processor memory for implementing the programmable scheme logic required for the realization of the protection / control schemes, in addition to the built-in protection algorithms. Numerical relays shall have inrush detection feature for blocking of user selectable protection functions.
- J. Numerical relays shall have feature of current measurement. Relay shall be able to provide the same in soft to solar SCADA system.
- K. Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
- L. Master trip (86) and non-86 trips shall be software configurable to output contacts.
- M. Numerical relays used at main pooling switchgear shall have provision of both current and voltage inputs. Number of CT inputs for numerical relays at all switchgear panels shall be as per actual protections requirement but not less than 4 sets, 3 nos. for phase fault & 1 no. for earth fault. Relays shall be suitable for CT secondary current of 1A. All 33kV feeders shall be provided with non-directional EF and OC protection. Numerical relays used at main pooling switchgear shall have voltage protection and measurement feature.
- N. Relay setting shall be based on time grading principle with minimum 100mSec shall be the grading margin. Least time setting at inverter transformer feeders and shall be increased towards the evacuation point (towards grid). Relay time setting shall be minimum 100 ms. However, relay current and time setting including time grading margin shall be as per Bidder offered system (with minimum as per above) considering smooth plant operation and proper protection integration/coordination with grid. Bidder can use same relay time setting for tie

TECHNICAL SPECIFICATIONS

feeder panels between two switchgears. Relay setting of solar plant feeders shall be done in coordination with 33kV main pooling switch (grid side) relay setting. Any special/other protections, control interlocks etc as per requirement shall be provided by the Bidder. Details shall be finalized during detailed engineering stage.

- O. For relay setting calculation grid side shall be taken upstream and inverter side shall be taken downstream. For any switchgear outgoing feeder shall be towards grid and incoming feeders shall be towards inverter to be considered.
- P. All CT & VT terminals on the relays shall be of fixed type suitable for connection of ring- type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.
- Q. All numerical relay shall have key pad / keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
- R. Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures and a separate output contact for indication of any failure.
- S. Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI programmable characteristics.
- T. Design of the relay must be immune to any kind of electromagnetic interference. Vendor shall submit all related type test reports for the offered model along with the offer.
- U. All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
- V. Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature.
- W. All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.
- X. Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.
- Y. Numerical relays shall have feature for Time synchronization through the SCADA System/ networking. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.
- Z. Ethernet switches shall be suitable to accept both AC & DC supplies with range of 70 % to 120 % of rated voltage.
- AA. Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

TECHNICAL SPECIFICATIONS

- BB. Bidder to depute relay OEM protection engineer at Owner/ Company EOC office for finalization of relay setting and configuration during detail engineering stage. All numerical protection relay configuration and setting shall be done as per approved setting and configuration at switchgear manufacturer work by relay OEM or his authorized representative. All numerical relay testing and logic/interlock checking during commissioning stage at site shall be done under the supervision of Relay OEM or his authorized representative.

7. OTHER PROTECTIONS AND CONTROL FUNCTIONS IN THE RELAYS:

- A. Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre-trip and post trip conditions.
- B. Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer function for protection function shall be as required. Timer functions shall be programmable for on/off delays.
- C. The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker state monitoring, PT and CT supervisions and recording facilities with Post fault analysis.
- D. The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.
- E. At least 200 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.
- F. Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be available on the user interface.
- G. The alarm/status of each individual protection function and trip operation shall be communicated to solar SCADA.
- H. Sequence of events shall have 1 ms resolution at device level.
- I. Measurement accuracy shall be 1 % for RMS Current and voltage.

8. BUSBARS AND INSULATORS

- A. All Busbar and jumper connections shall be of high conductivity aluminium alloy. They shall be adequately supported on insulators as per manufacturer's standard proven design to withstand electrical and mechanical stresses due to specified short circuit currents.
- B. Busbar cross-section shall be uniform throughout the length of switchgear. Busbars and other high voltage connection shall be sufficiently corona free at maximum working voltage.

TECHNICAL SPECIFICATIONS

- C. Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble-free connection. All bolted joints shall have necessary plain and spring washers. All connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminium to copper connections.
- D. Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators. In case of organic insulator partial discharge shall be limited to 100pico coulomb at rated voltage $\times 1.1 / \quad 3$. Use of insulators and barriers of in-flammable material such as Hylam shall not be accepted.
- E. Successful Bidder shall furnish calculation establishing adequacy of busbar sizes for the specified continuous and short time current ratings.
- F. All busbars shall be color coded.
- G. The temperature of the busbar and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of IEC 62271-1,2017, duly considering the specified ambient temperature (50 deg. C).

9. EARTHING AND EARTHING DEVICES

- A. A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.
- B. A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.
- C. The earth bus shall have sufficient cross section to carry the momentary short-circuit and short time fault currents to earth as indicated under switchgear parameters without exceeding the allowable temperature rise.
- D. Suitable arrangement shall be provided at each end of the earth bus for bolting to Employer's earthing conductors. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.
- E. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure framework and the truck shall be maintained even after painting.
- F. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e. SERVICE and ISOLATED as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.
- G. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of size not less than

TECHNICAL SPECIFICATIONS

2.5 sq. mm. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.

- H. VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.
- I. Separate earthing trucks shall be provided by the Contractor for maintenance work. These trucks shall be suitable for earthing the switchgear busbars as well as outgoing / incoming cables or busducts. The trucks shall have a interlock to prevent earthing of any live connection.
- J. As an alternative to separate earthing trucks the Bidder may also offer built-in earthing facilities for the busbars and outgoing / incoming connections, in case such facilities are available in their standard proven switchgear design. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick make type, independent of the action of the operator and shall be operable from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.
- K. Interlocks shall be provided to prevent:
 - a) Closing of the earthing switch if the associated circuit breaker truck is in Service position.
 - b) Insertion of the breaker truck to Service position if earthing switch is in closed position.
 - c) Closing of the earth switch on a live connection.
 - d) Energizing an earthed Section: Complete details of arrangement offered shall be provided during detailed engineering, describing the safety features and interlocks.
- L. The earthing device (truck / switch) shall have the short circuit withstand capability equal to that of associated switchgear panel.

All hinged doors shall be earthed through flexible earthing braid

10. PAINTING (INDOOR SWITCHGEAR)

All sheet steel work shall be pre-treated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "Class-C" as specified in IS: 6005. The phosphate surfaces shall

TECHNICAL SPECIFICATIONS

be rinsed and passivated. After passivation, Electrostatic Powder Coating shall be used. Powder should meet requirements of IS 13871 (Powder coating specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the Employer. The paint thickness shall be 50 microns or more as per the ambient conditions of installation area. Finished parts shall be suitably packed and wrapped with protective covering to protect the finished surfaces from scratches, grease, dirt and oil spots during testing, transportation, handling and erection.

11. INSTRUMENT TRANSFORMERS

- A. All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.
- B. All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules.
- C. The parameters of instrument transformers specified in this specification are tentative and shall be finalized by the Employer in due course duly considering the actual burden of various relays and other devices finally selected. In case the Bidder finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall
- D. offer instrument transformer of adequate ratings and shall bring out this fact clearly in his Techno commercial bid.
- E. All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.
- F. Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.
- G. All voltage transformers shall have suitable current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in isolated position. The secondary fuses shall be mounted on the fixed portion and the fuse replacement shall be possible without drawing out the VT truck from service position.

TECHNICAL SPECIFICATIONS

- H. All voltage transformers shall be designed and manufactured for 0.8 Tesla operating point on B-H curve. VT shall be fully insulated type (i.e. double pole construction and neutral side fully insulated to rated BIL). VT shall be manufactured without any joint in secondary winding.

12. SURGE ARRESTOR

The surge arrestors shall be provided as per tender SLD/ as per system requirement and shall be of metal oxide, gapless type generally in accordance with IEC 60099-4 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor selected shall be suitable for un-earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.

13. CONTROL SUPPLY AND SPACE HEATER SUPPLY

- A. Each switchboard shall be provided at least two (02) Nos of DC feeders for the control supply.
- B. In case two DC sources are provided, then suitable rated blocking diodes in both circuits has to be provided. Alternately Bidder can provide source selection switch.
- C. One suitable rated 240V single phase AC supply feeder per switchboard / Switchboard section for space heater supply. Bidder shall provide necessary switch and fuse to receive, isolate and distribute to each panel.
- D. Each sub circuit shall have separate fuses. Fuse size shall be determined so as to achieve selective clearance between main circuit and sub circuit in case of fault. Potential circuits for protection and metering shall also be protected by separate fuse.
- E. All fuses shall be of link type conforming to IS: 13703 / 9385 mounted on suitable fuse bases. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage. All accessible live connection to fuse bases shall be adequately shrouded.
- F. All DC circuits shall be fused on both poles. Single phase AC circuits shall have fuses on line and link on neutral. DC and AC supply monitoring relay shall be provided and alarm shall be generated in SCADA system in case of failure of supply

14. SPACE HEATER

- A. Each switchgear panel shall be equipped with thermostatically controlled space heater(s), suitably located in breaker and cable compartments to prevent condensation within the enclosure. The space heater shall be connected to 240V single phase AC auxiliary supply available in the switchgear, through switches and fuses provided separately for each panel.
- B. A 240V single phase 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF switch for connection of hand lamp.

15. TERMINAL BLOCKS

TECHNICAL SPECIFICATIONS

- A. Terminal blocks shall be 650V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded)/ cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals, the screw shall be captive, preferably with screw locking design.
- B. Terminal blocks for CT and VT secondary leads shall be of stud type, made up of unbreakable polyamide 6.6 grade. They shall be provided with links to facilitate testing, isolation star/ delta formation and earthing. Terminal blocks for CT secondary shall have the short-circuiting facility. The terminals for remote ammeter connection etc. shall also be disconnecting type only. All metal parts shall be of non-ferrous material. Screws shall be captive.
- C. At least 10% spare terminals for external connections shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available in each panel.
- D. There shall be minimum clearances of 250 mm between the terminal blocks and the cable gland plate and 150 mm between two rows of terminal blocks.
- E. All panel wiring for external connections shall terminate on separate terminal blocks which shall be suitable for connecting two (2) stranded copper conductors of 2.5 sq. mm on each side, or alternatively, the terminal blocks shall have the possibility of double shorting space to facilitate looping.

16. SWITCHGEAR WIRING

- A. All Switchgear panels shall be supplied completely wired internally up to the terminal block ready to receive Employer's external cabling. All inter cubicle wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided / done by the Contractor.
- B. All internal wiring shall be carried out with 650 V grade, single core, 1.5 sq. mm. Stranded copper wires having minimum of seven strands per conductor and color coded, PVC insulation. CT circuits shall be wired with 2.5 sq. mm. wires which otherwise are similar to the above. Extra flexible wires shall be used for wiring between fixed and moving parts such as hinged doors.
- C. All wiring shall be properly supported neatly arranged, readily accessible and securely connected to equipment, terminals and terminal blocks. Wiring troughs or gutters be used for this purpose.
- D. Internal wire terminals shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor. Insulation sleeves shall be provided over the exposed parts of lugs.
- E. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.
- F. Interconnection to adjacent panels shall be brought out to a separate set of terminal blocks located near the slots or holes, meant for the interconnecting wires.

TECHNICAL SPECIFICATIONS

Arrangement shall permit neat layout and easy interconnections to adjacent panels at site and wires for this purpose shall be provided by Contractor looped and bunched properly inside the panels.

- G. Contractor shall be fully responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.
- H. The Contractor shall provide the necessary clamps wiring troughs etc. for all wiring inside the switchgear enclosed including the Employer's power and control cables.

17. POWER CABLE TERMINATION

- A. Cable termination compartment shall receive the stranded Aluminium conductor, XLPE insulated, shielded, armoured / unarmoured, PVC jacketed, single core / three core, unearthed / earthed grade power cable(s).
- B. A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, CTs, gland plates etc. and the electrical clearances available shall be submitted for Employer's approval during detail engineering.
- C. Cable termination compartment shall have provision for termination of power cables of sizes as indicated during detailed engineering with removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material. Cable entry shall be from bottom. Any change will be intimated later.

18. NAME PLATES AND LABELS

- A. Each switch board shall have a name plate for its identification. All enclosure mounted equipment shall be provided with individual engraved name plates for clear equipment identification. All panels shall be identified on front as well as backside by large engraved name plates giving the distinct feeder description along with panel numbers. Back side name plates shall be fixed in panel frame and not on the rear removable cover.
- B. Name plate shall be of non-rusting metal or 3-ply lamicoid with white engraved letterings, on black background or as per manufacturer's proven standards. Inscriptions and lettering shall be subjected to Employer's approval.
- C. Suitable stenciled paint mark shall be provided for identification of all equipment, located inside the enclosure, as well as for door mounted equipment, from the back side in addition to plastic sticker labels, if provided. These labels shall be located directly by the side of the respective equipment, shall be clearly visible and shall not be hidden by equipment wiring. Type of labels and fixing of labels shall be such that they are not likely to peel off / fall off during prolonged use.

19. MODULE DESCRIPTION (Typical)

1

TECHNICAL SPECIFICATIONS

Sl No	Panel Type	Application	Applicability
1	DB	Transformer Feeder	Transformer Feeder
2	DC	Incomer Feeder	Incomer Feeder
3	DD	Bus Coupler Feeder	Bus Coupler Panel for MV Boards
4	DE-IC	Tie Feeder	Tie Incomer Panel
5	DE-OG	Tie Feeder	Tie Outgoing Panel
6	G	Bus PT	Bus PT Panel
7	ICOG	Standalone Transformer feeder	Standalone panel with both incoming & outgoing cables

20. TEST

A. TYPE TESTS

All equipment to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the following type tests carried out not earlier ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

A)	Reports of the following type tests carried out on circuit breaker / circuit breaker panels, of each voltage class and current rating shall be submitted.
i)	Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs , bushing and separators
ii)	Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators.
iii)	Power frequency withstand test on breaker mounted in side panel.
iv)	Lightning impulse withstand test on breaker mounted in side panel.
v)	Temperature rise test on breaker and panel together. For this test, the test set up shall include three panels with breakers, the test breaker and panel being placed in the centre.
	The adjacent panels shall also be loaded to their rated current capacity. Alternatively, the test panel may be suitably insulated at the sides, which will be adjoining to other panels in actual site configuration
vi)	Internal Arc Test as per IEC 62271-200
vii)	Measurement of resistance of main circuit.
viii)	Mechanical operation test.

TECHNICAL SPECIFICATIONS

B)	Short circuit withstand test of earthing device (truck / switch).
C)	Testing to observe compliance to degree of protection, shall be checked for each switch board enclosure and busbar chambers during routine inspection shall be as under. IP -4X: It shall not be possible to insert a one (1) mm. dia steel wire into the enclosure from any direction, without using force. IP-5X: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

- However if the contractor is not able to submit report of the type test(s) conducted not earlier than ten years prior to the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract free of at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.
- All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
- The type test reports once approved for any projects shall be treated as reference. For subsequent projects of Owner/ Company, an endorsement sheet will be furnished by the manufacturer confirming similarity and “No design Change”. Minor changes if any shall be highlighted on the endorsement sheet.

D) Type test reports for the following tests on the model of the Numerical relays, Ethernet switches shall be submitted for employer’s review

Sl. No.	TEST ITEMS	Standard
i)	Dimensions of structure and visual inspection	IEC 60297-3-101
ii)	Functional requirements:	Relevant
	– Steady-state simulation	IEC 60255-100
	– Dynamic simulation	series
iii)	Product safety requirements	IEC 60255-27
	(Including the dielectric tests and thermal short time rating)	
iv)	EMC requirements:	IEC 60255-26

TECHNICAL SPECIFICATIONS

	– Emission	
	– Immunity	
v)	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
vi)	Contact performance	N/A
vii)	Communication requirements	IEC 61850
viii)	Climatic environmental requirements:	IEC 60068-2-14,
	– Cold	IEC 60068-2-1,
	– Dry heat	IEC 60068-2-2,
	– Change of temperature	IEC 60068-2-78,
	– Damp heat	IEC 60068-2-30,
		IEC 60255-27
ix)	Mechanical requirements: – Shock	IEC 60255-21-1,
	– Vibration	IEC 60255-21-2,
	– Bump	IEC 60255-21-3
	– Seismic	
x)	Enclosure protection	IEC 60529,
		IEC 60255-27

Two (2) protected soft copies on CD-ROM of the approved test results shall be furnished with the equipment. These shall include complete reports and results of the routine tests and type tests (if the latter is carried out) on equipment. If the type tests are not conducted, the CDs shall contain copies of the results of type tests carried out on identical equipment earlier.

B. ROUTINE TESTS

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed to be included in the equipment price.

An indicative list of tests / checks is mentioned as QA chapter on HT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

C. COMMISSIONING CHECKS / TESTS

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects. In addition,

TECHNICAL SPECIFICATIONS

the Contractor shall carry out all other checks and tests recommended by the manufacturers.

General

- a) Check name plate details according to specification.
- b) Check for physical damage
- c) Check tightness of all bolts, clamps and connecting terminals
- d) Check earth connections.
- e) Check cleanliness of insulators and bushings
- f) Check heaters are provided
- g) H.V. test on complete switchboard with CT & breaker in position.
- h) Check all moving parts are properly lubricated.
- i) Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.
- j) Check for interchange ability of breakers.
- k) Check continuity and IR value of space heater.
- l) Check earth continuity for the complete switchgear board

Circuit Breakers

- a) Check alignment of trucks for free movement.
- b) Check correct operation of shutters.
- c) Check slow closing operation (if provided)
- d) Check control wiring for correctness of connections, continuity and IR values.
- e) Manual operation of breakers completely assembled.
- f) Power closing / opening operation, manually and electrically at extreme condition of control supply voltage.
- g) Closing and tripping time.
- h) Trip free and anti-pumping operation.
- i) IR values, resistance and minimum pick up voltage of coils.
- j) Simultaneous closing of all the three phases.
- k) Check electrical and mechanical interlocks provided.
- l) Checks on spring charging motor, correct operation of limit switches and time of charging.
- m) All functional checks.

Current Transformers

TECHNICAL SPECIFICATIONS

- a) IR value between windings and winding terminals to body.
- b) Polarity tests.
- c) Ratio identification checking of all ratios on all cores by primary injection of current.
- d) Magnetization characteristics & secondary winding resistance.
- e) Spare CT cores, if any to be shorted and earthed.

Voltage Transformers

- a) Insulation resistance test.
- b) Ratio test on all cores.
- c) Polarity test.
- d) Line connections as per connection diagram.

Cubicle Wiring

- a) Check all switch developments.
- b) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.
- c) All the wires shall be checked for IR value.
- d) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component / equipment.
- e) Check terminations and connections.
- f) Wire ducting

21. SPECIFICATION FOR 33KV RING MAIN UNIT (If applicable)

A. 33kV RING MAIN UNIT

Each Ring Main Unit shall have all the following major components in addition to the other items required for satisfactory performance of equipment:

- a) Painted MS enclosure with steel base frame for Ring Main Unit.
- b) 33 KV Ring Main Units, Non-extensible type along with requisite number of electrically operated breakers and manually operated Load break switches and earth switches as per Single line Diagram
- c) Control protection and metering requirements as per system requirement and single line Diagram
- d) Internal cabling for connections between the equipment's of Ring Main Unit, lighting & earthing system along with required hardware, gaskets, gland plates etc as required.

B. TECHNICAL REQUIREMENTS

CODES AND STANDARDS: IS: 13118, IEC: 62271-200

TECHNICAL SPECIFICATIONS

The equipment shall have the following features:

1. ELECTRICAL SYSTEM PARAMETERS		
i	Nominal system voltage	33 KV
ii	Highest system voltage	36 KV
iii	Rated insulation level	
	i) Impulse with stand voltage with 1.2 / 50 Micro second wave	170 KV(Peak)
	ii) One-minute power frequency with stand voltage	70 KV (RMS)
iv	Rated short circuit breaking capacity at specified site conditions (Minimum)	As per system fault current (Refer Cl. 1.0 of Chapter 2-A, Part A) with %age of DC component as per IEC-62271-100 corresponding to minimum operating time with operating conditions specified.
v	Rated short (Minimum) circuit making current	2.5 Times of system fault current.
vi	Rated short time withstand capacity (Minimum)	As per system fault current
vii	Rated operating duty cycle	O-3 minute-CO-3 minute – CO
viii	Maximum temperature rise over and ambient temperature of 50 deg.C	As per IEC: 62271-100
2. RMU CONFIGURATION		
i	RMU Configuration	Two Nos. Load break switches (LBS) and transformer circuit breaker as per system Requirement.
ii	Extensibility	Non-extensible type
iii	Load break switch, Circuit breaker & earth switch in RMU panel	All shall be fixed (Non-draw out) type
iv	Insulation medium for panel/ bus bar	SF6 gas or Dry air in sealed metallic tank
v	Breakers & load break switches	SF6 gas or Vacuum type (with disconnecter & earth switch)
vi	Internal Arc classified FLR	As per system fault current (for Min 1 sec)

TECHNICAL SPECIFICATIONS

3. RMU CONSTRUCTIONAL FEATURES		
i	RMU Panel type	Metal enclosed panel construction
ii	Service Location	Indoor/Outdoor
iii	Mounting	Free Standing
iv	Overall enclosure protection	IP54 minimum for MV Switchgear Compartments, Vermin proof
v	Doors	Front access with anti-theft hinge
vi	Covers	Bolted for rear access, with handles. All the accessible bolts / screws shall be vandal proof. One set of required Special tools per RMU shall be in the scope of supply.
vii	Construction	Sheet metal 2 mm thick CRCA/Aluzinc/Stainless-Steel (minimum) suitable for outdoor application.
viii	Base frame made of steel for RMU	Raised frame of 300 mm height
ix	Lifting lugs	Four numbers
x	Cable entry	Bottom
xi	Bus bar continuous rated current at Designed 50 deg.C ambient temperature	As per system requirement.
xii	Bus bar short time withstand capacity	As per system fault current (Minimum)
xiii	Maximum temperature rise above reference ambient 50 deg C	As per IEC reference standard
xiv	Earth bus bar	Aluminium sized for rated fault duty for 1
xv	Cooling arrangement	By natural air (without fan)
xvi	Panel internal wiring	Stranded flexible color coded PVC insulated copper wire 1.5 sq mm.(min.), 1100 volt grade
xvii	Gasket	Neoprene rubber
xviii	Marshalling terminal blocks	1.5 Sq mm, Nylon 66 material, screw type + 20% spare in each row of TB.

TECHNICAL SPECIFICATIONS

xix	Padlock facility	Required for all earth switches & all handles
xx	Explosion vents	To ensure operator's safety, design should ensure that gases / flames generated during flash over / blast in any of the compartment, must not come out from the front of RMU. Cable compartment & other compartments of the RMU should withstand Internal arc test for the indicated system fault current.

4. Requirements of sealed housing live parts (RMU SF6 gas chamber)

i	Enclosure	Stainless steel enclosure, IP67 class
ii	SF6 gas pressure low alarm	To be given
iii	Provision for SF6 gas filling	To be given (For 'sealed for life' design of RMU, this is not applicable)
iv	Provision for measurement SF6 gas pressure	Manometer with non-return valve indication
v	Arc interruption method for SF6 breaker/ Load break switch	Puffer type / rotating arc type
vi	Potential free contacts for SF6 gas 1NO +1NC pressure low	1NO +1NC
vii	Electrical Bushing	Preferably, bushing should be suitable for replacement at site.

5. LOAD BREAK SWITCH (LOAD BREAK ISOLATOR)

i	Type	Three poles operated simultaneously by a common shaft
ii	Arc interruption in dielectric medium	SF6 or vacuum
iii	Operating mechanism for close/ open	Electrically operated through SCADA.
iv	Continuous current rating of LBS at design ambient temperature of 50 deg C	100 Amps requirement minimum or as per system

6. CIRCUIT BREAKER

TECHNICAL SPECIFICATIONS

i	Type	Three poles operated simultaneously by a common shaft
ii	Arc interruption in dielectric medium	SF6 or vacuum
iii	Operating mechanism	Electrically Operated
iv	Emergency trip / open push button	On panel Front
v	Continuous current rating of Breaker at design ambient temp of 50 deg.C	100 Amps requirement minimum or as per system
vi	Short time withstand capacity	As per system fault current
vii	Breaker status auxiliary contact	2NO + 2NC wired to terminal block
viii	Current transformer Ratio	Suggestive rating: 100/1 A or as per requirement Other ratings as per manufacturer's standard may also be adopted. Sufficient space must be provided both in horizontal & vertical directions for mounting of CT's. Additionally, some CAUTION marking (by sticker/ paint) should be there to avoid CT's installation above the screen of cable (i.e. earth potential point.)
ix	CT accuracy class	Protection: 5P20 Metering: 0.5
x	Potential Transformer (PT) ratio and Accuracy Class	33000/ $\sqrt{3}$ /110/ $\sqrt{3}$ Accuracy class : 0.5 suitable for converter duty application as mentioned elsewhere in the specification
xi	Protections	Numerical relay as per requirements mentioned elsewhere in the specification. In addition to above Transformer protections like OTI, WTI, Buchholz, and Pressure Relief Valve (PRV) operated shall be suitably integrated in the protection circuit. Any AC/DC auxiliary supply requirement for the RMU shall be arranged as per requirement mentioned elsewhere in the specification.

TECHNICAL SPECIFICATIONS

xii	Relay aux contacts for remote indication	1NO+1NC Potential free wired to TB
xiii	Shunt trip (for door limit switch of enclosure or transformer) as per the adopted voltage	To be wired to terminal blocks

7. EARTH SWITCH

i	Type	Three poles operated simultaneously by a common shaft

ii	Switching in dielectric medium	Dry air in sealed medium or SF6
iii	Operating mechanism for Close/Open	Manual
iv	Short time withstand capacity	As per system fault current
v	Aux contacts	1NO+1NC free wired to TB
vi	LBS Earth Switch close / open	Potential free contacts wired to terminal block.
vii	CB Earth Switch close /open	Potential free contacts wired to terminal block.

8. INDICATION

i	Cable charge status indication for all Load Break Switches & Circuit Breaker	Circuit breaker capacitor type voltage indicators with LED on all the phases (Shall be clearly visible in day light)
ii	Spring charge status indication	On front for breaker
iii	Earth switch closed indication (For Each LBS)	front
iv	Load break switch ON/OFF indication	Green for OFF / Red for ON
v	Circuit breaker ON/OFF indication	Green for OFF / Red for ON
vi	Cable Fault Direction	Cable fault passage indicator.
vii	CB close / open	Potential free contacts wired to terminal block.
viii	Protection relay operated	Potential free contacts wired to terminal block.

TECHNICAL SPECIFICATIONS

ix	SF6 gas pressure low	Potential free contacts wired to terminal block.
9. RMU OPERATIONAL INTERLOCK		
i	Interlock type	Mechanical
ii	Load break switch & respective earth switch	Only one in 'close' condition at a time
iii	Circuit breaker & respective earth switch	Only one in 'close' condition at a time
iv	Prevent the removal of respective cable covers if load break switch or circuit breaker is 'ON'	Electrical / Mechanical
v	Prevent the closure of load break switch or circuit breaker if respective cable cover is open	Electrical / Mechanical
vi	Cable test plug for LBS/CB accessible only if Earth switch connected to earth	Mechanical

10. MIMIC DIAGRAM, LABEL AND FINISH		
i	On panel front with description of function & direction of operation of handles/buttons	
ii	Mimic diagram (Shall not be preferred with Stickers)	
iii	Operating instruction chart and Do's & Don'ts to be displayed on left / front side of panel enclosure on Al Sheet, duly affixed on panel.	
iv	Name plate on panel front	Fixing by rivet only
v	Material	Anodized aluminum 16SWG / SS
vi	Background	Satin Silver
vii	Letters, diagram & border	Black
viii	Process	Etching
ix	Name plate details	Month & year of manufacture, equipment type, input & output rating, purchaser name & order Number, guarantee period.

TECHNICAL SPECIFICATIONS

x	Labels for meters & indications	Anodized aluminum with white character on black background OR 3 Ply lamicoid.
xi	Danger plate on front & rear side	Anodized aluminum with white letters on red background
xii	Painting surface preparation	As per Appendix-1 of Part-A (For outdoor)
xiii	Painting external finish	As per Appendix-1 of Part-A (For outdoor) Shade-RAL 7032
xiv	Painting internal finish	As per Appendix-1 of Part-A (For outdoor) Shade-White

C. TESTS OF RMU

33 kV Switchgear/Ring Mains Unit shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of Owner/ Company, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

TECHNICAL SPECIFICATIONS

B-7(A): INVERTER TRANSFORMER

1. TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sr. No.	TRANSFORMER			INVERTER TRANSFORMER
i)	VA Rating & Quantity			As per system requirement
ii)	Voltage Ratio (KV)			As per system requirement
iii)	Duty, Application	Service	&	Continuous Solar application and Inverter converter duty (Outdoor)
iv)	Winding			AS per system requirement
v)	Frequency			50 Hz
vi)	Nos. of Phase			THREE
vii)	Vector Group & Neutral earthing			As per system requirement
viii)	Cooling			ONAN
ix)	Tap Changer			As per system requirement OCTC +/- 5% (min.)
x)	Impedance at75 ⁰ C			
	a) Principal Tap		As per system requirement and SLD* & as per Inverter manufacturer recommendation.	
	b) Other Taps			
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)			
	a) Top Oil		50 deg.C	
	b) Each Individual Winding		55 deg.C	
xii)	SC withstand time (thermal)			2 sec.

TECHNICAL SPECIFICATIONS

xiii)	Fault Level & Bushing CT	As per system requirement
xiv)	Termination	As per system requirement
xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV) Creepage distance : 31 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600/ IEC60076-7. As minimum
		requirement, Transformers shall be designed with 110% continuous thermal overloading capability. The same shall be tested during Temp Rise Type test.
xviii)	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage 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 char. up to 150%
xix)	Air Clearance	As per CBIP
xx)	Foundation	All the foundation shall be designed as per highest rating Transformer in case different capacity transformer are offered.

Note (common for Oil filled and dry type transformer):

- Inverter Transformer shall have copper/Aluminium Shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and Inverter manufacturer recommendation. Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with

TECHNICAL SPECIFICATIONS

2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.

- If Inverter transformer is provided indoor, it shall be necessarily dry type.
- Harmonic Factor as per Inverter manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.
- The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).
- The thermal design of Inverter Transformer needs to consider the temperature dependent performance of the Inverter. It is to in accordance with Inverter output and under worst condition it should not limit Inverter output.
- The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one Inverter supplying power to only one LV winding.
- For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings
- In case of inverter transformer, it shall be proven and of successfully type tested design
- Contacts from Inverter transformer fittings/protection devices shall be wired for tripping of Inverter transformer Circuit Breaker. Detailed scheme regarding same shall be finalized during detailed engineering.
- Single Line Diagram (SLD) will be finalized during detailed engineering however kVA rating of LV winding of inverter transformer shall not be less than kVA capacity of respective Inverters connected to it.

2. CODES AND STANDARDS

Transformers	IS:2026, IS:6600, IEC:60076
Bushings	IS:2099, IEC:60137,IS 3347 ,IS 12676
Insulating oil	IEC 60296 ,IEC 61099/IS16081
Bushing CTs	IS:2705, IEC 60185
Indian Electricity Act 2003, BEE Guideline & CEA notifications	

TECHNICAL SPECIFICATIONS

A. General Construction

Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.

The other important construction particulars shall be as below.

- a. The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- b. A double float type Buchholz relay conforming to IS: 3637 shall be provided.
- c. Suitable 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.
- d. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site
- e. The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.
- f. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
- g. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator with accuracy class of ± 2 deg.
- h. 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.
- i. M. 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 IP55 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 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level. 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.

B. Windings

TECHNICAL SPECIFICATIONS

- a. The Bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.
- b. The conductors shall be of electrolytic grade copper/electrolytic grade Aluminum free from scales & burrs.
- c. All windings of the transformers shall have uniform insulation.
- d. Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

C. Core

- a. The core shall be constructed from non-ageing, cold rolled, super grain oriented silicon steel laminations equivalent to M4 grade steels or better.
- b. Core isolation level shall be 2 kV (rms.) for 1 minute in air.
- c. Adequate lifting lugs will be provided to enable the core & windings to be lifted.

D. Insulating Mineral oil

No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm ² /s	□ 12 at 40 □ C □ 1800.0 at (-)30 □ C
2.	Flash Point, □ C	□ 140 □ C
3.	Pour point, □ C	□ (-)40 □ C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm ³ at 20 □ C	□ 0.895
6.	Interfacial Tension N/m at 25 □ C	□ 0.04
7.	Neutralisation value, mgKOH/g	□ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	□ 30 in bulk supply □ 40 in drum supply
10.	Anti-oxidants additives	Not detectable

TECHNICAL SPECIFICATIONS

11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	☐ 1.2 ☐ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	☐ 30 ☐ 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	☐ 0.005
14.	PCA content	☐ 1%
15.	Impulse withstand Level, kVp	☐ 145
16.	Gassing tendency at 50 Hz after 120 min, mm ³ /min	☐ 5

Subsequently oil samples shall be drawn at:

Sr. No.	Parameters	Before filling in main tank & tested for	Prior to energization following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

E. Bushings

- a. Bushing below 52 kV shall be oil communicating type with porcelain insulator.
- b. LV Bushing below 3.6 kV used within transformer cable box, epoxy type bushing confirming to IS 2099/IEC 60137 also allowed as alternate to porcelain type
- c. No arcing horns to be provided on the bushings.

Inverter Transformer LV bushing palms shall be silver/tin plated.

F. Bushing CTs

Shall be of adequate rating for protection (differential and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

G. Valves

TECHNICAL SPECIFICATIONS

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies.

Sampling & drain valves should have zero leakage rate.

H. Gaskets

- a. Gasket shall be fitted with weather proof, hot oil resistant, nitrile rubber-based gasket.
- b. If gasket is compressible, metallic stops shall be provided to prevent over compression.
- c. The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

I. PAINTING

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
Internal Radiator	Hot oil proof, low viscosity varnish and	---	---

TECHNICAL SPECIFICATIONS

surface	subsequent flushing with transformer oil		
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

J. Neutral Earthing Arrangement

Neutral earthing shall be done as per system requirement and SLD. In case of solidly earthed neutral of Transformers, it shall be brought through insulated support from tank to the ground level at a convenient point with 2 nos. copper flat, for connection to ground network (as applicable). Neutral of Transformer if not used should be taken out through bushing and covered by insulating cap.

K. Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above)

- (a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)
- (b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.
- (c) A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box
- (d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron.
- (e) The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.
- (f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.
- (g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

TECHNICAL SPECIFICATIONS

- (h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

L. FITTINGS

Following fittings shall be provided with Transformers covered under this sub section.

a)	-Conservator for main tank (transformer above 100 KVA shall be provided with MOG with low oil level alarm contact), drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement (Gas collecting arrangement applicable for transformer above 100 KVA).
c)	- For Auxiliary transformers below 2 MVA, diaphragm type explosion vent shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm (WTI only for transformer above 50 kVA) and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level).
e)	For transformer above 100 KVA: Top & bottom filter valves with threaded male adapters, bottom sampling valve, and drain valve/sludge removal valve at the bottom most point of the tank. For Transformer upto 100 KVA: common drain cum sampling cum bottom filter cum sludge removal valve and top filter valve can be provided.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads (jacking pad applicable for transformer above 100 KVA), towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.	

M. Tests and Inspection

S.N.	ROUTINE TESTS

TECHNICAL SPECIFICATIONS

1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check	√
5.	Magnetic Balance and Magnetizing Current Test	√
6.	Measurement of no load current with 415 V, 50 Hz AC supply	√
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage	√
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√
9.	IR measurement (As per IEC 60076-1)	√
10.	Separate Source Voltage Withstand Test /Applied voltage test.	√
11.	Induced overvoltage test/Induced voltage withstand (IVW) test .	√
12.	Repeat no load current/loss & IR after completion of all electrical test	√
13.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause of this sub section)	√
14.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
15.	IR measurement on wiring of Marshalling Box.	√

S.N.	TYPE TESTS#	
1.	Temperature Rise test at a tap corresponding to maximum losses as per IS 2026.	√
2.	Tank Vacuum & Pressure Test (as per CBIP norms)	√

N. Leakage test on assembled Oil filled Transformer (ROUTINE TEST)

All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 KN/sq. m measured at the base of the tank. The pressure shall be maintained for a period of not less than 6 hours during which time no sweating shall occur. Bidder can perform this test at site depending upon urgency subjected to Owner/ Company approval.

O. Fire Fighting

TECHNICAL SPECIFICATIONS

Fire Fighting arrangements for Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/statutory requirements. Firewall & soak pit as applicable (as per statutory requirement/TAC/IS 10028 / IS 1646) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to Owner/ Company approval. However, for all outdoor transformer at a distance of 1.0 m (min.) from transformer outer edge. A sump pit shall be provided for each pit. Transformer efficiency shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010.

P. DRY TYPE AUXILIARY TRANSFORMERS:

Dry Type Transformer shall be constructed in accordance to IS: 2026, IS: 11171 or equivalent to any other international standard, Indian Electricity Act 2003, BEE Guideline & CEA notifications. Transformer rating and all related technical parameters including tap changer (if applicable) shall be as per system requirement/SLD and relevant standards. Transformer shall be suitable for continuous indoor duty application. Transformer shall be complete & functional in all respect. The other important construction particulars shall be as below.

- a) The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. The enclosure shall be provided with suitable hardware (as required).
- b) The conductors shall be of electrolytic grade copper free from scales & burrs.
- c) Dry Type Transformer windings shall be of class F insulation or better. Cooling shall be AN.
- d) The core shall be constructed from non-ageing, cold rolled, grain oriented silicon steel laminations (M4 or better).

The fittings/accessories including protection/monitoring device (temperature scanner) generally required for satisfactory operation of the transformer, are to be provided.

TECHNICAL SPECIFICATIONS

B-8: AC CABLES

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS:7098 (Part -II)	Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV upto & including 33 KV
IS:1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS: 3961	Recommended current ratings for cables
IS: 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS: 5831	PVC insulation and sheath of electrical cables.
IS: 8130	Conductors for insulated electrical cables and flexible cords.
IS: 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332 Part-3:	Tests on electric cables under fire conditions. Tests on bunched wires or cables (Category-B).
IEEE-383	Standard for type test of Class IE Electric Cables

TECHNICAL SPECIFICATIONS

IS: 4905	Methods for random sampling.
IS: 10418	Specification for drums for electric cables.

1. GENERAL REQUIREMENTS

The cables shall be suitable for laying on racks, in ducts, trenches, conduits, over ground cabling and underground (buried) installation with chances of flooding by water.

All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

- A. Cables shall be armoured type if laid in switchyard area or directly buried. Cable lengths shall be considered in such ways that straight through cable joints are avoided. If cables are to be laid underground, laying shall be as per latest relevant IS code. 1.4 If cables are to be laid over ground (eg on RCC/concrete pedestals etc), the cables shall be UV-resistant supported by test reports.

B. CONDUCTOR

Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.

C. INSULATION

XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core cables, shall have distinct extruded PVC inner sheath of black colour as per IS: 5831.

D. ARMOUR

For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires. For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia.of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire

TECHNICAL SPECIFICATIONS

Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4mm thick GS formed wire / 4.0 mm dia GS wire

The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264ohm mm² per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.

The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wire / formed wire.

E. OUTERSHEATH

Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.

Oxygen index of min. 29 (as per IS 10810 Part-58). Acid gas emission of max. 20% (as per IEC-754-I).

Smoke density rating shall not be more than 60 % (as per ASTM D-2843).

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

Cable size and voltage grade - To be embossed Word 'FRLS' at every 5 metre
- To be embossed Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated) (If applicable) Sequential marking of length of the cable in metres at every one metre -To be embossed / printed
The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.

Allowable tolerances on the overall diameter of the cables shall be ± 2 mm maximum, over the declared value in the technical data sheets.

Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

TECHNICAL SPECIFICATIONS

2. CABLE SELECTION & SIZING

Cables shall be sized based on the following considerations:

Rated current of the equipment.

The Maximum Overall Voltage Drop: As per relevant clause in chapter A-4, Part- A.

Short circuit withstand capability.

Fault current- As per system fault current.

Time-As per protection time grading requirement subject to the minimum value mentioned at Cable sizing criteria of Chapter A-4.

3. DERATING FACTORS

Derating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

- a) Variation in ambient temperature for cables laid in air
- b) Grouping of cables
- c) Variation in ground temperature and soil thermal resistivity for buried cables.

4. HT POWER CABLES

For single-core armoured cables, the armouring may constitute the metallic part of insulation screening.

In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.

Distinct extruded PVC inner sheath of black colour as per IS:5831 shall be provided for the cables as follows:

- a) For all multicore cables.
- b) For single core armoured cables, where armouring is not being used as metallic screen

Cores of the cables of up to 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.

The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.

The eccentricity shall be calculated as

Eccentricity	Ovality

TECHNICAL SPECIFICATIONS

t_{max} -t_{min} - ----- 100 t max	d_{max} -d_{min} - ----- 100 d max
Where t-max/t-min is the maximum/minimum thickness of insulation and d-max/d-min is the maximum / minimum diameter of the core	

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%

Cables shall conform to IS: 7098 Part - II. These cables shall have multi-stranded, compacted circular, aluminium conductors, XLPE insulated, metallic screened suitable for carrying the system earth fault current, PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing for cables shall be “dry curing / gas curing”.

The metallic screen of each core shall consist of copper tape with minimum overlap of 20%. However, for single core armoured cables, the armouring shall constitute the metallic part of the screening.

The standard length for HT power cables shall be 1000 meter for all single core cables and 750 meters for 3 core cables. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. One drum length of each cable size can be of nonstandard length (not less than 250 meter) so as to match the ordered quantity. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/-2% and the payment shall be made based on the actual cable length supplied within this limit.

5. LT POWER CABLES

LT Power & control cables shall be of minimum 1100 volts grade XLPE /PVC insulated conforming to IS 1554 / IS 7098 (Part-I) for utilization voltages less than equal to 415 V. For cable connecting central inverter and inverter transformer, no. of runs and interconnecting trench, bus bar terminations, lugs shall be provided in such a manner so that no overheating of contacts & terminals encountered. Sufficient space for cabling & termination shall be kept.

The sizing of the cable will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let-out energy of the fuse. For breaker-controlled feeder, cable shall be capable of withstanding the system

TECHNICAL SPECIFICATIONS

fault current level for total breaker tripping time inclusive of relay pickup time.

Single core cables shall have no Inner sheath as per IS: 7098 Part-I

All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated.

1.1 KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer- sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armoured.

1.1KV grade PVC power cables shall have aluminium/copper conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

6. LT CONTROL CABLES

Conductor of control cables shall be made of stranded, plain annealed copper. Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables.

Cores of the cables shall be identified by colouring of insulation. Following colour scheme

shall be adopted:

1 core - Red, Black, Yellow or Blue

2 core- Red & Black

3 core-Red, Yellow & Blue

4 core-Red, Yellow, Blue and Black

For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

CABLE SELECTION & SIZING:

1

TECHNICAL SPECIFICATIONS

Control cables shall be sized based on the following considerations:

- (a) The minimum conductor cross-section shall be 1.5 sq.mm.
- (b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

1.1 KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I).

7. TESTS

Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of power and control cables enclosed at relevant section.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. All cables to be supplied shall be of type tested design.

During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of Owner/ Company, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

The reports for following type tests shall be furnished:

Sl	Type Test	Remarks
	Conductor	
1.	Resistance test	

TECHNICAL SPECIFICATIONS

	For Armor Wires / Formed Wires	
2.	Measurement of Dimensions	
3.	Tensile Test	
4.	Resistance test	
5.	Wrapping test	
6.	Torsion test	For GS round wires only
7.	Elongation test	For GS wire only
8(a)	Mass& uniformity of Zinc Coating tests	For GS wires/formed wires only.
8(b)	Adhesion test	For GS wires/formed wires only
For XLPE insulation & PVC Sheath		
9.	Test for thickness	
10.	Tensile strength and elongation test before ageing and after ageing	
11.	Ageing in air oven	
12.	Shrinkage test	
13.	Hot set test	For XLPE insulation only
14.	Water absorption test	For XLPE insulation only
15.	Loss of mass test	For PVC outer sheath only.
16.	Hot deformation test	For PVC outer sheath only.
17.	Heat shock test	For PVC outer sheath only
18.	Thermal stability test	For PVC outer sheath only
19.	Oxygen index test	For PVC outer sheath only
Sl	Type Test	Remarks
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only
22.	Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only
23.	Insulation resistance test (Volume Resistivity method)	
24.	High voltage test	
25. *	Partial discharge test	For HT cables only
26. *	Bending test	
27. *	Dielectric power factor test	
	a) As a function of voltage	

TECHNICAL SPECIFICATIONS

	b) As a function of temperature	
28. *	Heating cycle test	
29. *	Impulse withstand test	

* Not applicable for 3.3/3.3kV grade cables.

8. CABLE DRUMS

- (a) Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. However, For Single core cables up to 6 Sq. mm size, supplier can do alternative packaging of whole Drum/Spool to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stencilled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

B-9: CABLE INSTALLATION METHODOLOGY

1. CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

- IS:513 Cold rolled low carbon steel sheets and strips.
- IS:802 Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
- IS:1079 Hot Rolled carbon steel sheet & strips
- IS:1239 Mild steel tubes, tubulars and other wrought steel fittings
- IS:1255 Code of practice for installation and maintenance of power cables upto and including 33 KV rating
- IS:1367 Part-13 Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
- IS:2147 Degree of protection provided by enclosures for low voltage switchgear and control gear
- IS:2309 Code of Practice for the protection of building and allied structures against lightning.
- IS:2629 Recommended practice for hot dip galvanising of iron & steel
- IS:2633 Method for testing uniformity of coating on zinc coated articles.
- IS:3043 Code of practice for Earthing
- IS:3063 Fasteners single coil rectangular section spring washers.
- IS:6745 Methods for determination of mass of zinc coating on zinc coated iron & steel articles
- IS:8308 Compression type tubular in- line connectors for aluminium conductors of insulated cables
- IS:8309 Compression type tubular terminal ends for aluminium conductors of insulated cables.
- IS:9537 Conduits for electrical installation.

TECHNICAL SPECIFICATIONS

IS:9595 Metal - arc welding of carbon and carbon manganese steels - recommendations.

IS:13573 Joints and terminations for polymeric cables for working voltages from 6.6kv upto and including 33kv performance requirements and type tests.

BS:476 Fire tests on building materials and structures

IEEE:80 IEEE guide for safety in AC substation

grounding IEEE:142 Grounding of Industrial & commercial power systems

DIN 46267 (Part-II) Non-tension proof compression joints for Aluminium conductors.

DIN 46329 Cable lugs for compression connections, ring type, for Aluminium conductors

VDE 0278 Tests on cable terminations and straight through joints

BS:6121 Specification for mechanical Cable glands for elastomers and plastic insulated cables.

Indian Electricity Act. Indian

Electricity Rules.

Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

2. DESIGN AND CONSTRUCTIONAL FEATURE

Bidder to refer Appendix -1 of Ch. A-1 for acceptable cable laying methodology.

Inter Plant Cabling

Interplant cabling for main routes shall be laid in Cable trenches/cable trays/buried/duct banks. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. All buried cables shall be of armoured type.

TECHNICAL SPECIFICATIONS

Bidder can propose over ground cabling methodology (eg on RCC/concrete pedestals etc). In such cases, the cables shall be UV-resistant supported by test reports.

Cable Sizing Conditions

All cables shall be suitably derated as per the laying conditions for carrying the required load current and fault current. For derating, the ambient temperature for directly buried cables shall be taken as 50° C and 60° C for cables laid in air.

All XLPE cables shall be rated at 90° C conductor temperature for AC Voltage drop calculation and 80° C for DC Voltage calculation. However, for Voltage drop calculation in DC Cable, actual conductor temperature as per loading can be used

Trenches

PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps.

General

The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.

Sizing criteria, derating factors for the cables shall be met as per respective chapters. However, for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.

Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:

- Meet all safety requirements.
- Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc

3. EQUIPMENT DESCRIPTION

Cable trays, Fittings & Accessories

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays which are exposed to atmosphere shall be FRP based or better material with equivalent properties. The specifications for FRP cable trays are iterated below:

- a. The FRP cable tray shall be ultraviolet resistant. FRP cable trays shall be manufactured in accordance with latest version of NEMA FG-1-1984-1993 and IS-6746 or its equivalent.

TECHNICAL SPECIFICATIONS

- b. All cable trays and accessories shall be corrosion / chemical resistant, weather resistant, easy to drill and cut, Lightweight, high strength and flame retardant in accordance with ASTM E – 84 - Class 1 Rating and as per IS - 6746 – Very Low Flammability and resistant to ultraviolet light. The oxygen index shall be minimum 30 as per ASTM-D-2863.
- c. The minimum glass content in the FR material shall be 55%.
- d. The minimum thickness for any FRP Tray should be 3mm & there should be no negative tolerance in Thickness.
- e. The tray construction shall be such as to facilitate easy handling and to ensure easy laying of cables without causing damage to cables. The inside surface shall be free from sharp edges, burrs or projections.
- f. Each section of tray shall be complete with necessary connector plate and hardware. All Hardware (Nuts, bolts, washers etc.) shall be of Stainless-Steel Material Grade: 316 for FRP trays joining plates. The bends, tees, reducers, crosses and droppers shall have required bending radius but not less than 300mm.
- g. Suitable cable support systems based on FRP shall be supplied confirming with IS 6746. The average thickness for any FRP support should be 4mm & there should be no negative tolerance in Thickness.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.

Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.

Support System for Cable Trays

Cable tray support system shall be prefabricated similar or equivalent to "Unistrut make".

Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types: (i) C1:- having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder:

Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware's such as lock washers, hexagon nuts, hexagon head bolt, support

TECHNICAL SPECIFICATIONS

hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardware's fittings and accessories shall be prefabricated factory galvanized.

The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanized surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied

All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation.

Support system shall be able to withstand -

- weight of the cable trays
- weight of the cables (75 Kg/Meter run of each cable tray)
- Concentrated load of 75 Kg between every support span.
- Factor of safety of minimum 1.5 shall be considered.

Pipes, Fittings & Accessories

Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria

GI Pipes shall be of medium duty as per IS:1239

Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.

Hume pipes shall be NP3 type as per IS 458

Junction Boxes

Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of thickness 2mm. Top of the boxes shall be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanized as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation.

Terminal blocks shall be 1100V grade, 10Amps rated, made up of unbreakable polyamide

TECHNICAL SPECIFICATIONS

6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals, the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size upto 2.5 sq mm each. All internal wiring shall be of minimum 1.5 sq. mm cu. Conductor PVC wire.

Terminations & Straight through Joints

Termination and jointing kits for 33kV, 11kV, 6.6 kV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, taped type or heat shrinkable type. 33kV, 11kV and 6.6 kV grade joints and terminations shall be type tested as per IS:13573. 3.3kV grade joints and terminations shall be type tested as per VDE0278 or Applicable IS standard. Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard.

Straight through joint and termination shall be capable of withstanding the fault level for the system.

1.1 KV grade Straight Through Joint shall be of proven design.

Cable glands

Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. Cable glands shall be made of heavy-duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 microns. All washers and hardware shall also be made of brass with nickel chrome plating. Rubber components shall be of neoprene or better synthetic material and of tested quality. Cable glands shall be suitable for the sizes of cable supplied/erected.

Cable lugs/ferrules

Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipment. Cable lugs and ferrule shall conform to relevant standard.

Trefoil clamps

Trefoil clamps for single core cables shall be pressure die cast aluminium or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts,

TECHNICAL SPECIFICATIONS

washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current.

Cable Clamps & Straps

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, self-locking, de- interlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment

Receptacles

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanized or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON- OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polyamide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

Galvanizing

Galvanizing of steel components and accessories shall conform to IS:2629, IS4759 & IS:2633. Additionally, galvanizing shall be uniform, clean smooth, continuous and free from acid spots.

The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified.

Welding

The welding shall be carried out in accordance with IS:9595. All welding procedures and welders' qualification shall also be followed strictly in line with IS:9595

4. INSTALLATION

Cable tray and Support System Installation

TECHNICAL SPECIFICATIONS

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.

Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the support system along with tray, spacing etc in line with relevant standard.

The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated.

The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stencilled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meters. Risers shall additionally be painted/stencilled with identification numbers at every floor.

In certain cases, it may be necessary to site fabricate portions of trays, supports and other nonstandard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

Conduits/Pipes/Ducts Installation

The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/ roof/ wall/ cable tunnel/ cable trenches made for conduit installation shall be sealed and made waterproof by the Contractor **either with any proven fire sealing system rated for one hour or Modular multi-diameter cable sealing system consisting of frames, blocks, Compression wedge and its accessories. The Cable sealing system should have been tested for fire insulation for min. 1 hr as per BS 476 and shall also provide water sealing. System shall be anti- rodent and anti- termite.**

TECHNICAL SPECIFICATIONS

GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.

Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material.

Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit /pipe size (dia).	Spacing
Upto 40 mm	1 M
50 mm	2.0 M
65-85 mm	2.5 M
100 mm and above	3.0 M

For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.

Junction Boxes Installation

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

Cable Installation

Cable installation shall be carried out as per IS:1255 and other applicable standards. For Cable unloading, pulling etc following guidelines shall be followed in general:

- Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted

TECHNICAL SPECIFICATIONS

on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.

- While laying cable, ground rollers shall be used at every 2-meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.

Cables shall be laid on cable trays strictly in line with cable schedule.

Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centre lines and clamped at every two meters. All multi core cables shall be laid in touching formation. Power and control cables shall be secured fixed to trays/support with self-locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five-meter interval. For vertical tray arrangement, individual multi core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be banded to trays/supports by aluminium strips at every five meter interval and at every bend.

Bending radii for cables shall be as per manufacturer's recommendations and IS:

1255. Where cables crossroads/rail tracks, the cables shall be laid in Hume pipe/

HDPE pipe.

No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.

In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.

TECHNICAL SPECIFICATIONS

Wherever few cables are branching out from main trunk route troughs shall be used.

Wind loading shall be considered for designing support as well Cable trays wherever required.

Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.

The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time.

Separation

At least 300mm clearance shall be provided between:

- HT power & LT power cables,
- LT power & LT control/instrumentation cables,

Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:

No. of cores in cable	No. of spare cores
1C,2C,3C	NIL
5C	1
7C-10C	2
14C and above	3

Directly Buried Cables

Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255.

RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

TECHNICAL SPECIFICATIONS

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centres, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminium with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags while crossing the floors, unarmoured cables shall be protected in conduits up to a height of 500 mm from floor level if not laid in tray.

Cable Terminations & Connections

The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site.

Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.

The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.

Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.

All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.

All cable terminations shall be appropriately tightened to ensure secure and reliable connections

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

B-10: SCADA

1. GENERAL

- A. Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire solar plant and its auxiliary systems.
- B. Bidder shall include in his proposal all the Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in this specification.
- C. SCADA System shall have the provision to perform the following functions:
 - i) Remote control of all the HT Breakers either in hard or soft signal.
 - ii) Remote control of Inverter active and reactive power as per requirement mentioned in respective chapter.
 - iii) SCADA shall also be able to acquire, display and store real time data, status and alarm signal from following equipment included but not limited to as required or offered under the scope of this specification:
 - a) All the HT Switchgear/RMU equipment
 - b) Incomer and bus coupler breaker of LT Panel.
 - c) Power conditioning unit (PCU)
 - d) UPS and Battery charger as per requirement mentioned in respective chapter
 - e) Weather Monitoring Equipment
 - f) TEM/ABT/MFM meter, numerical relay, fire alarm panel, GPS time synchronization unit and transformer.
 - g) SCADA Hardware, Accessories and Communication link
 - h) Any other equipment required as per specification
 - iv) Display of status of major equipment in Single Line/Mimic Diagram. Mimic Diagram colour shall comply to IS 11954: Guide for colour coding of electrical mimic diagrams
 - v) Display and storage of derived/calculated/integrated values
 - vi) Generate, store and retrieve user configurable periodic reports. SCADA shall have facility to generate report in MS Excel file type.
 - vii) Remote monitoring of essential parameters of plant on the web using popular web browser without requirement of additional software. Same shall be authorized with user id and password using standard modem. User ID and password for remote view can only be changed by SCADA Administrator. Internet connection for transferring data to web shall be taken by Contractor in the name of Owner/ Company Site for O & M period.

TECHNICAL SPECIFICATIONS

Please refer Chapter A-4 for Nos. of Web Client Licenses for remote monitoring, Nos. of OWS/EWS/Historian with location.

viii) Performing self-monitoring and diagnostic functions

- D. The contractor shall provide at least one GPS clock, which shall be synchronized with the SCADA system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with plant SCADA shall be synchronized with GPS Clock through SCADA or directly with GPS Clock. The technical details of GPS have been specified elsewhere in the specification
- E. Type of signal from equipment (Hard wired or Soft) shall be as per specification of the equipment mentioned in the respective chapter and approved during detail engineering.
- F. SCADA shall provide real time performance monitoring according to IEC 61724 standard. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail.
- G. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is affected. Control system shall be designed to prevent abnormal swings due to loss of Control System power supply, failure of any Control System component, open circuit/short circuit. On any of these failures the controlled equipment/parameter shall either remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalized during detailed engineering. System shall be designed such that there will be no upset when power is restored. These operations shall be demonstrated by vendor during Factory Accepted Test (FAT) in the presence of Owner/ Company Representative.
- H. Contractor shall provide a Package/Split AC of suitable capacity decided by load requirement in SCADA Main control/CMCS room. All the power supply module, Ethernet switches and network accessories for non-air-conditioned area shall be suitable for operating in ambient temperature of 50 Deg C minimum.
- I. 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. The solar plant SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual solar inverter. Detailed control logic in the PPC shall be finalized during detailed engineering stage.

2. SCADA CONTROLLER SYSTEM:

1

TECHNICAL SPECIFICATIONS

- A. The SCADA at Main control /CMCS room shall be of PLC/RTU/DCS based as per specification given hereunder. For other locations such as Inverter Room, PLC/ IO modules/RTUs are acceptable.

Main control /CMCS room SCADA shall have the following feature:

- i) Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.
- ii) Main control /CMCS room SCADA 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 processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.
- iii) The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in non-volatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.
- iv) A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.

3. DATA COMMUNICATION SYSTEM (DCS)

The Data Communication System shall include a redundant Main System Bus with hot back-up. Other applicable bus systems like cubicle bus, local bus, I/O bus etc shall be redundant except for backplane buses which can be non-redundant.

The DCS shall have the following minimum features:

- i) Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator workstation.
- ii) The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.

TECHNICAL SPECIFICATIONS

- iii) If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.

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

- v) The design and installation of the system bus shall take care of the environmental conditions as applicable.
- vi) Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion.
- vii) Cat 6 UTP or fiber optic cables shall be employed.
- viii) The Contractor shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.
- ix) Contractor shall setup Gigabit Ethernet based Plant Local Area Network (LAN) to connect to different communication nodes at Inverter /Switchgear location etc. with redundant backbone using ring or better topology. For plant capacity more than 100MW (AC), there shall be more than one ring for each 100MW or part connecting field node (controller/switches) and CMCS SCADA in manner that there are equal nodes in each ring as far as possible. Each Modbus cable shall be provided with Surge protection device at SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.

4. HUMAN MACHINE INTERFACE SYSTEM (HMIS)

- i) HMIS configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.
- ii) The SCADA shall be OPC version 2.05a compliant and implement a OPC-DA 2.05a server as per the specification of OPC Foundation. All data should be accessible through this OPC server.
- iii) For communicating the generation data of plant in Owner/ Company, the SCADA system shall be interfaced/ connected with PI server of Owner/ Company on OPC Protocol. The details of Owner/ Company PI server shall be furnished during the detailed engineering.
- iv) Graphical Interface Unit (GIU) / Operator work station (OWS) shall perform control, monitoring and operation (as applicable) for plant equipment's connected with SCADA system.
- v) Engineering workstation (EWS) shall work as a programming station both for controller and SCADA. It shall be possible to use same EWS as programming station and the Human Machine Interface System.

TECHNICAL SPECIFICATIONS

- vi) SCADA System shall be provided with redundant OWS. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure at CMCS in the HMIS.
- vii) In addition to a desktop based EWS, vendor shall also provide dedicated portable
- viii) (laptop) based EWS.
- ix) All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays & other operator functions.
- x) The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.
- xi) The SCADA System shall have ability to perform operator functions for each OWS/ GIU as a minimum, include Control System operation (A/M selection, raise/lower, set point/bias change, on/off, open/close operation, mode/device selection, bypassing criteria, sequence auto, start/stop selection, drive auto selection, local- remote/other multi-position selection etc.); alarm acknowledge; call all kind of displays, logs, summaries, calculation results, etc.; printing of logs & reports; retrieval of historical data; and any other functions required for smooth operation, control & management of information as finalized during detailed engineering.
- xii) The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
- xiii) The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
- xiv) The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be on the basis of user profile. The system security shall contain various user levels with specific rights as finalized by the Employer during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).
- xv) Wherever Graphical Interface Unit is envisaged, it shall meet the minimum functional requirements of monitoring, operating & controlling the process and displaying information related to process locally. GIU shall be provided with TFT active matrix or LED display and keypad for operation.

TECHNICAL SPECIFICATIONS

GIU shall be ruggedly designed to withstand hard environments like high temperature, shock and vibration.

- xvi) In addition to GUI Display, one 50 Inch LED display shall be provided at SCADA Room.
- xvii) Bidder has to provide suitable hardware DMZ network firewall to restrict unauthorized access to HMI/ SCADA system. Details specification of hardware firewall is provided elsewhere in the specification.
- xviii) SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.
- xix) Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language.
- xx) The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.
- xxi) All programming functionalities shall be password protected to avoid unauthorized modification.

5. PROGRAMMING FUNCTIONALITIES

Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language. For example, the programming of PLC shall use either of the following:

- Flow-chart or block logic representing the instructions graphically
- Ladder diagrams

The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.

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

6. SOFTWARE REQUIREMENT

- i) All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The contractor shall provide sufficient

TECHNICAL SPECIFICATIONS

documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

- ii) The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
- iii) Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry.
- iv) SCADA system shall include the following standard protocols as a minimum:
 - a) Modbus (TCP/IP, RTU, ASCII).
 - b) Sub Station Protocol (IEC-61850 and IEC 60870 -5-101/104).

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

- v) The system shall have user friendly programming language & graphic user interface.
- vi) All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics/debug software, peripheral drivers software and latest versions of standard PC-based software, Antivirus software and latest WINDOWS based packages (MS Word, Excel and PowerPoint) etc. and any other standard language offered shall be furnished as a minimum.
- vii) All application software for SCADA system functioning like input scanning, acquisition, conditioning processing, control and communication and software for operator interface of monitors, displays, trends, curves, bar charts etc. Historical storage and retrieval utility, and alarm functions shall be provided.
- viii) The Contractor shall provide software locks and passwords to Employer's engineers at site for all operating & application software so that Employer's engineers can take backup of these software and are able to do modifications at site.
- ix) The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware/machine-specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good and it shall not be necessary for Employer to seek a new license/renew license due to up gradation/change of hardware/machine in Contractor's System at site. All licenses shall be valid for the continuous service life of the plant.
- x) All the SCADA Software with license Key shall be handed over to Owner/ Company on the DVD/CD media. All the hardware and software shall be licensed to Owner/ Company.

7. PARAMETRIC REQUIREMENTS

1

TECHNICAL SPECIFICATIONS

The control system shall be designed such that under worst case loading conditions the response time shall not be worse than the following: -

- i) On/Off Command: - The response time for screen update after the execution of the control command from the time the command is issued shall be one second (excluding the drive actuation time).
- ii) Adjustment Command: - 0.5 to 1 second.
- iii) On screen Updating and All Control related displays: - 1 second.
- iv) Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays: - 1 to 2 seconds.
- v) All the Analog data shall be scanned at the resolution of 1(one) second and refreshed on screen however, recording of data shall be as finalized during detail engineering.

8. INPUT/OUTPUT MODULES

- i) The SCADA system should be designed according to the location of the input/output cabinets as specified.
- ii) Input Output modules, as required in the Control System for all type of field input signals (4-20 mA, non-changeover/change over type of contact inputs etc.) and outputs from the control system (non-changeover/change over type of contact, output signals for energizing interface relays at suitable DC voltage as decided during detail engineering, 4-20 mA output etc.) are to be provided by the Contractor.
- iii) Electrical isolation of 1.5kV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal-operate the internal processing equipment.
- iv) The Input/output system shall facilitate modular expansion in fixed stages. The individual input/output cards shall incorporate indications on the module front panels for displaying individual signal status.
- v) Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator.
- vi) The I/O Module shall have the following features:
 - a) Power supply monitoring.
 - b) Contact bounce filtering.
 - c) Optical isolation between input and output signals with the internal circuits
 - d) In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be finalized during detailed engineering.

TECHNICAL SPECIFICATIONS

- vii) Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA. Analog output modules shall be able to drive a load impedance of 500 Ohms minimum.
- viii) In case of loss of I/O communication link with the main processing unit, the I/O shall be able to go to predetermined fail safe mode (to be finalized during detailed engineering) with proper annunciation.
- ix) Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) and Modbus link at Inverter and main control room shall be calculated based on the Input/output signal list to be submitted by the contractor for approval during detail engineering.

9. 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/

TECHNICAL SPECIFICATIONS

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.

10. OPERATOR INTERFACE DISPLAYS/LOGS/REPORTS

- i) Suitable Operator Interface Displays/Logs/Reports for control operation & monitoring shall be provided. The details shall be finalized during detailed Engineering stage.
- ii) Minimum quantities shall be as follows: -

Various displays on the OWS shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y & X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up/shutdown message displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis and as finalized during detailed engineering subject to the minimum quantities as given in subsequent clauses. For X-T & X-Y plots, the facility of providing a background grid on operator request shall be variable with adequate no. of divisions in both co-ordinates.

The minimum quantity of major types of displays per unit shall be as follows:

Sl	Display	Minimum Qty for Plant capacity of 50 MW or Less	Additional Qty for each 10 MW or part above 50 MW
a)	Control displays (group/sub-group/sequence/loop)	(On as reqd. basis subject to 100 minimum)	(On as reqd. basis subject to 100 minimum)
b)	P&ID/ mimic display	25	5
c)	X-Y Plot (with superimposed operating curves + using user selectable stored data)	25+25	5+5
d)	Group displays	30	5
e)	Operator guidance message	20	NIL
f)	System status & other diagnostic display	on as required basis	on as required basis

TECHNICAL SPECIFICATIONS

The assignment for the above will be done by the contractor as per the requirement of operation of contractor's system as well as for maintenance. The balance displays shall be left as spare for future modification/addition.

11. HISTORICAL STORAGE AND RETRIEVAL SYSTEM (HSRS)

- i) The HSRS shall collect, store and process system data from MMIPIS data base. The data shall be saved online on hard disk and automatically transferred to non-erasable long term storage media once in every 30 Days periodically for long term storage. Provision shall be made to notify the operator when hard disk is certain percentage full.
- ii) The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports.
- iii) The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same.
- iv) In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration on portable external long term storage media. Bidder shall provide two numbers of portable external hard drive of 2TB each.

For long term plant performance analysis, the following plant data as a minimum with time stamping and interval as indicated in below table but not limited to shall be stored daily on historian.

Important plant data for a very long duration (plant life) Storage on Historian

Sl.	Parameter	Time Interval
1	Weather Monitoring Stations data: Global Horizontal Irradiance, Global Inclined Irradiance and Diffuse Horizontal Irradiance, Ambient Temp, Wind Speed, Wind Direction, Rain Fall and Relative Humidity.	1 (One) Minute
2	Calculated Daily Global Horizontal Insolation, Global Inclined Insolation and Diffuse Horizontal Insolation.	24 (Twenty Four) Hours
3	Power Conditioning Unit (PCUs):- DC Voltage, DC Power, DC Current, SMB/SMU Current (PCU end), AC Active & Reactive Power, Power factor, AC Current & Voltage, Energy, Inverter room temp, Inverter Cabinet temp and Modules Temp	1 (One) Minute

TECHNICAL SPECIFICATIONS

6	MFM, Energy meter and Numerical Relay data:- Active & Reactive Power, Energy (day), Current and Voltage	1 (One) Minute
7	Export feeder/s Energy Meter Data:- Active & Reactive Power, Energy import and export, Current and Voltage and Grid Frequency.	1 (One) Minute
8	Daily energy export from each Inverter	24 (Twenty Four) Hours
9	Total sum of daily energy export from all Inverter	24 (Twenty Four) Hours

12. SCADA PANEL/CABINET/CONTROL DESK/FURNITURE

- i) The SCADA cabinets shall be IP-22 protection class.
- ii) The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets. Ventilation blowers shall be furnished as required by the equipment design and shall be sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.
- iii) The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables for Main control room.
- iv) 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, preferred height of the cabinet shall not higher than 2200 mm. The cabinets shall be equipped with full height front and rear doors. The floor mounting arrangement for other cabinets shall be as required by the Employer and shall be furnished by the Contractor during detailed engineering. Wall mounted cabinet is acceptable for Inverter room/sub-pooling switchgear.
- v) Cabinet doors shall be hinged and shall have turned back edges and additional bracing where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable

TECHNICAL SPECIFICATIONS

lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.

- vi) Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm. The Preferable finish colors for exterior and interior surfaces shall conform to following shades:

- a) Exterior:- As per RAL 9002 (End panel sides RAL 5012),
- b) Interior:- Same as above

Paint films which show sags, checks or other imperfections shall not be acceptable.

As an alternative, single coat of anodic dipcoat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable

- vii) Control desk shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. ASCII Keyboard shall be capable of being pulled out through a tray.
- viii) Contractor shall provide the two power supply feeders (DC supply or UPS AC) and one raw supply feeder of suitable rating to cater all the load requirements of SCADA panel/cabinet/control desk. System remain in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.
- ix) The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.
- x) Chairs – Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators and other personnel in control room area. These shall be designed for sitting for long duration such that these are comfortable for the back. Arm-rests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon.
- xi) One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.

TECHNICAL SPECIFICATIONS

xii) All the furniture shall be of reputed make (Godrej or Equivalent).

13. HMIPIS HARDWARE

- i) The HMIPIS as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.
- ii) The Workstation/Servers employed for HMIPIS implementation shall be redundant based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of Employer developed and third party software.
- iii) Redundant sets of communication controllers shall be provided to handle all the communication between the HMIPIS and redundant system bus and to ensure specified system response time and parametric requirements. Each communication controller shall have message checking facility. Power Fail Auto Restart (PFAR) facility with automatic time update shall be provided.
- iv) All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by Employer during detailed engineering. The LAN to be provided under HMIPIS shall support TCP/IP protocol (Ethernet connectivity) with OPC RDI for interface with PLCs/other systems and shall have data communication speed of min. 100 MBPS. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

Engineering Workstations/ Operator Workstations/ Historian/ Portable EWS

SI No.	Features	Industrial Grade Engineering Cum Operator Workstations/ Operator workstations/ Other workstations/ Documentation station (in case not part of prog. Stn.)
1.	Processor	Engineering Cum Operator Workstations: 64 bit Server Grade (Xeon or Equivalent), Octacore minimum For other Workstation: 64 bit (i5 or Equivalent)
2.	Memory	Engineering Cum Operator Workstations: 16 GB RAM upgradable to 24 GB minimum For other Workstation: 8 GB RAM upgradable to 16 GB
3.	Hard Disk	Engineering Cum Operator Workstations: 1 TB RAID1 For Historian: 1 TB ultra wide RAID1 For other Workstation: 500 GB ultra wide RAID1 for OWS/ 500 GB for Portable EWS

TECHNICAL SPECIFICATIONS

	Communication port	Engineering Cum Operator Workstations: 2 Serial bus. Expansion slot=2 For other Workstation: 4 Serial bus, Expansion slot=2 Portable EWS: 2 Serial bus.
4.	Monitor (color)	Min 22" TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz, Graphic Memory = 16 MB
5.	Removable bulk storage drive	1 TB (minimum)
6	Network Connectivity	Engineering Cum Operator Workstations: 4 Nos. Built-in Ethernet Network Port For other Workstation: 2 Nos. Built-in Ethernet Network Port Portable EWS: 1 No. Built-in Ethernet Network Port and 1 No. Wifi
7.	DVD R/W	16x or higher for EWS and OWS
8.	Keyboard	ASCII
9.	Pointing Device	Mouse
10.	Additional general-purpose software (for using over network by servers/work stations/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.
11.	Software	MS. Windows latest, MS Office Editor (EXCEL, WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.

LED Display

1

TECHNICAL SPECIFICATIONS

1	LED Display	50 Inch LED Display, Display Resolution : 1920 x 1080, Wall Mounted, Reputed make (Samsung/Sony/LG or Equivalent)

Printer

Sr	Features	Networked Color Laser Printer
1	Paper Size	A3
2	Printing Speed (min.)- in normal mode for A4 size paper	6 ppm (Color) 24 ppm (B&W)
3	Type	Heavy duty, at least 50000 pages/month
4	Resolution (black) (min.)	600 dpi
5	First page out time (with full graphic display)	=<1 min for color, <45 sec for BW
6	Paper input capacity (min.)	500 sheets
7	Additional features	Automatic Duplex Printing
8	Paper sheets (1 ream = 500 sheets) with printer (To be supplied with printer)	10 reams (A3) 20 reams (A4)

14. SUPPLY OF OUTDOOR WIRELESS ACCESS POINT

Bidder has to supply 2(two) nos. of Industrial outdoor IEEE 802.11 b/g/n wireless access point with 2x10/100Base-T(X) having Far Distance Air Connectivity up to 7 KM and protection class IP-67 .It shall be suitable for pole with minimum operating temperature of 55 Deg C.

Bidder to note that Wireless Access Point is for Owner/ Company's own use only. Bidder shall be responsible to provide Communication connectivity for OWS for location other than CMCS, if required under the scope using OFC/CAT/WiFi link as feasible and approved during detail engineering.

15. ADDITIONAL CLAUSE

TECHNICAL SPECIFICATIONS

Please refer to the Chapter A-4, Part-A for additional clause, if any related to this section of specification.

16. FACTORY ACCEPTANCE TEST (FAT)

FAT procedure shall be submitted by bidder for Owner/ Company approval and after approval of FAT procedure, FAT will be witnessed by Owner/ Company Engineering or authorized representative of Owner/ Company. SCADA shall communicate with all third party devices which are part of Solar Plant and the same shall be demonstrated during the FAT.

ROUTINE TESTS: All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price

An indicative list of tests / checks is mentioned in QA chapter on SCADA. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

17. TIME SYNCHRONISATION EQUIPMENT

Time Synchronization equipment shall be provided and shall be located in the Control

Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo

Positioning Satellite (GPS) for time synchronization of all components of the SCADA.

- A. It shall be complete in all respects including antenna, all cables, processing equipment, etc.
- B. All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.
- C. It shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long-life lithium batteries.
- D. It shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.
- E. The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.

TECHNICAL SPECIFICATIONS

- F. All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric protection relays as per requirement under this scope of technical specification or offered by bidder shall be synchronized with an accuracy of 1ms.
- G. The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable) required for time synchronization with SCADA and all other devices shall be in scope of contractor.
- H. The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.
- I. The system shall have provisions for combination of any of the following output signals:
- NTP (network time protocol) 100Mbps Ethernet port
 - IRIG-B00x (TTL, pulse width modulated signal)
 - 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
 - Any other output port as may be required for the offered system.
 - Alarm status contact indicating healthy status of system
- J. These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BCUs/ BPUs/Numerical Relays/IEDs etc as per scope of the specification. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.
- K. The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24-hour mode) and have a separate time display, having display size of approx. 144mm height.

18. TECHNICAL SPECIFICATION FOR NETWORK FIREWALL

Offered firewall shall include but not limited to the following features-

Technical Requirements for Network Firewall		
S No	Feature	Required parameter
A	General	

TECHNICAL SPECIFICATIONS

A1	Common Criteria Certification.	The offered product series or its operating system series must have achieved EAL (Evaluation Assurance Level) Certification of EAL4 or higher in the Common Criteria for Information Technology Security Evaluation (ISO/IEC 15408) for computer security certification.
A2	Architecture	The firewall should be a purpose built hardware appliance based next generation firewall (NGFW) solution having application awareness & Intrusion prevention function.
A3	End of sale	OEM End-of-sale declaration shall not have been released for the offered model at the time of the bid submission.

B.	Hardware Specifications & Performance Parameters	
B1	Firewall Interfaces	Minimum Four or AS REQUIRED Nos of gigabit 10/100 base T Ethernet ports to be provided.
		Provision of addition of at least Two Nos of gigabit Fiber SFP ports shall be available.
		Each Port must be configurable flexibly in any security zone as per the requirement without any fixed zone assignments.
		All the above specified interfaces shall be firewall interfaces. Internal Switch interfaces shall not be considered.
		The Firewall shall NOT have any wireless interfaces.
B2	Security Zones	At least four Security zones must be supported.
C	Firewall Inspection	
C1	Application Support for Inspection	Should support standard protocols
		Internet based applications like Telnet, FTP, SMTP, http, DNS, ICMP etc. should be supported for filtering
		Internet web 2.0 applications & widgets.
		Dynamic NAT as well as one to one NAT
		Port / IP Address Forwarding

TECHNICAL SPECIFICATIONS

C2	NAT & PAT	PAT
C3	Resistance to Evasion	The firewall shall be able to detect and block evasion techniques including SYN flood, Address spoofing and TCP split handshake etc.
D	Application awareness	
D1	Application intelligence and control	Firewall should support detection of application regardless of port, protocol etc.
		firewall must identify and control applications sharing the same session
		The firewall should allow creation of securities policies to identify, allow, block or limit an application regardless of port, protocol etc.
E	Intrusion Prevention System (Integrated with firewall)	
E1	General	The IPS must provide intrusion prevention functionality out of the box.
		The IPS should be capable of accurately detecting intrusion attempts and discern between the various types and risk levels, including unauthorized access attempts, pre-attack probes, suspicious activity, vulnerability exploitation etc

		The IPS should provide protection from Advanced Botnets, inbound and outbound.
		The IPS should use stateful detection and prevention techniques and provide zero-day protection against worms, Trojans, spyware, keyloggers, and other malware from penetrating the network.
E2	Detection Methods	The offered solution should use the following methods for detection of malicious traffic:
		(a) Signature based detection
		(b) Statistical Anomaly based detection
E3	Threat Intelligence and signature Updates	The IPS OEM should have a 24x7 security service update and should support real time signature update of the system as soon as updates are released.

TECHNICAL SPECIFICATIONS

E4	Exception List	The IPS should support the creation of Access Control Lists to bypass the inspection of any specific flow.
E5	DoS/ DDoS protections	The offered solution should be capable of preventing Denial of Service and Distributed denial of service attacks.
E6	Threat control features	The offered solution should provide the following Security features:
		a) Detection and blocking malicious web traffic on any port.
		c) Capability of detecting attacks within protocols independent of port used
		d) IPS Sensor should allow the admin to create IPS policies on the basis of IP addresses and range.
E7	Signature Tuning	The offered solution should allow enabling/disabling of each individual signature. Each signature should allow granular tuning to suit user requirement.

TECHNICAL SPECIFICATIONS

B-11: INSTRUMENTATION AND COMMUNICATION CABLE

1. COMMUNICATION CABLE (Optic Fibre Cable)

Optic Fiber cable shall be 8/12 core, galvanized corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor /indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multimode fibers on as required basis so as to avoid the usage of any repeaters. 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.

The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. Steel central number, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile force of 1000 N minimum. The compressive strength of cable shall be 3000 N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 deg. C to 70 deg. C.

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

Bidder to ensure that minimum 50% (but not less 4) cores are kept as spare in all types of optical fiber cables

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

Spliced/ Repaired cables are not acceptable.

Penetration of water resistance and impact resistance shall be as per IEC standard.

A. Communication Cable (Modbus)

Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor based on VDE 0881. Cable shall have minimum 2 pair each with conductor size of 0.5 SQMM and core identification shall comply with DIN 47100. Cable shall be flame retardant according to IEC 60332-1-2. or equivalent Standard Surge protection device to be provided shall be approved from UL/CSA or any national/international approved lab.

2. INSTRUMENTATION CABLES

A. Common Requirement

TECHNICAL SPECIFICATIONS

S No.	Property	Requirement
1.	Voltage grade	225 V (peak value)
2.	Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification.
3.	Continuous operation suitability	At 70 deg. C for all types of cables
4.	Progressive automatic on-line sequential marking of length in meters	To be provided at every one meter on outer sheath.
5.	Marking to read 'FRLS	To be provided at every 5 meters on outer sheath
6.	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet
7.	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8.	Ovality at any cross-section	Not more than 1.0 mm
9.	Others	a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name, insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacturer to be provided. b) Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground-buried installation c) Repaired cables shall not be acceptable.
10.	Color	The outer sheath shall be of blue Blue

B. Specific Requirement

S No.	Property	Requirement
	Type of Cable	F and G Type cables

TECHNICAL SPECIFICATIONS

A. Conductors			
1.		Cross section area	0.5 sq. mm
2.		Conductor material	High conductivity Annealed bare copper
3.		Colour code	As per VDE-815
4.		Conductor Grade	Electrolytic
5.		No & dia of strands	7x0.3 mm (nom)
6.		No. of Pairs	4,8,12,16,24,48
7.		Max. conductor resistance per Km (in ohm) at 20 deg. C	73.4 (loop)
8.		Reference Standard	VDE 0815
B. Insulation			
1.		Material	Extruded PVC type YI 3
2.		Thickness in mm (Min/Nom/Max)	0.25/0.3/0.35
3.		Volume Resistivity (Min) in ohm-cm	1 x 10 ¹⁴ at 20 deg. C & 1x10 ¹¹ at 70 deg. C.
4.		Reference	VDE 0207 Part 4
5.		Core diameter above insulation	Suitable for cage clamp connector
C. Pairing & Twisting			
1.		Single layer of binder tape on each pair provided	Yes
2.		Bunch (Unit formation) for more than 4P	To be provided
3.		Conductor identification as per VDE081	To be provided
D. Shielding			
1.		Type of shielding	Al-Mylar tape
2.		Individual pair shielding	To be provided for F-type cabl

TECHNICAL SPECIFICATIONS

3.		Minimum thickness of Individual pair shielding	28 micron
4.		Overall cable assembly shielding	To be provided
5.		Minimum thickness of Overall cable assembly shielding	55 micron
6.		Coverage Overlapping	100% coverage with 20% overlapping
7.		Drain wire provided for individual shield	Yes (for F-type) Size=0.5 mm ² , No. of strands=7, Dia of strands =0.3 mm, Annealed Tin coated copper
8.		Drain wire provided for overall shield	Yes. Size=0.5 mm ² , No. of strands=7, Dia of strands=0.3mm Annealed Tin coated copper

E. FILLERS

1.		Non-hygrosopic, flame retardant	To be provided

F. Outer Sheath

1.		Material	Extruded PVC compound YM1 with FRLS properties
2.		Minimum Thickness at any point	1.8 mm
3.		Nominal Thick-ness at any point	>1.8 mm
4.		Resistant to water, fungus, termite & rodent attack	Required
5.		Minimum Oxygen index as per ASTM D-2863	29%
6.		Minimum Temperature index as per ASTM D-2863	250 deg.C

7.		Maximum acid gas generation by weight as per IEC-60754-1	20%

TECHNICAL SPECIFICATIONS

8.		Maximum Smoke Density Rating as per ASTMD-2843	Maximum 60% To be provided (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as per ASTMD-2843)
9.		Reference standard	VDE207 Part 5,VDE-0816
	G. Electrical Parameters		
1.		Mutual Capacitance Between Conductors At 0.8 Khz (Max.)	120 nF/km for F type 100 nF/km for G-type
2.		Insulation Resistance (Min.)	100 M Ohm/Km
3.		Cross Talk Figure (Min.) At 0.8 Khz	60 dB
4.		Characteristic Impedance (Max) At 1 Khz	320 OHM FOR F-TYPE 340 OHM FOR G-TYPE
5.		Attenuation Figure At 1 Khz (Max)	1.2 db/km
	H. Complete Cable		
1.		Complete Cable assembly	Shall pass Swedish Chimney test as per SEN-SS 4241475 class F3.
2.		Flammability	Shall pass flammability as per IEEE-383 read in conjunction to this specification
	I. Tests		
1.		Routine & Acceptance tests	Refer Type Test requirement of Specification for C & I System
2.		Type tests	
	J Cable Drum		

TECHNICAL SPECIFICATIONS

1.		Type	Wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.
2.		Outermost layer covered with waterproof paper	Yes
3.		Painting	Entire surface to be painted
4.		Length	1000 m + 5% for up to & including 12 pairs 500 m + 5% for above 12 pairs

TECHNICAL SPECIFICATIONS

B-12: EARTHING SYSTEM

1. GENERAL REQUIRMENTS

This specification is intended to outline the requirement of earthing (grounding) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of earthing system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthing system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

Earthing requirement for outdoor metering yard/Switchyard has been mentioned elsewhere in the specification and hence shall be excluded from scope of this chapter unless earthing requirement of metering yard/Switchyard is specifically mentioned in this chapter.

Electrical Resistivity Test (ERT) of the soil is included in the scope of bidder.

A. EARTHING DESIGN REQUIRMENT

The object of protective earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrences take place.

Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system.

B. CODES AND STANDARD

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IS: 3043	Code of practice for Earthing.
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding

TECHNICAL SPECIFICATIONS

IS: 2309	Code of Practice for the protection of building and allied structures against lightning.
IS: 802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 4736	Hot-dip Zinc coating for MS Tubes.
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
	CEA regulations for electrical safety-2010
	Indian Electricity Rules/ Indian Electricity Act.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

2. Earth Electrode

The earth electrode is in direct contact with the ground provides means for conducting earth current with ground. Earth Electrode material should have good electrical conductivity and mechanical strength and should not corrode in wide variety of soil conditions. For an effective earthing system, following type of vertical earth electrodes can be used.

TECHNICAL SPECIFICATIONS

I. MS Rods

Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm.

II. Copper Bonded Rods

High tensile-low carbon steel rod having diameter not less than 14/17 mm of Length 3000 mm to be selected based on earth fault current. The Rod shall comply with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more in conformity to UL-467. Its surface shall be clean, free from mechanical defect and any visible oxide layer or foreign material.

A. Earthing Enhancement Compound

A low resistance earth electrode system is important to provide a low impedance path for the better dissipation of lightning/fault currents, and to protect personnel and equipment by minimizing and equalizing voltage potential differences. Earthing (ground) enhancement materials shall be used to improve the ground electrode resistance. Earth enhancement material shall be a superior conductive material which improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It shall be tested and should conform to the requirements of IEC 62561-7. It shall have the following characteristics:-

- a) High conductivity, improves earth's absorbing power and humidity retention capability, non-corrosive in nature having low water solubility but highly hygroscopic.
- b) Carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties. Cement shall not mix separately & shall not have Bentonite.
- c) Resistivity of less than 0.2 ohms -meter.
- d) It shall not depend on the continuous presence of water to maintain its conductivity and shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.
- e) It shall not dissolve, decompose or leach out with time and shall be environmental friendly, suitable for soils of different resistivity and any kind of earth electrode.

The Earth enhancement material shall be supplied in sealed, moisture proof bags, marked with Manufacturer's name or trade name, quantity etc. The minimum quantity of earth enhancement compound to be used with each earth-pit shall be 25 Kg.

B. Earthing conductor

Earthing conductor is the conductor for buried below the ground at the depth of 600 mm connecting earth pits to make interconnection of earth pit. To interconnect earth

TECHNICAL SPECIFICATIONS

pits, following type of conductor can be used. Application of specific conductor and its size has been mentioned in relevant clause:

I. Galvanised Steel Flat (GS) Flat

GS/GI Flat (Strip) conductor shall comply to IS 2026 with Galvanization of 85 Micron as per IS. Material shall be clean and free from mechanical defects.

II. Copper Clad Steel (CCS) Earthing Conductor

The Copper Bonded Steel Grounding Conductor shall be made of steel with the coating of 99.99% pure copper complying to ASTM B 869-96 and ASTM B 452-93 standards. Each strand of CCS shall have continuous, uniform coating and the conductor surface shall be smooth and free from mechanical defects.

III. MS Rod

Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm and diameter of 40 mm.

C. Earthing Technical and Installation Requirement

Careful consideration should be given to installing an earthing system that meet or exceed statutory requirements. Contractor shall select certified product and ensure good workmanship for installation for satisfactory performance to fulfill the designed parameters all the times. Following care shall be taken while installation of earthing.

- I. Metallic frame/ structure of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armor of multi-core cables shall be earthed at both ends. Metallic Sheaths and armor of single core cables shall be earthed as per requirement mentioned elsewhere in the specification. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable. Metallic column for Inverter/Switchgear shelter/E-house shall be earthed with two distinct connections at minimum two column. All the wall cladding section shall be earthed at minimum two location with flexible copper cable of not less than 50 sq. mm.
- II. Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points

TECHNICAL SPECIFICATIONS

shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.

- III. Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.
- IV. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.
- V. Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti- corrosive paint/compound.
- VI. Suitable earth risers as approved shall be provided above finished floor/ground level, if the equipment is not available at the time of laying of main earth conductor.
- VII. Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding. Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.
- VIII. Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.
- IX. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.
- X. A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same. Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively.
- XI. Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded preferably below permanent moisture level. Minimum spacing between electrodes shall be 600mm.
- XII. Earth pits shall be treated with earth enhancement compound if resistivity is more than 20 ohm meter.

TECHNICAL SPECIFICATIONS

- XIII. 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. All equipment required for testing shall be furnished by contractor.
- XIV. Contractor shall obtain all necessary statutory approvals for the earthing system before charging of the plant and electrical equipment.

3. TECHNICAL DETAILS FOR AC EARTHING SYSTEM

This section outlines the requirements of protective and functional earthing system to discharge AC fault current to earth and provide equipotential bonding for Transformer, HT and LT Switchgear Panel and other similar electrical equipment, Transformer neutral and shield.

The Contractor shall furnish the detailed design and calculations as per IEEE 80/IS 3043 for Employer's approval for equipment earthing.

1. Conductors above ground level and in built up trenches -Galvanized steel
2. Conductors buried in earth -Mild steel rod of 40 mm dia
(Any alternate proposal by bidder shall be reviewed and decided during detailed engineering based on requirement)
3. Earth electrodes- Mild steel rod of diameter 40mm or Copper bonded steel rod of dia not less than 17 mm
4. Life Expectancy - 25 years
5. Fault Level - Mentioned Elsewhere
6. Min. Steel corrosion - As per IS 3043
7. Soil Resistivity -Actual as per site condition

The sizes of earthing conductors for various electrical equipment shall be as below:

S No.	Equipment	Earth Conductor Buried in Earth	Earth conductor above ground level and in built up trenches
1	33kV/11kV/6.6kV/3.3 kV/ switchgear equipment and 415V switchgear	--	65 x 8mm GS flat
2	415 V MCC/ Distribution boards / Transformers	--	50 x 6mm GS flat
3	LT Motors above 125 KW	--	50 x 6mm GS flat

TECHNICAL SPECIFICATIONS

4	LT Motors 25 KW to 125 KW	--	25 x 6mm GS flat
5	LT Motors 1 KW to 25 KW	--	25 x 3mm GS flat
6	Fractional House power motor	--	8 SWG GS wire
7	Control panel & control desk	--	25 x 3 mm GS flat/25 sq mm Cu cable
8	Push button station/Junction Box	--	8 SWG GI wire
9	Columns, structures, cable trays and bus ducts enclosures	--	50 x 6mm GS flat
10	Crane, rails, rail tracks & Other non-current carrying metal parts	--	25 x 6mm GS flat

A. Contractor shall ensure there at least two earth pits each dedicated for earthing of each Transformer, HT/LT Switchgear panel, transformer neutral, Battery Charger/UPS/Control Panel etc. shall be provided. Earth electrode shall be located near to the equipment and all earth electrodes shall be interconnected with parallel conductor buried in earth surrounding the equipment.

B. Earthing system of different locations such as Inverter room/Pooling Switchgear/Sub pooling switchgear/Inverter shelter etc. shall be interconnected in single network of earthing with buried conductor of the size 65X8 MS Flat laid at 600 mm depth (if specifically required to achieve the earth resistance value within the acceptable limit based on the soil property of site). Contractor shall submit the calculation based on the system of earth conductor and electrode connected in single network. Location and manner of interconnection shall be approved during detail engineering.

Bidder shall also interconnect the earthing system of Solar PV plant with Owner/ Company existing earthing system wherever available (applicable for Solar Projects being setup inside existing Owner/ Company Projects).

C. For functional earthing of electronic component such as SCADA, contractor shall provide 1 no. (Min) isolated earth electrode near to the equipment connected with 2 run of copper cable of size not less than 25 sqmm. Contractor shall comply to the recommendation of OEM (Original Equipment Manufacturer) for electronic earthing and electrode can be connected with other earth electrode as per recommendation of OEM.

D. Each inverter duty transformer having shield between HV and LV winding shall be provided with 2 nos. Isolated earth electrode connected with each other for

TECHNICAL SPECIFICATIONS

functional earthing of transformer shield. Each electrode shall be connected with transformer shield with separate 25X6 Cu flat. .

4.0 TECHNICAL DETAIL SOLAR ARRAY (DC) EARTHING

This section outlines the earthing requirement for discharging DC fault current to earth of Solar PV plant and provide equipotential bonding for Module Mounting Structure (MMS), SMB Mounting structure, Module Frames etc.

System Requirement for the solar array DC earthing:

Conductors buried in earth -GS

Flat or CCS Conductors above ground level

-GS

Flat or CCS

Earth Electrode -32 mm or higher dia MS Rod or Copper bonded
Steel rod

of dia. not less than 14 mm

Life Expectancy -25 Years

System fault level -5 KA for 1 Sec.

Soil resistivity -Actual as per site conditions

Min. Steel corrosion -As per IS 3043

- A. Each Module mounting structure (MMS), SPV Module frames, mounting arrangement for String Monitoring Boxes, Metallic Junction Boxes, Metal frames/Panel, Metallic Pipes of the solar array shall be effectively earthed by two separate and distinct connections to earthing system. Earthing system for solar array shall consist interconnected earth pits' electrodes connected by 25X6 GS flat (Min.) or Copper Clad Steel (CCS) earthing Conductor of size not less than 120 SQMM laid at the depth of 600 MM below the ground. Minimum size of riser conductor to connect the structures to buried earthing conductor and structure to structure in the solar farm shall be 25X3 GS Flat or CCS of Min. 70 SQ MM size.
- B. Periphery fencing wherever provided shall be earthed at every 100 meter interval with 25X3 GS flat connected with DC or AC side nearest buried earthing conductor.
- C. Earthing conductor for connection to structure and equipment may be kept on the ground below MMS. However, these conductor shall be laid 300 mm below the ground along the pathway and/or crossing the pathway.
- D. Equipment and structure in the solar farm shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.
- E. The Contractor shall furnish the detailed design and calculations for Owner's approval as per IS 3043 to determine the number of earth pit and size of earth conductor. However the no. of earth pit electrodes for the DC earthing shall be as per Chapter A-4, Part A.

TECHNICAL SPECIFICATIONS

- F. Buried earth conductor shall be laid all around periphery of solar array farm. GS flat above the ground for structure earthing shall be connected to the nearest buried conductor or electrode. All the earth electrodes shall be interconnected in single network/mesh and no electrode or group of electrodes shall be isolated/islanded. These electrodes shall be uniformly distributed in the solar farm at maximum practical extent and location of earth electrode shall be approved during detail engineering. A continuous earth path is to be maintained throughout the PV array.
- G. Connection of DC earthing system and AC earthing system with location and manner of connection shall be approved during detail engineering. Contractor shall submit the design calculation of earthing system of AC and DC side as standalone (no interconnection) system.
- H. Connection of riser to the structures shall be bolted or welded type. Portion of galvanized structure which undergoes welding at site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterwards.
- I. Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection, welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding.
- J. Each PV Module frame shall be earthed in accordance with module manufacturer guidelines. In case module frame earthing is to be separately provided, it shall be earthed with minimum 2.5 SQMM flexible copper cables with lug at suitable location of module frame. Nos. of PV modules in single loop of earthing connection to module frame shall be as per Module manufacturer recommendation. Both ends of the loop of copper cable for earthing shall be connected with nearest earthed structure or earth conductor.
- K. Contractor shall seek owner's approval for connecting solar array earth mesh with any other earth mat/earth grid of the solar PV plant.
- L. Size of earth conductor, nos. of earth pits given in this clause is applicable for solar array earthing only. Relevant method and practice of laying of earthing conductor, earth pits and riser not mentioned herewith but given elsewhere in this specification is applicable to solar array earthing also.
- M. Inverter functional earthing (Negative earthing, Anti PID Earthing) shall be carried out as per guideline of OEM. Contractor shall submit complete detail of such earthing from OEM and implement the earthing accordingly

5.0 TECHNICAL SPECIFICATION FOR MAINTENANCE FREE EARTHING SYSTEM:

S.No		Description
1.		COPPER BONDED EARTH RODS
	1.1	The Earth Rods shall have a nominal (actual) dia of 17.2 mm and Length of 10'(3 M). The Rods shall have a steel core with molecular bonding Of 250 micron of copper as per ANSI/UL 467,CSA-CS22.2 No. 41

TECHNICAL SPECIFICATIONS

1.2	The core used shall be 1018 steel cold drawn with tensile strength of min. 80000 psi.
1.3	A nickel layer is applied to steel core (and subsequently copper) by an Electrolytic process forming a metallurgical bond between the three. The copper used shall be rated at 99.95% Copper. The thickness of copper layer shall be uniform 0.010" (250 micron) throughout the rod length.
1.4	The Earth Rod shall be UL (Under writers Laboratory) listed and should have the UL mark, with UL Code Number, Company Name & Part Number. The Life Expectancy of Copper Bonding must be guaranteed for more than 35 Years.
1.5	The Rods should be manufactured by a company of high reputation to ensure Quality of Copper Bonding. Having a Minimum Experience of 20 years.
1.6	The Ground Rod must be able to disperse/handle 42 KA, the bidder to Provide necessary test certificate from approved Laboratory.
1.7	The Ground Rod must have passed the Bend Test for a minimum of 70 Degree bend.
1.8	The Ground Rod Must be compliant to EN-50164-2:2008.
1.9	The Ground Rod Must be compliant to IEC-EN 62561-2:2018 & IS 1772
2.	GROUND ENHANCEMENT MATERIAL-GEM(25 A)
2.1	GROUND ENHANCEMENT MATERIAL-GEM (25 A) shall be permanent and maintenance free (no Re-Charging with Salts or any other Chemicals) and shall maintain its earth resistance with time.
2.2	It must set up firmly and should not dissolve or decompose or otherwise pollute the soil or local water table.
2.3	GROUND ENHANCEMENT MATERIAL-GEM(25 A) must be suitable for use in dry form or slurry form.
2.4	The GROUND ENHANCEMENT MATERIAL-GEM(25 A) shall not depend on the continuous Presence of water to maintain its conductivity. It shall not require any periodic Charging treatment or replacement.

TECHNICAL SPECIFICATIONS

B-13: PLANT ILLUMINATION SYSTEM

This chapter covers supply and installation of suitable illumination system along the approach roads to inverter room and inverter room(s), transformer yard and other facilities inside the plant.

1. DESIGN PHILOSOPHY

A comprehensive illumination system shall be provided in the entire project. Each building shall be provided with adequate light fittings, 6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room, etc

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.

2. LIGHTING SYSTEM DESCRIPTION for CMCS and inverter room

Normal AC Lighting System: AC lighting system 415V, 3Phase, 4wire, will be fed from lighting panels Control Board (LPs) which in turn will be fed from the lighting distribution boards (LDBs) of AC Switch board MCC.

Emergency AC Lightning System: The emergency lighting system consisting of 20% of the lights shall be fed from UPS DB or DCDB as per scheme adopted by the EPC bidder. Load of the same has to be considered for UPS/ Battery and charger sizing. Bidder shall provide indoor and outdoor emergency lighting at each inverter room, CMCS, security room and main gate.

3. Lighting Fixture, Lamps & Accessories

- a. All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site.
- b. AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of +/-10%, frequency variation of +/- 5% and combined voltage and frequency variation (absolute sum) of 10% DC lighting fixtures and accessories shall be suitable for operation on 220 V, with variation between 190 V & 240 V.

All lighting fixtures shall be complete with lamp(s), lamp holder(s), LED chip assembly, terminal blocks, clamps, locking arrangements, fixing brackets etc. Driver circuit/Control gears shall be provided as applicable / specified. The fixtures shall be fully wired upto terminal block. The internal wiring of the fixtures shall be done with suitable low smoke halogen free thermo-plastic or silicon rubber insulated or fire retardant PTFE copper conductor wires of suitable size and type. Further fuse protection of suitable rating in input side shall also be provided specifically for LED luminaires. However, the normal cross section of conductor shall be not less than 0.5 Sq. mm and minimum thickness of insulation shall be 0.6 mm. The wiring shall be capable of withstanding the maximum temperature to which it will be subjected under

TECHNICAL SPECIFICATIONS

- specified service conditions without deterioration and affecting the safety of the luminaire when installed and connected to the supply. All fixing /locking screws, washers, nuts, brackets, studs etc, shall be zinc plated and passivated.
- d. All lighting fixtures shall be provided with an external, brass/GI earthing terminal suitable for connecting 14 SWG, GI earthing wire. All metal or metal enclosed parts of the housing and accessories shall be bonded and connected to the earthing terminal as so to ensure satisfactory earthing continuity throughout the fixture
 - e. The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection
 - f. The reflectors shall be manufactured from CRCA sheet steel or aluminium as specified. The aluminium reflectors shall be made of high purity aluminium sheet, polished electrochemically brightened and anodized or proven alternate arrangement of anodizing
 - g. Starters shall have bi-metal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without use of any tool. Starter shall have brass contacts and radio interference suppressing capacitor.
 - h. LED luminaires body shall such designed that heat sink/heat dissipating housing shall be mounted outside the overall luminaires fixture housing, and shall be suitably clearing the driver circuit. Further for outdoor type LED luminaires, the exposed heat sink shall be suitably designed to avoid dust/foreign particles accumulation on the same.
 - i. LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified along with finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere.

4. LED Luminaires:

A. CODES AND STANDARDS

All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of techno-commercial bid opening. In case of conflict between this specification and those (IS codes, standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards & codes.

16101:2012	General Lighting. LEDs and LED modules Terms and definitions
16102(Part 1):2012	Self Ballasted LED Lamps for General Lighting Services. Part-1 Safety Requirements.
16102(Part 2):2012	Self Ballasted LED Lamps for General

TECHNICAL SPECIFICATIONS

	lighting Services.
	Part-2 Performance Requirements.
16103(Part I):2012 Requirements.	LED modules for General lighting Safety
15885(Part 2/Sec. 13):	2012Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules
16104:2012	d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements.
16105:2012	Method of Measurement of Lumen maintenance of Solid- state Light (LED) Sources.
16106:2012	Method of Electrical and photometric Measurements of Solid-State Lighting (LED) Products
16107:2012	Luminaire Performance
16108:2012	Photobiological safety of Lamps and Lamp Systems
IS 513	Cold rolled low carbon steel sheets and strips
IS 12063	Classification of degree of protection provided by enclosures.
IS 14700 – Limits (Part 3/Sec. 2) < 15%	Electromagnetic compatibility (EMC) for Harmonic emission – THD (equipment, input current < 16 Amps. per phase.
IS 9000 (Part 6)	Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
IS 15885 requirements for (Part 2/Sec. 13) DC or AC supplied electronic control gear	Lamp control gear: particular for LED modules.
IS 16004 – 1 and 2)	for LED modules.
IS 4905	Method for random sampling
IEC 60598	Ingress protection, luminaire performance and safety
IEC 61000-3-2	Total Harmonic Distortion
IEC 61000-4-5	Surge Protection

TECHNICAL SPECIFICATIONS

IES-LM 80 along with Lumen Depreciation and Rated life of LED chip TM 21/ IS 16105

IES-LM 79/ IS 16106 Luminaire optics and color parameter and electrical parameter

B. LED LIGHTING SYSTEM

LED Luminaires shall be used for the lighting of all the indoor & outdoor areas. However, for DC lighting & hazardous areas conventional type luminaires shall be used. In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

The individual lamp wattage for LED shall be upto 3 watt for outdoor type luminaires. However, for indoor type luminaires fractional wattage LEDs are also acceptable. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall not be less than 80 Lm/W. Heat sink/heat dissipation arrangement shall be provided in the luminaires. The LED used in the luminaires shall have colour rendering index (CRI) of Min 70 and 80 for outdoor and indoor luminaires respectively.

Colour designation of LED shall be “cool day light” (min 5700K) type for indoor type LED luminaires. Further for outdoor type luminaires, the colour designation shall be 5000K, except for well glass type LED luminaires, where the colour designation shall be 4000K. The LED luminaires shall have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life.

The beam angle for LED chip for indoor type luminaires shall be 120 degrees. However for highbay & flood light type outdoor luminaires the LED chip with suitable beam angle shall be used to deliver better lumen-output. The maximum junction temperature of bare LED without heat sink shall be limited to 85 deg C, further the lumen maintenance at this temperature shall be min 90%. The THD of tube light based LED Luminaires shall be less than 20%. For other type of luminaries, it shall be minimum 10%.

Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink/ heat dissipation arrangement, with proper thermal management shall be designed for the luminaires.

Driver Circuit: LED modules and drivers shall be compatible to each other. The LED module driver's ratings and makes shall be as recommended by corresponding LED manufacturer.

LED Drivers may have following control & protections: -

- Suitable precision current control of LED.
- Open Circuit Protection
- Short Circuit Protection
- Over Temperature Protection
- Overload Protection
- Surge Protection

TECHNICAL SPECIFICATIONS

Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have IP55 degree of protection (for outdoor panels) and IP-4X for indoor panels (inside buildings).

Wires of different phase shall normally run in separate conduit.

Power supply shall be fed from 415 / 240 V normal AC supply through suitable number of conveniently located lighting distribution boards (LDB) and at least one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc.

Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location.

Incandescent lamps may be used only with DC Lighting.

Electrification of all building shall be carried out as per IS 732-1989, IS 4648-1968 and other relevant standards.

Indoor Lighting fixtures shall generally be controlled from switch boxes of each area not directly from lighting panel. Each switch shall control a maximum of three fixtures.

All luminaires and their accessories and components shall be of type readily replaceable by available Indian makes.

Following test reports to be submitted for LED chip/LED luminaires:

- a. LED parameters like Lumen per watt, CRI, Beam angle from manufacturer.
- b. LM 80/IS: 16105 report.
- c. LM 79/IS: 16106 report

5. JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES

Junction box for indoor lighting shall be made of fire-retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.

Junction boxes for street lighting poles and lighting mast if applicable, shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.

All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.

Conduits, Pipes and Accessories:

Heavy duty PVC conduits conforming to IS: 9537 Part-III along with various accessories shall be used for indoor wiring in the buildings. These conduits shall be concealed in the wall/floor/roof. However, in PEB's, conduits can be fixed on surface.

Pull out boxes shall be provided at suitable interval in a conduit run. Boxes shall be suitable for mounting on Walls, Columns, etc. Pull-out boxes shall have cover with screw. Pull out boxes used outdoor shall be weather proof type suitable for IP:

1

TECHNICAL SPECIFICATIONS

55 degree of protection and those used indoor shall be suitable for IP: 4X degree of protection.

6. LIGHTING WIRES

Lighting wires shall be 1100 V grade, light duty PVC insulated unsheathed, stranded copper/aluminium wire for fixed wiring installation. colour of the PVC insulation of wires shall be Red, Yellow, Blue and Black for R,Y,B phases & neutral, respectively and white & grey for DC positive & DC negative circuits, respectively. Minimum size of wire shall not be less than 1.5.sq.mm. for copper

7. LIGHTING POLES

The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. Height of the poles should be chosen so as not to affect working of Solar panels. The poles shall be FRP based confirming to AASHTO LTS-4-12, 2013, IS 2713- 1980, ANSI C136.20 2012 and tested as per relevant ASTM standards. The FRP poles shall be ultraviolet resistance, corrosion proof, electrically insulated and shall have no reaction to direct contact with water. They shall be fire retardant with low flammability when tested in accordance to IS 6746. The thickness for any FRP Poles shall be $\geq 6\text{mm}$ & there should be no negative tolerance in thickness. Poles shall be highly resistant to impact deflection and bending, and shall be electrically non-conductive. The System shall be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.

The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB. Lighting shall be provided along boundary/periphery and at roads connecting Boundary Gate to strategic locations like CMCS/Switchyard

For internal roads, lighting may be provided at intermediary locations as per bidders O&M practices

8. EARTHING

Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends.

Alternately Vendor may offer technically superior and proven product subject to approval of employer.

9. AVERAGE ILLUMINATION LEVEL

Location	Average Illumination Level (Lux)	Type of Fixture
Control Room	300	LED Luminaries

TECHNICAL SPECIFICATIONS

Store Room	200	LED Luminaries
Switchgear Room, HT Breaker Room	150	LED Luminaries
Inverter Room	150	LED Luminaries
Street lighting- Roads mentioned in Cl 7.0 above	10	LED Luminaries
Yard/ Substation	20 (general) 50 (on strategic equipment)	LED Luminaries

TECHNICAL SPECIFICATIONS

B-14: AUXILIARY POWER SUPPLY SYSTEM

1. GENERAL

A. Auxiliary power supply arrangement shall be in line with tender SLD. Each Inverter Room/local pooling/sub-pooling/CMCS room shall have its own auxiliary power supply system comprising of AC distribution board (ACDB) which shall be fed from LV side of Inverter transformer through suitably rated auxiliary transformers. ACDB in CMCS room shall have two incomers (100% rated) fed from two different sources. At CMCS, auxiliary transformer directly feed from 33kV switchgear are also acceptable. Following consideration shall be taken while arriving kVA capacity of auxiliary transformer,

20 % future load margin.

The minimum kVA capacity of auxiliary transformer for CMCS requirement shall be 50kVA.

B. All non-critical auxiliary loads shall be fed directly from ACDB. However, emergency, and important load shall be fed from suitable sized Uninterrupted Power Supply (UPS) or Battery system. Input AC supply for Uninterrupted Power Supply (UPS) and Battery Charger shall be fed from ACDB. Bidder shall consider the following one of the supply options for feeding different equipment loads:

Sl No	Equipment Name	Option - 1 ACDB	Option-2 UPS AC	Option-3 Battery DC supply
1.	SCADA including remote RTU/IO panel		☐	☐
2.	SCADA HMI		☐	☐
3.	Data logger		☐	☐
4.	Fire Detection /Alarm Panel		☐	☐
5.	Emergency Lighting		☐	☐
6.	CCTV (if applicable)		☐	☐
7.	HMI of SCADA		☐	☐
8.	Inverter's Auxiliary supply (if applicable)		☐	☐
9.	Energy Meter/MFM		☐	☐
10.	Sub and Local Pooling Switchgear control & protection		☐	☐
11.	Main Pooling Switchgear (CMCS) control & protection			☐
12.	Switchgear spring charging motor		☐	☐

TECHNICAL SPECIFICATIONS

13.	switchgear space heater	☐		
14.	Illumination, Fan supply etc	☐		
15.	Module washing system	☐		
16.	Other non-critical auxiliary loads	☐		
17.	Switchyard control and protection			☐
18.	Switchyard PLCC			☐

- C. For inverter stations and sub-pooling systems, UPS system shall comprise of 1 x 100% UPS with 30 minutes backup. For CMCS, UPS system shall comprise of 2 x 100% UPS with 30 minutes backup for each. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing required backup as above. Bypass Line static switch, manual bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories. In place of UPS, bidder can provide DC supply system (1 x 100% Battery with Charger system for inverter stations/sub-pooling systems and 2x 100% system for CMCS) with backup as indicated as above, if the auxiliary power supply requirement of the loads is in DC.
- D. Each Battery with charger system shall consist of 1 x 100% charger and 1 x 100% Battery bank for required back up and 1 x 100% DCDB, and other necessary protective devices and accessories. DC supply system voltage shall be 12V or above upto 220V DC.
- E. The rated AC output capacity shall be taken for UPS battery size calculation. However, the minimum UPS rating shall be 2KVA and the battery sizing shall be calculated on a minimum load of 1 KW (DC) for required backup. All UPS having rating 5KVA or more shall have three phase input.
- F. The Bidder can provide alternate arrangement with suitable redundancies such as power pack with required backup for switchgears/RMUs located at local pooling/inverter station.
- G. Solar Plant Main Pooling Switchgear shall be powered from 2X100% DC supply system. Each DC supply system shall consist of 1x100% charger, 1 x 100% station Battery bank rated 110V/220VDC (+10%,-20%) for providing minimum 30 minutes backup and DC switchgear. In case UPS fed from above DC supply system, in that case separate DC system for UPS is not required.
- H. Requirements of DC supply system for switchyard is mentioned in switchyard chapter. Bidder can offer common DC system for both switchyard and CMCS, but their individual requirements must be met.
- I. For CMCS, each UPSDB shall have two incomers fed from two separate UPS and one bus coupler. Similarly, each DCDB/DC switchgear shall have two incomers fed from two separate Battery-Charger and one bus-coupler.
- J. DC system shall be design in such way that it is possible isolate the battery and charger for boost charging of batteries, while corresponding DC switchgear section shall be

TECHNICAL SPECIFICATIONS

capable of being in service and continue to supply the DC load by closing of bus coupler.

- K. Bidder shall submit configuration diagram, power supply distribution scheme, single line diagram and data sheets, all calculations such as Rectifier Modules/UPS Charger/Inverter rating calculations, battery sizing calculation etc. for UPS, Battery Charger & Battery system during detailed engineering stage for employer's review and approval.
- L. Size and rating of UPS, Battery Charger and Battery shall be finalized during details engineering stage. Following shall be considered for sizing calculation;
 - i. UPS load power factor shall be taken as 0.8 lagging.
 - ii. UPS efficiency shall be taken as 80%.
 - iii. UPS and charger design margin shall be taken 10% at 50 deg C.
 - iv. IEEE-485 standard shall be followed for sizing calculation of Lead Acid Batteries and IEEE-1115 standard shall be followed for sizing calculation of Nickel- Cadmium batteries.
 - v. For Battery sizing calculation, lowest electrolyte temperature shall be taken as 5 deg C more than the minimum ambient temperature or 15 deg cel whichever is lower, with Temperature correction factors as per relevant standards.
 - vi. Batteries aging factor shall be taken as 1.25 and design margin factor shall be taken as 1.10.

2. UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

- A. The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150
- B. % rated capacity for 10 seconds. The overall efficiency of UPS shall be at least 80% on full load.
- C. The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.
- D. For UPS capacity 5 kVA or more, in addition to indications/display on UPS panel, important alarms along with important analog signal shall also be provided for use in SCADA. For UPS capacity less than 5 kVA bidder shall provide status, common alarm, and trip DI (soft or hard) signal to SCADA
- E. The UPS chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates. The charger should be capable to fully charge the required batteries as well as supply the full rated load through inverter. The charger shall be able to re-charge the fully discharge battery within 8 hours. The

TECHNICAL SPECIFICATIONS

charger shall be design for input supply variation of $\pm 10\%$ and frequency variation of $\pm 5\%$. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The detailed specification for the battery charger for UPS rating of 5kVA and above has been mentioned in the battery charger section below in this specification.

- F. The UPS inverter shall be of continuous duty, solid state type using proven Pulse Width Modulation (PWM)/Quasi square wave/step wave technique. Ferro-resonant types Inverters are not acceptable. The nominal voltage output shall be 230 Volts single phase, 50 Hz. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, etc. The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum.
- G. The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from faulty inverter to standby AC source. Manual bypass switch shall be employed for isolating the UPS during maintenance.
- H. Contractor has the option of supplying either Nickel Cadmium type batteries or Lead Acid Plante type batteries. The detailed specification for the batteries has been mentioned in the battery and charger section below in this specification.
- I. Equipment enclosures shall match and line up in assemblies of freestanding floor mounted cabinets designed for indoor service.
- J. Individual enclosure shall be ventilated switchboard type fabricated from not less than 1.6- mm thick sheet steel. Enclosures shall be furnished with concealed hinges. Front and rear doors shall be designed to permit easy access to all components for maintenance or replacement. The enclosures shall be reinforced with formed steel members as required to form a rigid self-supporting structure. Doors shall have three-point latches.
- K. Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings.
- L. The cabinets shall be IP-42 protection class for indoor application and IP55 or better for outdoor application.
- M. The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.
- N. The Contractor shall also carry out the site tests on UPS as required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.
- O. One set of tools shall be provided for maintenance and testing purposes.

3. BATTERY CHARGER

- A. The chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates, effective current limiting features and filters to

TECHNICAL SPECIFICATIONS

minimise harmonics. The charger should be capable to fully charge the required batteries as well as supply the full rated load. Furthermore, the charger should be able to re-charge the fully discharged battery within 8 hours. The charger shall be current limited for charger circuit protection and protection of battery from overcharge shall also be provided. The current limit shall be continuously adjustable. The chargers shall have a slow walk-in circuit. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The charger shall be design for input supply voltage variation of $\pm 10\%$ and frequency variation of $\pm 5\%$.

- B. Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle or Boost charging.
- C. All Battery Chargers 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. Means shall be provided to avoid current/ voltage surges of harmful magnitude/nature which may arise during changeover from Auto to Manual mode or vice-versa under normal operating condition.
- D. Soft start feature shall be provided to build up the voltage to the set value slowly. The chargers shall have load limiters 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 characteristic shall be such that any sustained overload or short circuit in DC system shall neither 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. After clearance of fault, the Charger voltage shall build up automatically when working in automatic mode.
- E. When on automatic control mode during Trickle charging, the Charger output voltage shall remain within $\pm 1\%$ of the set value for AC input voltage variation of $\pm 10\%$, frequency variation of $\pm 5\%$, a combined voltage and frequency (absolute sum) variation of 10% and a continuous DC load variation from zero to full load. 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 Trickle charging output range specified & shall be capable of matching the float voltage correction recommendations (w.r.t. temperature) as suggested by the respective battery manufacturer. Step-less adjustment of the load limiter setting shall also be possible from 80% to 100% of the rated output current for Trickle charging mode.
- F. During Boost charging, the Battery Chargers 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

TECHNICAL SPECIFICATIONS

limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be Vernier type.

- G. Energizing the Charger with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere, shall be less than fifteen seconds.
- H. Momentary output voltage of the Charger, without the Battery connected shall be within 94% to 106% of the voltage setting during sudden load Change from 100% to 20% of full load or vice-versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above-mentioned change.
- I. Suitable filter circuits shall be provided in all the Chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.
- J. The DC System shall be ungrounded and float with respect to the ground potential when healthy. An earth fault relay shall be provided by the bidder in the DC distribution board for remote annunciation.
- K. Digital Outputs shall be configured for connection to the SCADA for real-time charger status updating. Outputs like charger output current, output voltage, float/boost mode, etc may be configured to provide the update to SCADA.
- L. The Battery Chargers as well as their automatic regulators shall be of static type. The Chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50°C.
- M. For Lead Acid plante battery:-Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC lead-acid Batteries while supplying the D.C. loads. The Batteries shall be Trickle charged at 2.25 Volts per cell. All chargers shall also be capable of Boost charging the associated D.C. Battery at 2.3 to 2.7 Volts per cell at the desired rate.
- N. For Nickel-Cadmium battery:-Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC Nickel- Cadmium Batteries while supplying the D.C. loads. The Batteries shall be Trickle charged at 1.4 to 1.42 Volts per cell. All chargers shall be capable of Boost Charging the associated D.C. Battery at 1.54 to 1.7 Volts per cell at the desired rate.
- O. All Battery Chargers 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.
- P. The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective Charger.

TECHNICAL SPECIFICATIONS

- Q. Digital or analog indicating instruments shall indicate DC current, DC voltage & AC voltage.
- R. The Chargers shall be indoor, floor mounted, self-supporting sheet metal enclosed cubicle type. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The Charger shall be fabricated using cold rolled sheet steel shall not be less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied by the Contractor. The Charger shall be tropicalized and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The Chargers shall have hinged double leaf doors provided on front and/or backside for adequate access to the Charger internals. All the Charger cubicle doors shall be properly earthed.
- S. Treatment as per IS: 6005. Two coats of lead oxide primer followed by powder painting with final shade of RAL9002 for complete panel except end covers & RAL 5012 for end covers.
- T. All acceptance and routine tests as per the manufacture recommendations and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. An indicative list of tests / checks is mentioned in QA chapter on Battery charger. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
- U. The cabinets shall be IP-42 protection class for indoor application and IP55 or better for outdoor application.
- V. The Contractor shall also carry out the site tests on battery charger systems required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.

4. BATTERY: NICKEL-CADMIUM BATTERY

A. BATTERY PARAMETER

a)	Battery Voltage	To be decide during Detail Engineering
b)	No. of Cells	To be decide during Detail Engineering
c)	Battery type	Nickel-Cadmium

TECHNICAL SPECIFICATIONS

d)	Nominal discharge voltage per Cell	1.2
e)	Float voltage	1.42V/Cell

Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

B. CODES AND STANDARDS

- A. All standards, specifications and codes of practice referred to herein, shall be the latest editions including all applicable official amendments and revisions as on date of opening of techno-commercial bid. In case of conflict between this specification and those (IS codes, Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:

IEC 60623/ IS 10918	Specification for vented type Nickel Cadmium Batteries.
IS 106	Quality tolerances for water for storage batteries
IEC 60993	Electrolyte for vented Nickel-Cadmium cells
Indian electricity rules	
Indian electricity acts	

- B. Equipment complying with other internationally accepted standards such as IEC., BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.
- C. DC Batteries shall be stationary Nickel Cadmium Pocket plate type conforming to IS:10918. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.
- D. DC batteries shall be suitable for standby duty. The batteries shall normally be permanently connected to the load in parallel with a charger and shall supply

TECHNICAL SPECIFICATIONS

the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

C. Construction Features: -

a) Containers

Containers shall be made of polypropylene plastic material. Containers shall be robust, heat resistance, leak proof, nonabsorbent, alkali resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of translucent containers.

b) Vent Plugs

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition, the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS:10918. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminal posts shall be clearly marked.

d) Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

e) Electrolyte

The electrolyte shall be prepared from battery grade potassium hydroxide conforming to IEC 60993. The cells can be shipped either in charged condition or in dry condition. Necessary electrolyte for make-up shall be supplied separately.

f) Connectors and Fasteners

Nickel plated copper connectors shall be used for connecting adjacent cells and PVC insulated flexible copper cables shall be used for inter-row / inter-tier / inter-bank connections. Bolts, nuts and washers shall be Stainless Steel / Nickel coated steel to prevent corrosion. The thickness of Nickel coating of connectors should be not less than 0.02 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds.

TECHNICAL SPECIFICATIONS

g) Battery racks

Mild steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

h) Test

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146(for all applicable tests for containers) / IS-10918 (for NI-CD batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery. Charges for these shall be deemed to be included in the equipment price. An indicative lists of tests / checks is mentioned in QA chapter on Battery. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

5. BATTERY: LEAD –ACID PLANTE BATTERY

A. BATTERY PARAMETER

a)	Battery Voltage	To be decide during Detail Engineering
b)	No. of Cells	To be decide during Detail Engineering
c)	Battery type	Stationary Lead Acid Plante
d)	Nominal discharge voltage per cell	2.0V
e)	Float Voltage	2.25V/Cell

B. CODES AND STANDARDS

IEC 60896	Stationary Lead-Acid Batteries
IS : 266	Specification for sulphuric acid
IS : 1069	Specification for water for storage batteries
IS : 1146	Specification for rubber & plastic containers for lead acid storage batteries.
IS : 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates).

TECHNICAL SPECIFICATIONS

IS : 3116	Specification for sealing compound for lead acid batteries.
IS : 8320	General requirements and methods of tests for lead acid storage batteries.
IS : 6071	Specification for synthetic separators for lead acid batteries.
	Indian Electricity Rules
	Indian Electricity Acts

- a. Equipment complying with other internationally accepted standards such as IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.
- b. DC Batteries shall be stationary lead acid Plante positive plate type conforming to IS:1652. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.
- c. DC Batteries shall be suitable for standby duty. The Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.25 V/cell.

C. Construction Features:-

Containers

Containers shall be made of transparent glass, hard rubber, suitable robust, heat resistance, leak proof, non absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of transparent containers. Float type level indicator shall be provided in case of opaque containers. The stem portion of the float should be long enough to prevent falling of the float inside the container even if there is no electrolyte in the container. The marking for the electrolyte level should be for the upper and lower limits. The material of level indicator shall be acid proof and oxidation proof. Container shall be closed/sealed lid type. Lid and sealing compound shall be non-cracking type. The container made of hard rubber and plastics shall be type tested as per IS: 1146. All type tests shall be carried out for sealing compound as per IS: 3116.

TECHNICAL SPECIFICATIONS

The pole sealing arrangement should be such that no acid particle get entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

Vent Plugs

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte sample.

Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS : 1652 as applicable.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative post shall be clearly marked.

Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

Cell Insulator

Each cell shall be separately supported on PVC/porcelain/hard rubber insulators fixed on the racks with adequate clearance between adjacent cells. Minimum distance between adjacent cells shall be more than the bulge allowed for two cells in accordance with IS: 1146.

Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately.

Connectors and Fasteners

Lead or Lead coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. The thickness of lead-coating of connectors should not be less than 0.025 mm. The lead coating thickness shall be measured in accordance with APPENDIX F of IS:6848 (latest edition). All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied by the contractor.

TECHNICAL SPECIFICATIONS

Battery racks

Wooden racks for all the batteries shall be provided. These racks shall be made of good quality first class seasoned teak wood in line with CPWD specification. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries rack and wooden support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

Test

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for rubber & plastic containers for lead-acid storage batteries)/IS 1652 (for lead-acid plate batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery. Charges for these shall be deemed to be included in the equipment price. An indicative lists of tests / checks is mentioned in QA chapter on Battery. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents

6. AUXILIARY EQUIPMENT

Manual discharge resistance bank suitable for each type of battery bank of UPS/Battery Charger has to be provided by contractor.

Following shall be provided (as per applicability) for maintenance purpose		
a	Hydrometers	2 Nos.
b	Set of hydrometer syringes suitable for the vent holes in different cells	2 Nos.
c	Thermometer for measuring electrolyte temperature	2 Nos.
d	Specific gravity correction chart	2 Nos.
e	Wall mounting type holder made of teak wood for hydrometer & thermometer	2 Nos.
f	Cell testing voltmeter (3-0-3 V)	2 Nos.
g	Alkali mixing jar	2 Nos.
h	Rubber aprons	5 Nos.

TECHNICAL SPECIFICATIONS

i	Pair of rubber gloves	
j	Set of spanners	5 Nos.
k	No smoking notice for each battery room	2 Nos.
l	Goggles (industrial)	2 Nos.
m	Instruction card	2 Nos.
n	Temperature indicator	1 No. per room
o	Cell lifting facility	1 Set per room

7. Following shall be taken as minimum load value for sizing calculation of UPS/Battery Charger/Battery system. However, Bidder needs to provide the details auxiliary power rating of each individual equipment. & any other load apart from below required for completion of the system is also in the scope of the bidder.

Sl No	Description	Rated Power in Watt	Remarks
1	HT Switchgear VCB Panel		
(i)	Closing Coil	300	First minute load
(ii)	Tripping Coil	300	Last minute load
(iii)	Spring Charging Motor	400	First minute load
(iv)	Numerical Relay	20	Continuous load
(v)	Auxiliary Relays	20 (total)	Continuous load
(vi)	LED Indication Lamps	10 (total)	Continuous load
(vii)	Misc. load	20 (total)	Continuous load
2	Inverter (if applicable)	300	Continuous load
3	SCADA panel at CMCS	2000	Continuous load
4	SCADA HMI including LED Display and Printer	500	Continuous load
5	SCADA RTU panel at PEB	400	Continuous load
6	Transformer N2 Injection unit at PEB (if applicable)	100	Continuous load
7	Fire Alarm Panel at CMCS	300	Continuous load
8	Fire Alarm Panel at PEB	200	Continuous load
9	WMS	100	Continuous load
10	Emergency Load (light + Fan) at CMCS	300	Continuous load
11	Emergency Load at PEB	100	Continuous load

TECHNICAL SPECIFICATIONS

Following shall be considered for main pooling/final pooling HT switchgear as a minimum.

- (i) Per switchboard only one panel spring charging motor load shall be considered.
- (ii) All outgoing and tie feeder panel trip coil load (subject to Minimum 3 Nos) shall be considered.
- (iii) All outgoing feeders+ Aux transformer feeders+ 50% of incomer panel closing coil load shall be considered.

Following shall be considered for inverter station HT switchgear/RMU.

- i) Per switchboard only one panel spring charging motor load shall be considered.
- (ii) All panel trip coil and close coil load shall be considered.

8. SITE TESTS

The contractor shall carry out the following site tests as applicable on UPS, Battery Charger and Battery system. However, any other site test is required to be conducted as a standard practice of the OEM or deemed necessary by the employer and mutually agreed between the contractor and the employer, the same shall also be carried out.

A. Light Load Test

This test is carried out to verify that the UPS/Battery Charger is correctly connected and all functions operate properly. The load applied is limited to some percent of rated value. The following points should be checked:

Output voltage, frequency and the correct operation of meters;

Operation of all control switches and other means to put units into operation. Functioning of protective and warning devices.

B. A. C. Input Failure Test

The test is performed in UPS/Battery Charger with a fully charged battery and is carried out by tripping input supply feeder or may be simulated by switching off all rectifiers and bypass feeder as at the same time. Output voltage variations are to be checked for specified limits with an oscilloscope /Recorder.

C. A. C Input Return Test

AC input return test is performed in UPS/Battery Charger by closing AC input supply feeder, or is simulated by energizing rectifiers. Proper operation of rectifier starting and voltage and frequency variations are to be observed. This test is normally performed with a fully or partially charged battery.

TECHNICAL SPECIFICATIONS

D. Auto changeover Test

This test shall be carried out in UPS ACDB fed from two separate UPS system. Auto changeover of one UPS source to standby UPS to be check by tripping the active UPS manually or by simulation condition. This test shall be check as per approved auto changeover logic.

E. Transfer Test (for UPS)

This test is applicable for UPS with bypass, particularly in the case of an electronic bypass switch. Transients shall be measured during load transfer to bypass caused by a simulated fault and load retransfer after clearing of the fault.

F. Full load test

Load tests are performed by connecting the actual load to the UPS/Charger output. Load tests are necessary for testing output voltage and frequency, rated stored energy, recharge time, ventilation, and temperature.

G. Rated Stored Energy Time (Battery test)

This test is a load test to prove the actual possible time of battery operation. If rated load is not available in the case of large UPS/Battery charger, it is possible to apply a partial load to check the actual battery discharge characteristics and compare these with characteristics specified by the battery manufacturer. Discharge time with rated load shall then be calculated. The test shall be performed with a fully charged battery and also may be done under other battery conditions to be specified, if so agreed. Active power output of the UPS/Battery Charger and the battery voltage shall be recorded during the test. Since new batteries often do not provide full capacity during a starting up period, the discharge test may be repeated after a reasonable recharge time if the original test has failed.

H. Rated Restored Energy Time

Restored energy depends on the charging capacity of the rectifiers and the battery characteristics. If a certain recharging rate is specified, it shall be provided by repeating the discharge test after the specified charging period.

I. Battery Ripple Current

If battery ripple currents are specified, then the ripple current which depends on UPS operation shall be checked under normal operating conditions. Rough measuring methods are sufficient.

TECHNICAL SPECIFICATIONS

B-15: LIGHTNING PROTECTION SYSTEM

1. GENERAL REQUIRMENTS

This specification is intended to outline the requirement of external lightning protection (ELP/Lightning protection) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of external lightning protection system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthing system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

Lightning protection requirement for outdoor metering yard/Switchyard has been mentioned elsewhere in the specification and hence shall be excluded from scope of this chapter unless Lightning protection requirement of metering yard/Switchyard is specifically mentioned in this chapter.

A. LIGHTNING PROTECTION DESIGN REQUIRMENT

The object of a lightning protection system is to protect buildings/structure and equipment's from direct lightning strikes, potential fire as well as the effects of injected lightning currents (non-incentive flash). It consists of termination systems for direct lightning, down conductors and an earth-termination system.

Care must be taken for while designing the lightning protection that surges are prevented in the electrical system to reduce failure of electrical and electronic equipment's.

B. CODES AND STANDARD

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IS/IEC 62305	PROTECTION AGAINST LIGHTNING
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.

TECHNICAL SPECIFICATIONS

IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
NFC 17 -102	Early streamer emission lightning protection systems
CEA regulations for electrical safety- 2010 Indian Electricity Rules/ Indian Electricity Act.	

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The lightning protection system includes lightning terminal, Down conductor, test link, earth electrode, installation of lightning terminal, down conductor and earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with lightning terminal.

Detail specification of earthing system has been mentioned elsewhere in the specification

2. DOWN CONDUCTORS

Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.

Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.

All joints in the down conductors shall be welded type.

Down conductors shall be cleated on outer side of building wall, at 750 mm interval or welded to outside building columns at 1000 mm interval.

Lightning conductor on roof shall not be directly cleated on surface of roof. Supporting blocks of PCC/insulating compound shall be used for conductor fixing at an interval of 1500 mm.

All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.

Lightning conductors shall not pass through or run inside GI Conduits. Testing link shall be made of galvanized steel of size 25x 6mm.

TECHNICAL SPECIFICATIONS

Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths oxide layer or foreign material.

3. LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY

A. Codes and Standard

IS/IEC 62305: PROTECTION AGAINST LIGHTNING

NF C 17-102 : LIGHTNING PROTECTION
WITH EARLY STREAMER AIR
TERMINATION ROD

B. Complete Solar Array with associated structure shall be protected from Direct Lightning Stroke. Lightning Protection for solar array shall be achieved with any or both of the following two systems as per specification provided in the following section.

Single Rod Air Terminal (Faraday Rods) Early Streamer Emission (ESE) Air Terminal

Suitable earthing and equipotential bonding shall be ensured for the lightning protection Air Terminal as per applicable standard/Equipment manufacturer guidelines.

Current carrying parts and accessories such as clamps, fasteners, down conductor, Test links and earth termination etc. shall be preferably procured from OEM of Air Terminals if it is supplied by them as part of lightning protection system.

C. LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY WITH E.S.E AIR TERMINAL

Solar array shall be protected from direct lightning stroke with Early Streamer Emission air terminal in accordance to NF C 17-102 .

Number and location of ESE air terminal shall be decided during detail engineering. For this purpose, design calculation considering protection level IV (minimum) and Autocad drawing of the layout of ESE terminal shall be submitted to Owner/ Company for approval.

ESE air terminal shall be type tested as per Annexure- C of NF C 17-102 (Latest Revision) in the manner as mentioned in the standard.

ESE Air terminal shall be supplied with test link, counter, down-conductor, Two earth pits, support mast and accessories required for completeness for ESE Lightning protection system.

Owner shall test ESE terminal (Each terminal/Sample basis) before installation with suitable instrument for functionality of terminal. Vendor shall replace the terminal free of cost if found defective.

Support mast for ESE Air terminal shall be heavy duty hot dip galvanized material and shall be suitable to withstand dynamic and static forces acting on it without

TECHNICAL SPECIFICATIONS

failure. Foundation for the mast shall be M20 Grade concrete or better with minimum depth of 1200 MM.

4. LIGHTNING PROTECTION SYSTEM FOR BUILDING AND ENCLOSURE

Contractor shall provide lightning protection for Inverter room/shed/shelter/enclosure, main control room, Switchgear Room/shed/shelter and similar housing per IS/IEC 62305.

ESE Air Terminal shall not be used for lightning protection of Metering yard/Switchyard.

TECHNICAL SPECIFICATIONS

PART-C: CIVIL WORKS

TECHNICAL SPECIFICATIONS

C-1: TOPOGRAPHY SURVEY AND SOIL INVESTIGATION

1. TOPOGRAPHICAL SURVEY

Bidder shall conduct the Topographical Survey for the allocated plot in the proposed solar project. Topography report shall be provided by Owner/ Company for references purpose. The scope of work and technical specification for the same is as below:

A. Scope of Work

The Bidder shall carry out the Topographical Survey and prepare of Plans (Survey Maps) and report of the entire area for locating the Solar PV Power plant and its other systems.

Carrying out the Benchmark (GTS) to site(s) under survey by parallel levelling, establishing and constructing benchmark, grid and reference pillars in the field and spot level survey of the entire area at specified intervals and development of the contours. Bidder can also use DGPS for establishing the coordinates.

Carrying out cross-section of river/canal taking spot levels at an average 20 meters intervals or less depending upon the site conditions.

Furnishing all field data & drawings with Longitude and Latitude of all corners and strategic points. Furnishing of the survey report as described in detail in the succeeding paragraphs is also included in the scope of this work.

The work shall include construction of two permanent Benchmarks and reference pillars which shall be shown on the survey drawings.

Latitude and Longitude: The work shall be carried out in **UTM grids system**.

At least 50-meter width of the adjoining solar plots and area shall also be covered in the survey for correlation with adjoining plots. Presence of any well and/or tube well in the site or adjoining areas and water level in them shall be marked in the documents / Drawings.

B. Topographical Survey and Mapping

Positions, both in plan and elevation, of all natural and artificial features of the area like waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutch 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 used in Survey of India Maps), all hills and valleys within the area/areas is to be surveyed and plotted on maps by contours.

Method of the survey, contour intervals etc. shall be decided by the bidder with prior approval of the Owner (Owner/ Company), in case of steep slopes and dense jungle etc. where grading is not possible. Any unusual condition or formations on the ground, locations of rock outcrops (if visible on the surface) and spring/falls, possible aggregate deposits etc. shall also be noted and plotted on the maps.

TECHNICAL SPECIFICATIONS

The field work shall be done with Total Station Equipment in the following steps:

Establishing horizontal and vertical controls and locating reference grids and benchmark in the area. Surveying for establishing spot levels and plotting contours. Surveying for locating the natural and manmade details as described earlier.

The grids for the survey work shall be established in N-S & E-W direction (Corresponding to Magnetic North).

C. Contouring

Bidder shall carry out spot level surveying at an interval of average 50 meters for contouring the area. Levels shall also be taken on all traverse stations and on salient points located at random over the area (ground points). Contours are to be interpolated at 0.5 M intervals after the above points are plotted.

D. Preparation & Submission of Survey Maps and Documents

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 etc. All the maps should be prepared in digitized forms using computer software like AutoCAD – Release 2016 or latest.

Bidder shall submit all data pertaining to the Survey and Array layout in original (.dwg &.pdf format) including all levels & co-ordinates in X-Y-Z format for the entire area in scale in Soft format and in hard copy (3 no's in A0 size).

2. GEOTECHNICAL INVESTIGATION SCHEME

The scheme for geotechnical investigation shall be as given at Clause 2.A and shall be approved by Owner before execution. The Bidder shall carry out geotechnical investigation for establishing the sub-surface conditions and to decide type of foundations for the structures envisaged, construction methods, any special requirements/treatment called for remedial measures for sub-soil/ foundations etc. in view of soft sub-soils, aggressive sub-soils and water, expansive/swelling soils etc. prior to commencement of detailed design/drawings.

The Bidder shall obtain the approval for the field and laboratory testing scheme before undertaking the geotechnical investigation work.

The detailed Geotechnical Investigation has to be carried out by the bidder in line with the Technical Specification. Bidder shall carry out the design of foundation etc. based on the approved geotechnical report.

Field test shall include but not be limited to the following:

Boreholes, Standard Penetration Test (SPT), collection of disturbed and undisturbed soil samples (UDS), Trial Pits (TP), collection of water samples, Electrical Resistivity Test (ERT) etc.

TECHNICAL SPECIFICATIONS

Owner has carried out geotechnical investigation in the proposed area. The geotechnical investigation report comprising of Boreholes, Laboratory tests, Chemical analysis, etc. in respect of the sub-strata prevailing at site is enclosed as Annexure of Technical Specification, for Bidder's reference. These are solely for the purpose of guidance of the Bidder.

Bidder shall carry out his own Geotechnical Investigation, as per the requirements of Technical Specification provided at Cl. 2.A below. No time extension would be admissible on account of this.

Bidder shall carry out the design of foundation etc. based on the approved geotechnical investigation report.

A. Scheme of Geotechnical Investigation

Minimum 1 No. of borehole of 7 m depth shall be carried out in every 12.5 acres of land. Minimum 1 number of ERT & 1 no. TP shall be carried out for every 100 acres or less area, as per layout. Depth of bore hole at Control Room Building shall be 12 m and that at Switchyard location shall be 15m or depth of borehole at these locations shall be as per approved geotechnical investigation scheme.

SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery upto 20%, met within a borehole. This test shall be conducted at every 1.5 m interval or at change of strata. The starting depth of SPT shall be 0.5m from ground level. UDS shall be collected at every 1.5m interval or at change of strata. In case UDS is not possible to collect, then interval of SPT shall be reduced to 1m instead of 1.5m.

The laboratory tests shall be conducted on soil, rock & water samples collected during field investigations in sufficient numbers. Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free Swell Index, Shrinkage Limit, Swell Pressure Test, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc.

On completion of all field and laboratory work, the Bidder shall submit a Geotechnical investigation report for approval. The Geotechnical investigation report shall contain field and laboratory observations/ data/ records, analysis of results and recommendations on type of foundation for different type of structures envisaged for all the areas of work.

Recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc. shall also be covered in the report, as applicable.

TECHNICAL SPECIFICATIONS

Geotechnical investigation work shall preferably be got executed by the Contractor through the Enlisted agencies, refer APPENDIX- 5 of Chapter A-5, Part A.

B. Foundation System

Foundation system for various facilities shall be designed and adopted as per approved geotechnical investigation report and relevant IS standard. The general requirements for the foundation system to be adopted, are as given below.

- 1) All structures/ equipment shall be supported either on suitable open foundation (isolated, combined, raft) or pile foundation depending on type of structures/ facilities, sub-strata, topography, etc.
- 2) If the encountered sub-strata is black cotton soil, the same shall be either replaced up to the full depth of black cotton soil or expansive soil shall be stabilized by suitable treatment.
- 3) No foundation shall rest in black cotton soil.
- 4) All foundation system shall be designed in accordance with the latest revisions of relevant Indian Standards. For short pile foundation, method by B. B. Broms shall be followed for calculating lateral resistance and lateral deflection of a pile.
- 5) Contractor shall furnish design of piles for approval.
- 6) Level of Ground water table for design purpose shall be considered as per the recommendation of geotechnical investigation report.
- 7) Minimum depth of foundation shall be 1.0m below ground level.
- 8) Testing of piles and interpretation of pile load test results shall be carried out as per the stipulations of IS: 2911 (Part-4). Contractor shall obtain approval for the pile load test scheme before undertaking the pile load test.
- 9) As per recommendation of Geotechnical Investigation Report, even for smaller structures, shallow foundations may not be feasible. Shallow foundation may be adopted with ground improvement. Accordingly, SBC value of improved ground shall be estimated based on ground improvement scheme adopted.
- 10) **Further, for design purpose, the ground water table shall be considered at ground level.**

Foundation system for various facilities shall be as per the table below:

Type of Structure	Type of Foundation
	Bored Cast In-situ Pile

TECHNICAL SPECIFICATIONS

MMS	Precast Driven Pile/ Spun Pile
	Stiffened Deep Cement Mixing (SDCM)
Boundary Wall/Fencing	Short Pile Foundation
Switchyard	Pile Foundation
CMCS Building	Pile Foundation
Inverter Stations	Pile Foundation
Transformer	Pile/Raft Foundation

Note: Optimized foundation type and size shall be decided during detailed engineering, however following minimum requirement considering aggressive behavior of soil to be adopted.

Minimum Grade of concrete: M30

Minimum diameter and capping of pile: 300mm

Chemical composition of Subsoil and Ground Water:

Details of treatment for foundations/ below-ground/ buried structures required to counteract soil/ ground water chemical environment shall be as per findings of geotechnical investigation. This shall require use of dense and durable concrete, control of water cement ratio, increase in clear cover, use of special type of cement and reinforcement, coating of concrete surface, etc. as per relevant IS codes. Bidder shall furnish the details of corrosion protection measures.

However, based on the Geotechnical Investigation carried out by the Owner, it may be inferred that near soils are typically slightly alkaline and are extremely corrosive to uncoated steel and are very highly corrosive to rebar in concrete materials. Based on chemical test results of subsoil and ground water, project site can be classified in Class 3 as per Table - 4 of IS: 456: 2000. Accordingly, minimum cement content, maximum water- cement ratio, cover to reinforcement and type of cement shall be provided.

As chloride is encountered along with sulphates in both sub-soil and ground water, Ordinary Portland cement with C3A content between 5 and 8 % or Portland slag cement conforming to IS: 455, may be used for all buried RCC structural members.

Environmental exposure condition for exposed concrete surfaces shall be considered as 'severe' and for buried concrete, it shall be adopted as 'very severe', as per IS: 456.

TECHNICAL SPECIFICATIONS

C-2: SITE LEVELLING AND GRADING

A. Site levelling works involves the following works:

- 1) Site levelling works/scheme shall match with the specific functional requirement of Solar PV optimum generation considering the full utilization of the plot area for the desired capacity
- 2) Site grading level shall be fixed with due reference to site drainage of the whole area, existing drainage pattern and system requirements.
- 3) For Plant boundary wall and fencing.

B. Based on the spot level, contour survey done and meeting above requirements, bidder can propose different site grade levels. The site levelling may be carried in patches/blocks. Bidder may also propose the site leveling and grading matching with the **natural topography** of the land considering the optimized use of the land, however bidder shall ensure to meet the desired power generation capacity in the allotted plot area. Bidder shall also ensure that no water ponding and flooding occurs in the low lying areas & effective drainage is provided in the whole plot area, in all kind of site levelling and grading or plant at natural topography schemes, bidders has to provide proper and effective drainage system in line with “Drainage System” chapter. After performing the optimization of levels from the detailed site survey by the Bidder, the final formation level of the plot in various areas shall be finalized. The area shall be suitably cut and filled to suit the layout requirement. The site levelling and grading scheme incorporating the above aspects shall be submitted to Owner/ Company for prior approval.

C. Fill shall normally be made up of Cohesive Non swelling material capable of being compacted up to 95% Standard Proctor density. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Bidder. The slope at the edge of graded areas shall not be steeper than 1:1.5 (1 vertical to 1.5 horizontal) in cutting and 1:2 in filling.

D. All buildings & switchyard area/sub-station area shall be constructed in levelled area. No foundation shall be allowed on back filled soil and in that case the depth of foundations shall reach up to NGL. Final Level will be approved in detail engineering.

E. The slope protection measure shall be provided in case inter levelled patches level difference is more than 2.0m. Random rubble/boulder/stone pitching/concrete blocks etc. shall be provided for the slope protection for road side slope, storm water ditches/drainage, embankment slopes, inter levelled patches slopes etc. as per design requirements.

F. Suitable sand erosion control measure shall be provided in case any sand dune or very loose soil areas fall inside the plot area. The same may be made with

TECHNICAL SPECIFICATIONS

Random rubble/boulder/stone pitching/concrete blocks etc. Bidder shall also provide sufficient grass/buses/trees covers on these dune / loose soil patches.

- G. Bidder shall also provide suitable sand erosion protection measure around the foundation as mentioned at relevant places in the technical specification.

H. Green Belt development:

The selection of plant types should be adaptable for agro climatic zones. Planting arrangement to be considered such that very little or no shadow falls on solar modules. Final selection for plants and seeds can be done by advice from forest / agriculture department and / or local experts. However, owner recommends the following:

Canopy vegetation (trees): Neem OR Babool

Trees to be planted by root-ball method to fast track growth. Crown: 20 meters

For ground cover vegetation: Cenchrus Owner/ Companyiaris OR Cenchrus setigerus Ground cover vegetation to be done by seed germination on site.

Crown: 70-80 cm

Bidders are also encouraged to plan additional suitable green belt with local shrubs and grasses in and around the respective plot area to control the soil erosion and better temperature in the plot area.

TECHNICAL SPECIFICATIONS

C-3: BOUNDARY WALL, FENCING AND GATE

1. General

The scope of work includes providing either or combination of following as per scope defined in **Plot Map** (General design data for Solar PV Site) of the proposed Solar Plant for the peripheral and common boundary.

- a) Pre-Stressed Precast Boundary Wall – Bidder's Choice
- b) Chain Link Fencing (e.g. Any Statutory Requirements)
- c) RCC Fencing Poles with Barbed Wire (e.g. Office Areas)

2. Pre-Stressed Precast Boundary Wall

- a) Boundary wall shall be provided by bidder on the periphery of allotted plot/plots. Bidder scope of work includes casting of pre-stressed precast boundary wall panels, columns etc. at bidder's facility/facility established by bidder at site/manufacturing unit, transportation of precast units at site and storage at locations identified by Owner/ Company, excavation for casting of foundation and fixing of panels as per drawing, construction of foundation, erection of columns to plumb & wall panels with required T&Ps, fixing of concertina with all items, backfilling as per specification etc. complete in all respect.
- b) Bidder construction drawing shall also incorporate suitable scheme to place precast boundary wherever there is changes in ground levels, corner, joint, water body crossings, etc. Opening for gates/drains and for other crossing has to be suitably provided as per the requirement/drawing/instructions of engineer in charge.
- c) The size of the foundation shall be decided based on the site conditions however the minimum diameter of the foundation shall not be less than 300 mm and depth 1800 mm.
- d) Bidder has to ensure that damages such as cracks and chipping off of corners do not happen during handling due to knocking etc. In case, such damages happen, the same has to be brought to the notice of engineer in charge.
- e) In case the damage is minor, the same has to be made good using approved epoxy resin. Non shrink grout can be used for chipped off corners. No monetary claim shall however be admissible for such repairs. The engineer in charge reserves the right to accept or reject any damaged precast unit and the decision shall be binding on the bidder.
- f) Suitable foundation and boundary wall arrangement with steel grating/grill shall be made in the boundary wall scheme to ensure intact wall/safety in the water body/ drains entry and exit points in the plot area. The boundary wall shall be at sufficient height from water level. The toe wall for fencing at water body area shall be made of RCC only. Alternatively, in place of Toe wall, Concertina Fencing at Ground can also be provided as per Tender Drawing.

TECHNICAL SPECIFICATIONS

- g) Boundary wall if provided, shall be executed in line with tender drawing Title: Pre- Stressed Precast Boundary Wall.
- h) Cutting of high strength cable, distressing and lifting shall be as per the standard IS: 1343. Pre-stressing tendons of high tensile steel / wire shall be as per IS: 6003-2010. For 4mm dia wires min Tensile strength shall be 1715 N/mm². Pretension force should not exceed 80% of ultimate tensile strength of the tendon. The pre-stressing shall be released from the panels and poles only when 50% of the characteristic strength of concrete is achieved.
- i) Prestressed precast boundary wall members shall be designed as per IS-1343

Tolerances:

SL no	Item	Tolerance		
1	Length	(+/-) 0.1%		
2	Straightness or bow	1/750 of length		
3	Cross section dimensions	(+/-)3 mm		
4	Squareness	When considering the squareness of the corner, length of the two adjacent sides being checked shall be taken as base line. The shorter side shall not vary in length from the perpendicular by more than 5 mm.		
5	Flatness	The maximum deviation from a 1.5m straight edge placed in any position on a nominal plant surface shall not exceed 5 mm.		

3. Chain Link Fencing:

“Chain link fencing The fencing shall be of Chain link (GI or poly coat GI as specified) mesh fabric with internal, corner and stay posts of RCC (min 200mm x 200mm size, M30 grade) or Hot dipped GI angle (min. ISA 75x75x6 mm), as applicable, along with 230 thick brick/ 300 thick RR masonry toe wall, with 100mm thick M15 PCC foundation (min. width 450mm and min. depth 450 mm below GL).

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

TECHNICAL SPECIFICATIONS

The brick masonry toe wall shall be plastered with 15thick CM (1:4) plaster on both faces and shall have min. 50 thick PCC (1:2:4) coping finished smooth and projecting 35mm on either side of the wall with top sloping inwards.

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.

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

In case of pond/ drain crossing the fence, RCC beam of adequate size supported on RCC columns on either side and suitable grill of MS square rods (vertical spacing not more than 150mm) of min. Size 25x25 mm and min. 3 no. horizontal 20 SQ MS rods or 50 mm x 8 mm thick flats secured to RCC beam and columns; shall be provided in place of toe wall for smooth flow of water.

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

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

All MS sections shall be painted with 2 coats of epoxy paint of approved make and shade over 2 coats of suitable primer.”

4. RCC Fencing Post with Barbed Wire:

RCC fencing post shall be a straight type of total length of 1.8 meters. The height of RCC post shall min 1.2 meters from finished ground level.

Hooks for fixing Barbed Wire

Hooks shall be made of 6 mm dia MS bar. 9 Nos. Hooks shall be provided for fixing ‘Steel Barbed Wire, A-3 or B-3 IS 278’ at 1.8 meters post. The top hook should be provided 60 mm below the top of post and bottom hook should be provided 140 mm above the bottom of the pole. The central distance between the top and bottom hooks shall be equally divided to fix remaining hooks. Diagonal steel barbed wire fixed with RCC fencing post shall also be provided.

Inclined strut or stay post on either side shall be provided at every 15 meters c/c, corner and end. The maximum distance between two RCC, fencing post shall be 2.5 meters c/c.

Reinforcement of RCC Post:

In Post	Vertical 6 Dia Bars 4 Nos.	In Strut	Vertical 6 Dia Bars 4 Nos.
	Stirrups 6 Dia Bars 9 Nos.		Stirrups 6 Dia Bars 10 Nos.

TECHNICAL SPECIFICATIONS

Dimensions RCC Post

1. Bottom: 165 mm x 165 mm square, and
2. Top: 100 mm x 100 mm square.

Cement Concrete Mix and Manufacturing

Cement concrete to be used having the nominal mix of ratio 1:2:4 with 12.5 mm nominal size coarse aggregate. RCC Post shall be embedded into PCC block made from Cement Concrete nominal mix 1:5:10 below ground level. Concrete Mix shall be conforming to Grade M-15 of IS 456 (2000). RCC Fencing post shall be manufacturer at the factory and In order to ensure desired compressive strength, RCC fencing poles should be compacted with the help of plate form vibrator. The surface shall be uniform and free from voids. The concrete cover over the reinforcement shall not be less than 15 mm.

Tolerances for RCC Fencing Poles

SL no	Item	Tolerance
1	Length	(+/-) 0.1%
2	Straightness or bow	1/750 of length
3	Cross section dimensions	(+/-)3 mm

5. Chain Link Fencing for Yard (Transformer Yard, Metering Yard, etc.)

As per Tender Drawing Title: CHAIN LINK FENCING FOR YARD AND COMMON FENCING (5779-004(B)-POC-A-003C)

6. Main Gate

Mild Steel frame gate woven with chain linking having minimum span 4 m conform to IS: 2062 shall be provided. The gate shall be complete with the guide track, castor wheel, all fitting and fixture like hinges, aldrops, locking arrangement, posts, etc. The width of approach road shall cover the gate width at the main entrance with a suitable transition. All members used in gates shall be finished by cleaning of steel surfaces as per IS: 1477 (Part-II) and applying zinc chrome or zinc phosphate primer, followed by two coats of synthetic enamel paint. For finishing coat suitable colour pigment shall be added. All paints including primer shall be of reputed brand/manufacturer and as approved by the Engineer-In-charge. The method of application shall be as per the recommendations of the manufacturer.

One man movement passage gate (minimum 1.2m width) shall also be provided at the main entry gate. 400 mm height concertina with all supporting members shall also be provided on a gate (gates other than main entry gate) for better security.

TECHNICAL SPECIFICATIONS

The minimum size & requirements of the Gate's including all items shall be as per the fencing tender drawing title: "Details of Main Gate".

The main gate shall be constructed inside the plant/plot boundary line to provide sufficient space for Heavy motor vehicle and light motor vehicle for inspection/check before entering the solar plant and vehicles shall not disturb the traffic in the main approach road.

7. HT cable support

As per detailed Engineering, if overground cabling is envisaged to avoid submergence during flooding, following would be followed for overground support.

TYPE RCC Pedestals or Galvanized Steel Structure over Concrete Pedestals shall be constructed for laying of the HT cable from Transformer to 33kV switchgear. Height of such structures would be as per Electrical Cabling – Technical Requirement (System Design), w,r,t Flood Level Report.

TECHNICAL SPECIFICATIONS

C-4: DESIGN OF MODULE MOUNTING STRUCTURE & CIVIL WORKS

1. Design criteria for module mounting structure (MMS)

The design calculations and drawings for MMS shall be submitted for prior approval of Owner/ Company before the commencement of construction. The construction methodology for MMS, seasonal tilt mechanism / Tracker system (if allowed as per Ch. B-2) and its foundations shall be submitted for Owner/ Company approval before the start of works.

2. Scope:

This section covers the loads and design requirement of the structures, racking, and all other items required to furnish and install a complete ground mounting structural system which constitutes a photovoltaic array(s).

3. Design Loads:

- A. Dead Load: The load obtained by summing up the weight of modules and self-weight of Structure including Purlins, rafter/beams, Bracings, struts, columns, necessary fittings, etc. to be added as a Dead load.
- B. Wind Load: The wind load (positive and negative) normal to surface on the modules and wind load on the structural members.
- C. Refer Appendix-1 of Technical specification for site-specific design parameters.
- D. The concept of wind tunnel studies may be considered in the design philosophy for fixed seasonal module mounting structure as well as tracker system.

If the Bidder is going for wind tunnel study for the design and analysis of complete MMS following has to be ensured.

- i. It must be done from an institute of repute having suitable wind tunnel facility (IITs / SERC Chennai or equivalent level institute in India).
- ii. If the study is done by any reputed international facility the study results must be vetted by the wind domain expert at any of the IITs / SERC like institutes in India.

Bidder may also refer to the detailed provisions in chapter B-2 for Tracker system.

4. Design Parameters:

TECHNICAL SPECIFICATIONS

- A. MMS design & analysis to be done on computer software (preferably STAAD) and the Bidder shall submit a write-up on the computer program used and its input (soft format) and output data for review and approval.
- B. An increase in allowable stresses of structural materials should not be considered during design and analysis.
- C. Wind pressure for following loads shall be considered as follows:
 - a. Dead Load of steel with all members, fittings & panels.
 - b. Load due to fair wind direction on design tilt angles of solar mounting structural members.
 - c. Load due to adverse wind direction on design tilt angles of solar mounting structural members.
 - d. Load on the side face of mounting structural members.
- D. Wind pressure coefficient, load and load combination shall be as per Indian standards (latest revision) such as IS: 875, IS: 800, IS 801.
- E. Design analysis and the forces on MMS (Compressive force, uplift force, shear and moment) shall be used for the design of foundation system.
- F. Seasonal Tilting MMS type (as applicable): Mechanized arrangement for lifting MMS during seasonal tilting shall be provided with MMS. The lifting forces shall be transferred only through rafter/beam for lifting the MMS during seasonal tilt with a suitable hook, clamp, etc. and fixed at rafter/beam.
- G. Technical requirements/ parameter of the Tracker System shall be as per Chapter A-2 of this specification. The Tracker System shall be of proven design. Design shall be based in accordance with the site climatic conditions and seismic loads, soil characteristics, thermal loads caused by expected fluctuations of materials and ambient temperatures and the minimum required design wind speed.

5. Vertical Deflection and Horizontal Sway Limits:

Limiting Deflection: The limiting permissible vertical deflection for structural steel members shall be as per following:

- a) Maximum vertical deflection in purlin = $\text{Span} / 180$,
- b) Maximum vertical deflection in rafter (cantilever span) = $\text{Span} / 180$ and
- c) Maximum lateral deflection in column/vertical post = $\text{Height} / 240$
- d) All deflection limits can also be as per the serviceability limit defined by the module manufacturer & tracker manufacturer OR the proposed deflection limits duly approved by the module manufacturer during detailed engineering.

TECHNICAL SPECIFICATIONS

6. Materials Specification & Coating for Structural Steel Works:

A. Hot-rolled/Cold-formed steel sections:						
Members	Reference code	Yield strength, min, MPa	Non-Coastal		Coastal Area	
			Coating, Reference code	Min Thickness (mm)	Coating Reference code	Min Thickness (mm)
Column/ Vertical Post	IS 2062 / IS 1079	250	90 microns (IS 4759) (minimum)	2.0	110 micron (IS 4759) (minimum)	3.0
Bracing/Rafter/ Beam/Purlin				2.0		
Steel Tubes in all sections	IS 1161	240		2.0		
Hollow Steel in all sections	IS 4923	240		2.0		
Coupler/Plate/Cleat Splice/Sag Angle	IS 2062	250		2.0		2.0
		Yield strength, MPa	Coating Class Designation			

TECHNICAL SPECIFICATIONS

Rafter/ Beam/ Purlin (Pre- Galvanized steel sections)	ASTM A653M/ IS 1079	255-550	Z600 (ASTM A653M/ IS 277	1.6	Not recommended in coastal areas

NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement mentioned above in the table. 4. All structural calculations of cold formed steel section for checking the adequacy for strength and deflection criteria is to be done taking into consideration the maximum permissible negative tolerance over specified BMT i.e, the lower limit of BMT is to be considered. 5. The tolerance on Base Metal Thickness (BMT) thickness of steel shall be as given in IS 1852.

B. Hot-dip Aluminium-Zinc alloy metallic coated sheet steel strip and sheet sections:

Members	Reference code	Yield strength , MPa	Coating Class Designation	Min Thickne ss (mm)	Coastal Area
Rafter/ Beam	ASTM A792M/ IS 15961	250 - 550	AZM 165 (ASTM A792M) / (IS 15961)	1.2	Not recommended in coastal areas
Purlin	ASTM A792M/ IS 15961	250 - 550	AZM165 (ASTM A792M) / (IS 15961)	0.9	Not recommended in coastal areas

NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement mentioned above in the table. 4. All structural calculations of cold formed steel section for checking the adequacy for strength and deflection criteria is to be done taking into consideration the maximum permissible negative tolerance over specified BMT i.e, the lower limit of BMT is to be considered.

2

TECHNICAL SPECIFICATIONS

	5. The tolerance on Base Metal Thickness (BMT) thickness of steel sheets and coils shall be as given in IS/ISO 16163

Painting of Steel Surfaces embedded in Concrete : For the portion of Steel surfaces completely embedded in Concrete as reinforcement or otherwise for foundation systems, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of **Inorganic Zinc Silicate** Primer of Minimum 50 Micron Dry Film Thickness (DFT).

C. Bidder shall also use principles governing design that shall prevent or reduce the risks of corrosion as per IS 9172 and other relevant IS codes.

7. Connections:

Sl No	Connection	Grade
1	Solar PV module to purlin/structure connection.	SS304, A2-70
2	Bolts required to loose and tighten seasonally for seasonal tilting in the module mounting structure.	
3	Other structural fixed connections.	HDG 5.6 & 8.8
4	Foundation Anchoring.	HDG 4.6

Note: Fastener shall conform to IS 1367

- A. SS304 Fasteners (nuts, bolts, washers and U-bolts) shall be of corrosion-resistant austenitic steel. SS 304 Fasteners shall have a good anti-seize finish with proper wax coating for better durability and firm resistance to all types of failure including seasonal removal and re-fixing of bolts.
- B. All fasteners shall be provided according to the connection design requirement. All bolts shall be tightened with designed torque mechanically immediately after the erection of MMS to avoid any possible damage due to any incidental storm during the erection stage.
- C. One set of fasteners shall consist of one hexagonal head nut, one hexagon shape bolt, and two washers. The bolts and nuts with inbuilt washers may also be provided.
- D. In the ground mounting structure system with seasonal tilt arrangement, the column post and rafter/beam at seasonal tilt point of rotation shall be preferably hinged plate and bolt system.

8. Foundation System

TECHNICAL SPECIFICATIONS

Top of concrete/ height of collar for MMS foundation shall be minimum 300mm above Finish ground level. The proposed foundation system for MMS shall be based on findings/results of the approved geo technical investigation report. Following kind of foundation may be provided:

1. Short pile foundation (Min. 300mm dia.)
2. Rock anchor with concrete collar (Min. 700 sq.cm.)
3. Isolated, strip or raft foundation
4. Concrete ballast foundation

9. List of applicable Indian standards

IS 2062 - Hot Rolled Medium and High Tensile Structural Steel.

IS 811 - Cold Formed Light Gauge Structural Steel Sections.

IS 1161- Steel Tubes for Structural Purposes.

IS 4923 - Hollow steel sections for structural use.

IS 4759 - Hot-dip zinc coatings on structural steel and other allied products
IS 4736 - Hot-dip zinc coatings on mild steel tubes

IS 1868 - Anodic coatings on aluminium and its alloys.

IS 2629 - Recommended practice for hot-dip galvanizing of iron and steel.

IS 15961 - Hot dip aluminium-zinc alloy metallic coated steel strip and sheet (plain)
IS 9172 -Recommended design practice for corrosion prevention of steel structures.

TECHNICAL SPECIFICATIONS

C-5: CIVIL & STRUCTURE WORKS - GENERAL DESIGN CRITERIA

1. GENERAL

The layout, design and drawings for Buildings, Structure and foundation system shall be approved from Owner/ Company before the start of works. Design of RCC and Steel structures shall be carried out as per IS 456 and IS 800 respectively. Refer appendix-D1 for site specific design parameters.

2. INVERTER ROOMS & SECURITY ROOM

The following structures shall be designed and provided by the bidder:

A. Inverter Rooms: Inverter rooms consist of PCU's, LT panels, batteries, etc. shall be provided based on manufacturer recommendation, easy passage of O&M persons and cable trench layout required.

The inverter rooms shall be made through any of the options as mentioned below:

- a) RCC framed structure with bricks/concrete blocks masonry walls,
- b) Pre-Engineered Building in line with PEB Tender drawing & technical specification (IR PEB shall be provided only in **non-coastal area**),
- c) Steel Containerized solutions.
- d) On elevated RCC Platform.

The battery and its associated equipment shall be suitably segregated inside the Inverter room with proper ventilation arrangement.

The equipment inside the inverter room shall be placed to provide sufficient space for their maintenance.

B. Security Room: Prefabricated security room or brick/stone masonry with RCC slab near the entry of the main gate. The toilet room shall be made of brick/stone masonry with water facility

The buildings and allied works shall be designed to meet **NATIONAL BUILDING CODE** (SP: 07 2016) requirements. Finish floor level of all building/rooms shall be minimum 450 mm above from Finish graded level.

SPECIFICATION FOR RCC BUILDINGS AND OTHER RCC/MASONRY STRUCTURE.

Any building if made of RCC framed structure with bricks/concrete blocks masonry walls will be made in line with provisions of IS 456. The thickness of outer masonry walls shall be minimum 230mm in case of bricks and minimum 200mm thick in case of concrete blocks. The roof shall be designed for a minimum superimposed

TECHNICAL SPECIFICATIONS

load to 150 kg/m². The bidder shall also provide rainwater harvesting system at all RCC building roofs (if provided).

3. GENERAL CIVIL WORKS

REINFORCED CONCRETE STRUCTURE, ALLIED WORKS AND FOUNDATION

- a) All RCC works shall be designed mix as per IS 456 (2000). For structural concrete items, Ordinary Portland cement (43 Grade) conforming to IS: 8112 and Fly ash- based Portland pozzolana cement conforming to IS: 1489 (Part-1) shall be used for superstructure. Type of cement for sub-structures shall be decided based on the approved geotechnical Investigation report and special protection measures against chemically aggressive environment, specified at Cl B of Chapter C-1 of this specification.
- b) Coarse aggregate for concrete shall be crushed stones chemically inert, hard, strong, durable against weathering of limited porosity and free from deleterious materials. It shall be properly graded. It shall meet the requirements of IS: 383.
- c) Sand shall be hard, durable, clean and free from adherent coatings of organic matter and clay balls or pellets. Sand, when used as fine aggregate in concrete shall conform to IS: 383. For plaster, it shall conform to IS: 1542 and for masonry work to IS: 2116.
- d) **Reinforcement steel:**

Non-coastal area	Coastal area
Reinforcement steel shall be of high strength deformed TMT steel bars of grade minimum Fe-415 and shall conform to IS: 1786. Ductile detailing in accordance with IS: 13920 shall be adopted for superstructure and substructure of all RCC buildings/structures	Reinforcement steel shall be of high strength deformed TMT steel bars with corrosion inhibitors, Corrosion Resistant Steel (CRS) re-bars, Fusion Bonded Epoxy Coated (FBEC) re-bars or Zinc Coated re-bars of grade minimum Fe-415 shall conform to IS: 1786. Ductile detailing in accordance with IS: 13920 shall be adopted for superstructure and substructure of all RCC buildings / structures. Dense concrete around reinforcement, provision of thick covers, and addition of corrosion

TECHNICAL SPECIFICATIONS

	protection with re-bars shall be provided to the RCC structures

- e) The following minimum grades of concrete for design mix and nominal mix shall be adopted for the type of structures noted against each unless not specified elsewhere.

Grade as per IS 456	Non-coastal area	Coastal area
M30	-	All RCC structural elements above and below ground level, precast concrete, transformer foundation, Equipment foundation, cable trench, oil pit, Grade Slab, Paving, culverts, road and MMS Foundation.
M25 (in-situ concrete) M30 (Precast)	All RCC structural elements above and below ground level, precast concrete, MMS foundation, cable trench, oil pit, Grade Slab, Paving, culverts	-
M25	Fencing work.	Fencing work, Base slab of drains. Plain Concrete Cement.
M25	Base slab of drains.	

TECHNICAL SPECIFICATIONS

M15	Plain Concrete Cement.	

The bidder shall carry out the design mix of M-30 and M-25 grade concrete on priority. The design mix shall be approved from Owner/ Company before the start of work.

* The use of nominal mix for M-20 grade (If applicable) may be accepted only in exceptional cases subject to approval of Owner/ Company Engineer-In-Charge. The same shall be the adopted subject to approval from Owner/ Company for specific work.

- f) In case Geotechnical investigations require any special kind of cement or higher grade of concrete, the same shall be provided. The foundation system shall be made which transfer loads safely to the soil for the module mounting structures, depending on soil conditions, geographical condition, regional wind speed, bearing capacity, slope stability etc. All foundation system and foundation depth shall be decided based on the approved geotechnical investigation report. No foundation allowed on back filled soil and the foundation depth to reach upto natural ground level (NGL).
- g) All loads shall be considered in line with IS: 875. Seismic loads for design shall be in accordance with IS: 1893 and relevant Standards.
- h) IS: 2502 Code of Practice for Bending and Fixing of Bars for concrete Reinforcement must complied for reinforcements. IS 5525 and SP 34 shall be followed for reinforcement detailing.
- i) A minimum 75 mm thick PCC shall be provided below RCC wherever RCC structure is laid over the ground. Proper and sufficient formwork/shuttering shall be provided for the required period as per IS 456.

Masonry Work

- a) Brickworks shall be using at least class designation 7.5 of approved quality as per IS: 1077, IS: 2212 and IS: 3495. Concrete blocks shall be of a minimum compressive strength of 7.5 N/mm² and shall be of Grade-A as per IS: 2185. Stone masonry work with hard stone in building works, foundation, plinth and drains shall be Coursed Rubble or Random Rubble masonry work with the stone of good quality and durability. The masonry surface shall be plastered with minimum 18mm plaster in case of CMCS walls. The stone masonry work shall be in line with IS: 1597, IS: 1122 and IS: 1126.
- b) The cement mortar for all kind of masonry work shall be in the ratio 1 cement and 6 sand by weight.
- c) Bricks/blocks required for masonry work shall be thoroughly soaked in the clean water tank for approximately two hours. Brick shall be laid in English

TECHNICAL SPECIFICATIONS

bond style. Green masonry work shall be protected from rain. All masonry work shall be kept moist on all the faces for a period of seven days.

- d) Bricks of class designation 5.0 N/mm² and 3.5 N/mm² may be permitted to have slight distorted & rounded edges provided no difficulty shall arise on this account in laying of uniform courses in non-load bearing structures and shall be subject to the approval of Owner/ Company. Tolerances on dimensions up to +/- 8% shall be permitted. Dimension test to be carried out as per IS code.
- e) The external wall for the building shall be 230 mm thick walls and internal wall 230/115 thick as per requirements. The external wall of CMCS facing the transformer area shall be as per IS: 1646 - Code of practice for fire safety of buildings (general): electrical installations.
- f) Use of fly ash brick for masonry shall be subjected to approval of Owner/ Company.
- g) The suitable damp-proof course shall be provided the proportion of cement, sand & aggregate shall be 1:2:4 using 6 mm down stone chips with a waterproofing admixture. The thickness of the damp-proof course shall be minimum 40 mm.

Plastering

All external surfaces shall have 18 mm cement plaster in two coats, under layer 12 mm thick cement plaster 1:5 and finished with a top layer 6 mm thick cement plaster 1:6 (DSR 2013-13.11). White cement primer shall be used as per the manufacturer's recommendation.

At least one coat of plaster shall be applied to interior walls by hand or mechanically, to a total thickness of 12 mm using 1:6, 1 cement and 6 sand. Plastering shall conform to IS 1542, IS 1661, IS 1630. Oil bound washable distemper on smooth surface applied with minimum 2 mm thick Plaster of Paris putty for the control room. Plaster of Paris (Gypsum Anhydrous) conforming to IS: 2547 shall be used for plaster of Paris punning.

Water Supply

GI pipes of Medium quality conforming to IS 1239 (Part I-1990) or CPVC pipes conforming to IS 15778 shall be used for all portable hot and cold-water distribution supply and plumbing works.

The Syntax or equivalent make PVC storage water storage tank conforming to IS: 12701 shall be provided over the roof of the CMCS with adequate capacity for 10 No person and 24-hour requirement, complete with all fittings including float valve, stopcock etc. The capacity of the tank shall be minimum 500 litres.

Grouting

TECHNICAL SPECIFICATIONS

Cement mortar (1:2) grout with non-shrink additives shall be used for grouting below base plate of a column. The grout shall be high strength grout having a minimum characteristic compressive strength of min 30 N/mm² at 28 days.

Structural Steel

Structural steel design shall be carried out as per IS 800 and IS 801. Structural steel shall conform IS 2062 / IS 1079 or equivalent, Pipe shall be as per medium/high grade of IS 1161, Chequered plates shall conform to IS 3502 and Hollow steel sections for structural use shall conform to IS 4923.

Structural Steel/Steel Sheet Painting

All non-hot dip galvanised structural steel (excluding Module Mounting & SCB structure)/ Outdoor metal containers/ Enclosure/ Rolling shutter items shall be provided with paint designed for a minimum maintenance-free life of fifteen (15) years (high durability) as per **ISO 12944 and IS 800 or equivalent for its corrosion category**. For finishing coat suitable colour pigment shall be added. All paints including primer shall be of the reputed brand/manufacturer and as approved by the Engineer-In-charge. The method of application shall be as per the recommendations of the manufacturer. For corrosive category of refer appendix of site-specific data.

4. Transformer Yard and Metering Yard Civil Works

- a) Transformer and equipment's foundations shall be founded on piles/isolated spread footings depending on the final geotechnical investigation report. Metering yard equipment's structures shall be designed as per IS 801 and IS 800.
- b) Transformer foundations shall have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit shall be filled with granite stones of 40 mm size uniformly graded.
- c) The bidder can propose soak pit under Transformer or Burnt oil pit at a distance connected to transformer soak pit depending upon oil quantity in Transformers. It shall be sized to accommodate the oil volume of the transformer connected to it, without backflow. The Gravel-filled level under transformer shall be in accordance with FGL outside pit and transformer bottom level.
- d) The area around the transformer and equipment's shall be covered with gravel and galvanized chain link fence of height min 1.8 m with fence posts and gates shall be provided. The portion of the fence covering towards rail track shall be made of a removable type for movement of the transformer during erection /removal. In addition, a small gate, 1.2 m wide shall be provided for an entry. The transformer yard fencing work shall conform to CEIG requirements.

TECHNICAL SPECIFICATIONS

- e) Transformer track rails shall conform to IS 3443. The requirement of a fire barrier wall between transformers shall be as per Electricity Rules and IS 1646 recommendations.

5. PIPE /CABLE RACKS & TRENCHES

- a) The conventional methods of cables laying and installation shall conform to IS 1255 for laying direct in ground, drawing in ducts, laying on racks in air, laying on racks inside a cable tunnel and Laying along buildings or structures, etc.
- b) Outdoor RCC Cable Trenches: RCC outdoor cable trenches in switchyard area shall be provided with pre-cast RCC removable covers with lifting arrangement. The top of outdoor trenches shall be kept at least 100 mm above the gravel level so that rainwater does not enter the trench.
- c) Indoor RCC Cable Trenches: RCC indoor cable trenches shall be provided with 50X50X4 mm angles grouted on the top edge of the trench wall for holding minimum 6 mm thick mild steel checkered plate covers conform to IS: 3502 with lifting arrangement.
- d) RCC cable trenches shall be constructed with wall thickness minimum 100 mm.
- e) Trench Drainage: The trench bed shall have a slope of approx. 1/500 along the run & 1/250 perpendicular to the run. In case straight length exceeds 30 m, suitable expansion joint shall be provided at appropriate distances. The expansion joint shall run through vertical wall and base of the trench. All expansion joints shall be provided with approved quality PVC water stops. Suitable drainage at the lowest point of the trench shall be provided.

PLANT DRAINAGE SYSTEM

- a) All Drains within a plot are in Bidder's Scope. Drawing by park developer shared as part of Tender Drawings is for reference purpose only however overall design should be on similar lines as provided in the said drawing. Lining of drains shall be as per provisions of Bidding Documents and applicable IS/IRC Code provisions.
- b) Internal drains in all plots would also be developed and connected to Main drains (Along the Main Roads on West and East Side of Main Owner/ Company Plot) in due course of time. Main drains need to be designed as per layout of Roads and shall be suitable to take care of entire North Block's catchment area such that Main drains to be constructed in Northern Side (upper region plots, at a later date) can be suitably connected to the Main Drains in due course of time.
- c) Surface drainage system shall be designed considering 'Heaviest rainfall in one hour in mm'. The minimum value of surface run off coefficient shall be

TECHNICAL SPECIFICATIONS

considered as 0.6 in the design of drainage system. The drainage system shall be designed as per the IRC specifications and prevailing industry practices.

- d) The drainage scheme shall be designed considering the catchment areas contributing to the existing drains, solar plant gradients and solar PV array layout. As per plant drainage requirement, a network of open drains shall be designed & provided to carry surface runoff. The drains shall be trapezoidal, rectangle section made of earthen type lining (Compacted Earth Lining) and hard surface lining (stone masonry/pitched, Boulder, Precast cement concrete/stone slab, *in-situ* cement lime/concrete lining, soil cement lining, etc.)
- e) Bidders can also propose suitable detention pond, recharge dugwells, recharge pits, recharge trenches, and recharge soakways for quick disposal of storm water in the vicinity of the solar block/plot.
- f) Bidder shall also ensure that drainage from his plot does not encroach/flood into the adjacent property and adjacent solar plots (if any). Bidder shall try to maintain existing natural drain and shall remodel the natural drains in case of any disturbance made. The same shall be as per the technical/design requirements without affecting the drainage pattern. The bidder plot drainage scheme shall include to drain out the drainage of the allotted plot and shall include contributing catchment area consisting of adjoining plots and nearby catchment area.
- g) Provision of culverts and their design to be submitted separately. The road on the culvert portions of the drains shall be concrete road.

All Buildings shall be provided with plinth protection all around, sloped towards side drains. Plinth Protection shall be 75mm mm thick PCC laid over well compacted 75mm well grades brick ballast base. Building peripheral drains shall be stone masonry/brick masonry/concrete works. These side drains shall be connected to area drains by either open drains or combination of open drains and underground pipes.
- i) Grade level shall be fixed with due reference to highest high flood level of the receiving body of water. Laying of Hume pipe shall be in line with IS: 783.
- j) Recommended Side Slopes for lined and unlined drains, other than RCC drains and Brick wall drains

Sl	Type of Soil	Side Slopes (Horizontal: Vertical)
1.	Very light loose sand to average sandy soil	2: 1 to 3: 1
2.	Sandy loam, Ordinary soil	1.5 : 1 to 2 : 1 (in cutting) 2 : 1 (in embankment)

TECHNICAL SPECIFICATIONS

3.	Sandy gravel/murum	1.5 : 1 (in cutting) 1.5 : 1 to 2 : 1 (in embankment)
4.	Black cotton	1.5 : 1 to 2.5 : 1 (in cutting) 2 : 1 to 3.5 : 1 (in embankment)
5.	Clayey soils	1.5 : 1 to 2 : 1 (in cutting) 1.5 : 1 to 2.5 : 1 (in embankment)
6.	Rock	0.25 : 1 to 0.5 : 1

i) A. Limiting velocity in **unlined drains**:

Very light, loose and to average sandy soil	0.60 m/sec.
Ordinary soil, Sandy loam, black cotton soil & similar soil	0.90 m/sec.
Murum, hard soil	1.1 m/sec.
Gravel and disintegrated rock	1.5 m/sec.

Limiting Velocities in Different Types of **Lining in drains**:

Stone-pitched lining	1.5 m/s
Burnt clay tile or brick lining	1.8 m/s
Cement concrete lining	2.7 m/s

All above parameters may be suitably adjusted based on inputs being made available by Owner/ Company (Owner) for reference purpose. Also, any specific reference mentioned for Drain design in any IS Code or IRC Code would also be acceptable subject to approval of overall design during detailed Engineering stage.

All project drains would connect to the main drains of Park as per detailed layout to be prepared during detailed Engg. stage.

ELECTRIFICATION OF BUILDING

Electrification of all building shall be carried out as per IS 732-1989, IS: 4648-1968 and other relevant standards.

APPROACH ROADS

TECHNICAL SPECIFICATIONS

The approach road to the Solar Power Plant shall originate from the main approach road and connect to CMCS building, Metering yard/ Switchyard and Gates (whether or not such buildings are in Bidder's scope, all internal roads and their connection to Park facilities within project would be in Bidder's Scope only).

Approach Road: The approach road to the Solar Power Plant shall originate from the main approach road and connect to all Inverter rooms, module cleaning station and gates. Approach road shall be minimum 3.0-meter-wide with minimum 500 mm wide shoulder on both sides.

Main Roads between the plots have been marked in the Layout Drawings, internal roads within the plot would be finalized as per bidder's detailed array layout.

Road sections for Main Roads (as marked in Layout Drawing) and Internal roads (with in the plot) shall be constructed as per respective Plot Map attached in Attachment.

LIST OF APPLICABLE INDIAN STANDARDS

Indian codes, and/or standards shall govern, in all the cases wherever they are available. In case of a conflict between such codes and/or standards and the specifications, the stringent provisions shall govern. Such codes and/or standard referred to shall mean the latest revision, amendments/changes adopted and published by the relevant agencies. In case of any further conflict in this matter, the same shall be referred to the Engineer-in-charge, whose decision shall be final and binding.

Other internationally acceptable standards shall be accepted, only if, no Indian Standards are existing. However, other standards also will be accepted if the Bidder establishes that the works are meeting the requirements of Indian Standards also.

A brief list of Indian Standards applicable to these works is as below:

IS: 875-I	Code of Practice for Design Dead Loads for Building and Structures
IS: 875-II	Code of Practice for Design Imposed Loads for Building and Structures
IS: 875-III	Code of practice for design loads (other than earthquake) for buildings and structures.
IS: 1893	Criteria for earthquake resistant design of structures.
	Foundations
IS: 1080	Code of practice for design and construction of shallow foundations in soils

TECHNICAL SPECIFICATIONS

	(other than raft, ring and shell)
IS: 1904	Code of practice for structural safety of building foundations
IS: 2950	Code of practice for design and construction of raft foundations.
IS: 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles
IS: 6403	Code of Practice for determination of bearing capacity of shallow foundations
IS: 8009	Code of Practice for foundation settlement calculations
IS: 2911	Design & Construction of Pile Foundation – Code of Practice
	Concrete Structures
IS: 456	Code of practice for plain and Reinforced concrete
IS: 3370	Code of practice for concrete structures for the storage of liquids.
IS: 3414	Code of Practice for design and installation of joints in buildings
IS: 5525	Recommendation for detailing of reinforced concrete works
IS: 6313	Code of practice for anti-termite measures in buildings
IS: 13920	Ductile detailing of Reinforced Concrete Structures subjected to Seismic forces
IS: 1904	Code of practice for design and construction of foundations in soils general requirements
	Steel Structures
IS: 800	Code of practice for use of structural steel in general building construction
IS: 801	Code of practice for use of cold-formed light gauge steel structure members
IS: 802	Code of Practice for use of Structural Steel in over Head Transmission Line Towers.
IS: 806	Code of practice for use of steel tubes in general building construction.
IS: 808	Dimensions for hot rolled steel beam, column channel and angle section
IS: 811	Specification for Cold Formed Light Gauge Structural Steel Sections
IS: 813	Scheme of symbols for welding
IS: 1079	Hot Rolled carbon Steel Sheet and Strip – Specification

TECHNICAL SPECIFICATIONS

IS: 2062	Hot Rolled Medium and High Tensile Structural Steel – Specification
IS: 4923	Hollow steel sections for structural use.
IS 1161	Steel tubes for structural purpose
IS: 2721	Galvanized steel chain link fence fabric – Specification
Painting and Coating	
IS: 4736	Hot-dip zinc coatings on mild steel tubes
IS: 4759	Hot-dip zinc coatings on structural steel and other allied products – Specification
IS:1868	Anodic coatings on aluminum and its alloys
IS 2395-I	Painting of Concrete, Masonry and Plaster Surfaces – Code of: Operations and Workmanship
IS 2395-II	Code of practice for painting concrete, masonry and plaster surfaces: Schedule
IS 1477-I	Code of Practice for Painting of Ferrous Metals in Buildings: Pre-treatment
IS:1477-II	Code of practice for painting of ferrous metals in buildings: Painting
ISO 12944-1	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments
ISO 12944-5	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 5: Protective paint systems

Water supply and sanitary

IS: 1239	Mild steel tubes and tubulars and other wrought steel fittings
IS: 1172	Code of basic requirements for water supply, drainage and sanitation
IS: 1742	Code of Practice for building drainage
IS: 2527	Code of practice for fixing rainwater gutters and down pipes for roof drainage.
IS: 15778	Chlorinated polyvinyl chloride pipes for potable hot and cold water distribution supplies
IS: 16088	Chlorinated polyvinyl chloride pipes for automatic sprinkler fire extinguishing system
IS: 10124	Fabricated PVC fittings for potable water supplies
IS: 4985	Un-plasticized PVC pipes for potable water supplies

TECHNICAL SPECIFICATIONS

IS: 13592	Un-plasticized Polyvinyl Chloride (PVC-U) Pipes for Soil and Waste Discharge System Inside and Outside Buildings Including Ventilation and Rainwater System
IS: 12818	Un-plasticized polyvinyl chloride (PVC-U) screen and casing pipes for bore/tubewell
IS: 2470	Code of Practice for installation of septic tanks

Lining

IS 3872	Lining of Canals with Burnt Clay Tiles - Code of Practice.
IS 3873	Laying cement concrete/stone slab lining on canals - Code of practice.
IS 4515	Stone Pitched Lining for Canals - Code of Practice.
IS 7113	Soil-Cement Lining for Canals - Code of Practice.
IS 7873	Code of practice for lime concrete lining for canals.
IS 9097	Guide for laying lining of canals with hot bitumen or bituminous felts.
IS 10430	Criteria for Design of Lined Canals and Guidance for Selection of Type of Lining.
IS 10646	Canal linings - Cement concrete tiles.
IS 11809	Lining for canals by stone masonry - Code of practice.
IRC:SP:50	Guidelines on urban drainage.

Miscellaneous

IS: 1905	Code of Practice for structural use of un-reinforced masonry
IS: 3067	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
SP: 6	Handbook for structural engineers (all parts)
SP: 7	National Building Code of India
SP: 16	Design Aids for reinforced concrete to IS:456
SP: 20	Handbook on masonry design and construction
SP: 22	Explanatory handbook on codes for earthquake engineering
SP: 24	Explanatory handbook on Indian Standard Code of Practice for plain and reinforced concrete
SP: 25	Handbook on causes and prevention of cracks in buildings

TECHNICAL SPECIFICATIONS

SP: 32	Handbook on functional requirements of industrial buildings
SP: 34	Handbook of concrete reinforcement & detailing
IRC: 37	Guidelines for design of flexible pavements
IRC: 42	Guidelines on Road Drainage
IRC: 58	Guidelines for the design of rigid pavements for highways
IRC: 73	Geometric design of roads

TECHNICAL SPECIFICATIONS

PART-D: GENERAL SYSTEMS

TECHNICAL SPECIFICATIONS

D-1: WEATHER MONITORING STATION

As a part of weather monitoring station, Bidder shall provide following measuring instruments with all necessary software & hardware required to integrate with SCADA so as to enable availability of data from meteorological instrument in SCADA. Each instrument shall be supplied with necessary cables, transmitters and accessories (Mounting and base stand etc.) provided by OEM of the sensors only.

Aux. power required by instruments and data logger (If supplied) shall be from UPS only. Data logger shall have provision to receive redundant power supply.

All the instruments to be supplied shall have valid calibration certificate.

Single sensor for measuring combination of Wind Speed, Wind Direction, Relative humidity and Rainfall is also acceptable however offered sensor shall meet the specification as mentioned in following sections.

Bidders are advised to ascertain themselves, the applicable regulation related to weather data which has to be transmitted to control centers like SLDC/RLDC (Telemetry). Any signal/parameter/equipment though not specifically mentioned but which are required as per statutory regulation are also included in the scope of bidder.

Weather Monitoring Station available in Ramsar Chhota, Barala & Bandarewala villages and bidder required to gather all the required data from there.

1. TEMPERATURE SENSORS

A. Ambient Air Temperature Sensor (Qty -1 no.)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	-10 °C -60 °C
3.	Accuracy	+/- 0.2 °C
4.	Operating Temperature	0 °C -60 °C
5.	Radiation Shield	Non-aspirated Radiation Shield

B. Indoor Air Temperature Sensor (Qty – 1 no. at each Inverter room)

“In case outdoor inverter is offered and associated equipment like PLC/RTU panel etc. is offered inside a closed room then minimum 2 such rooms shall be provided with temperature monitoring to be hooked up with SCADA.”

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature

TECHNICAL SPECIFICATIONS

2.	Range	0-120 ° C
3.	Accuracy	+/- 0.2 ° C
4.	Operating Temperature and calibration	0 to 120 ° C

C. Module Temperature Sensor (Qty – 1 no. per 05 MWp)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-150 ° C
3.	Accuracy	+/- 0.2 ° C
4.	Operating Temperature	0 to 150 ° C

Module temperature sensor shall be fixed on the back of module surface with adhesive or tape without using any mechanical fastener.

2. Additional Measurement

As per regulatory requirement, following measurement for the Solar PV is also included in the scope of bidder.

- i. Direct Normal Irradiance (DNI)
- ii. Sunrise and Sunset time
- iii. Rainfall (mm)
- iv. Cloud Cover –(Okta)
- v. Air Density

Instrument and accuracy for the above-mentioned measurement shall comply with applicable regulation (“Implementation of the framework on forecasting, scheduling and imbalance handling for Renewable Energy (RE) generating stations including Power Parks on Wind and Solar at Inter-State Level”).

3. CALIBRATION

All the measuring instruments to be supplied shall have valid and traceable calibration certificate. Each Pyranometer shall be recalibrated at an interval not more than two years and all other instruments shall be recalibrated at an interval not more than four years.

4. DATA LOGGER

Weather Monitoring system shall be provided with standalone Data logger suitable for outdoor application with IP65 Protection and industrial grade hardware suitable for operating temperature up to 55 Deg. C. Data logger shall be calibrated and proven in field for at least one year in outdoor environment. Data logger shall have following minimum features:

TECHNICAL SPECIFICATIONS

Processor	2x 800 MHz 32 bits
Time synchronization	With Built in GPS Clock or with Solar SCADA GPC Clock
Wireless communication	GSM/GPRS Modem FTP,SFTP,HTTP,HTTPS,MQTT,SNTP, SNMP,SMTP,ICMP,SSH,Ethernet TCP/IP,UDP,DHCP,Mysql,DCP,OPC UA,
Data storage	SD card, Min 2GB for storage of raw and processed data locally at resolution of 1 Second for retrieval whenever required. Data to be stored shall be in unencrypted CSV or equivalent format. 8 GB Industrial Grade, SQL Lite DB onboard possible minimum data logging freq. is 1 mili second
Display	LCD display for easy maintenance and debugging for site engineer
Scan resolution	3 sec or better
Analog to Digital Converter (ADC)	16 Bit, Sampling -10 Hz (Min)
I/P Channel	As required with 20 % spare of each type of channel
Code/ Standard	(IEC 61140, EN 61140, VDE 0140-1)
	Cyber Secured as per IEC 62443-4-1/2

It shall have facility for arithmetic processing (Time Integration, Simple Average, and Moving Average etc.) of incoming raw data. Data logger shall be interfaced with Solar SCADA on modbus preferably on TCP-IP. Vendor shall submit Factory Acceptance Test (FAT) report and procedure before dispatch of material to site.

Data logger shall be provided with key-locked door access and all the cables (Power and Signal) to the data logger shall be protected with heavy duty HDPE pipes.

Project file (software, settings and sample reports) shall be handed over to site on permanent storage media (CD/DVD) in two copies after data integrity is verified by site and weather monitoring is commissioned. Any configuration changes shall be possible only with authorized User ID and password.

TECHNICAL SPECIFICATIONS

5. METEOROLOGICAL STATION

Sensors shall be installed at suitable height for which Mast/Structure for the sensor shall be provided by the bidder. Proper fencing shall be provided around meteorological station where the Pyranometer, Wind, Ambient Temp. Sensor, Data logger etc. are installed.

6. SOILING STATION

The Soiling Measurement System shall measure the performance loss from a PV array due to accumulation of dust, dirt, and other site-specific contaminants, collectively known as “soiling”. Soiling Stations shall use two full-sized modules. One is allowed to soil naturally, while the other is cleaned with an automatic washing system. Power and energy are monitored for both modules.

Bidder scope cover supply of complete system and its installation that includes Data logger, Automatic Module Cleaning System, cabling, software setup and interface with solar SCADA as per the technical requirement mentioned herein. Bidder shall also provide Solar PV module and its support structure.

One soiling station for every 100MW capacity and part thereof shall be

provided. TECHNICAL REQUIREMENT

The system shall consist of an automatic cleaning system that prevents soiling accumulation on the PV reference module (clean one), another PV module (Soiled one) which is allowed to accumulate soiling at the site-specific rate, an electronic data acquisition and analysis unit.

All components are provided in outdoor rated NEMA 4/IP 65 enclosures for long-term outdoor use. All cables are rated for outdoor use.

Following requirements are to be taken care by bidder:-

Data logger shall be field tested and shall be in satisfactory operation for a period not less than 6 Months.

Data logger shall be calibrated (Measurement uncertainty less than 2%) before dispatch and calibration shall be traceable to any National/International lab. Data logger shall have flash memory not less than 1GB for local storage of data.

Bidder shall submit the write up detailing the philosophy of measurement of soiling loss in his proposal. Measurement shall be based on comparison of Isc & Power.

Datalogger shall have feature that includes but not limited to Moving Average calibration, Time Integration etc.

Bidder to facilitate the interfacing of data of Soiling Station to Solar SCADA on Modbus TCP/IP for trending, storage, retrieval and display of data

Automatic Cleaning System

TECHNICAL SPECIFICATIONS

The automatic cell-washing system cleans the PV reference module for accurate measurements. The system uses a suitable liquid spray to clean the reference module at user-determined intervals. The liquid tank is minimum 100 Liter. Under typical soiling conditions the liquid reservoir must be refilled periodically using the suitable liquid specified by OEM of Soiling station/PV module supplier.

Bidder shall supply 2 Nos of spare spray nozzle along with supply.

Measurements

The following measurement readouts are available via the Modbus interface: Direct Soiling loss readout shall be available in SCADA for display and recording.

Temperature Rating

The system shall be rated for operation in ambient air temperatures from -20 °C to 60 °C

Any alternate technology proposed by bidder shall be reviewed during detailed engineering stage.

7. PV Analyzer (complete KIT with software's)

Bidder shall provide minimum 2 Numbers of PV Analyzer Kits of reputed make to measure the PV Module performance. Analyzer kit shall have all necessary hardware connectors and required software for data analysis.

SL No	Details	Values
1.	PV Voltage	0-1500 V DC
2.	PV Current	0-30 A DC
3.	Voltage Accuracy	+/- 0.25 V
4.	Current Accuracy	+/- 40 mA
5.	Operating Temperature	0-60 Deg C

TECHNICAL SPECIFICATIONS

D-2: FIRE FIGHTING AND ALARM SYSTEM

1. GENERAL

The SPV plant shall be equipped with suitable fire protection & firefighting systems for protection of entire equipment, switchyard & control room as per CEIG requirements.

Bidder shall comply with recommendation of Tariff Advisory Committee for incurring minimal premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

2. The firefighting system for the proposed power plant for fire protection shall consist of:

- a. Sand buckets
- b. Portable fire extinguishers
- c. Microprocessor based fire alarm panel.

Portable Fire Extinguishers and Sand Buckets

Bidder to provide following numbers of type tested portable fire extinguishers as per relevant code in the rooms mentioned below.

Rooms (if applicable)	DCP Type (ABC type) (10 Kg. Capacity)	CO2 Type 9 kg capaci ty	Foam Type Hand 9 kg	Hand Portable pressurized water C02 9 Litre	Sand Buckets
Control Room	2	2	1	1	1
Each Inverter Room	1	1			
ACDB Room (If applicable	1	1			
Each Transformer Yard	1	1	1		1
Switchyard/ Metering Yard	2	2			1
Security Room		1		2	
Pantry				2	

TECHNICAL SPECIFICATIONS

Microprocessor based fire alarm panel

Bidder to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions in each loop. Fire detection alarm system shall include) but not limited to the following items

- i. Fire Alarm control Panel
- ii. Multi Sensor smoke detector
- iii. Heat Detectors
- iv. Hooter cum strobe
- v. Manual call Point
- vi. Hooter
- vii. Fault isolation modules
- viii. Control Modules
- ix. Cables from Sensors to Fire panels.
- x. Digital output from the fire detection system shall be integrated with SCADA
- xi. Network Control Module
- xii. Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA

Multi sensor type smoke detectors and heat detectors shall be provided for below false ceiling areas of control room and ACDB and/or inverter rooms. One (01) sensor shall be provided for each 20 sqm of area. All the cable trench inside the control room and inverter room shall be provided with Multi Sensor smoke detector.

Fault Isolation module shall be provided in every room and for every 15 sensors at location proposed by Bidder to be approved by employer during detail engineering.

Fire Alarm Control Panel Indication

- i. Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.
- ii. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.

TECHNICAL SPECIFICATIONS

- iii. If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.
- iv. All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset

There shall be weather proof Hooter cum strobe outside and strobe inside each Inverter room and control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. All the hardware, relay and accessories required for completeness of fire alarm system is in Bidder scope. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Each Inverter room and control room shall be also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

Bidder shall submit document to employer for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report.

Bidder shall consider 30 % design and aging margin for selection of nos. of sensors in each loop and length of each loop. Bidder shall submit the certificate from OEM indicating maximum nos. of sensors in single loop and maximum length of single loop allowed with offered panel and type of cable to be used. Each Fire Alarm Control panel shall have provision for minimum 10 (Ten) % rounded to next higher integer but not less than 2 (two) nos. spare loops for future use of employer.

Bidder shall submit Site Acceptance Test (SAT) for approval by employer. Complete fire alarm system shall be checked at site for verification of faithful performance and completeness of the system. Bidder shall carry out necessary modification and supply hardware/accessories if required free of cost at site.

TECHNICAL SPECIFICATIONS

D-3: MODULE CLEANING SYSTEM

1. Wet Cleaning system with Fresh Water:

- A. Bidder shall provide permanent arrangement for module washing in the SPV Plant. This shall include installing storage tank/deep tube/bore wells with pump and motor, requisite storage arrangement and laying network of HDPE pipe conforming to IS 4984 and other relevant codes. The module washing shall be complete in all respect and the details shall conform to the relevant IS codes. The complete scheme shall be subject to approval of the owner including inputs points, design and drawings for the system. Opening from the HDPE pipe with manual isolating valves should be provided at regular intervals. The opening pipes for fixing the movable/Hose pipes for spraying water on module shall be made of GI pipe. Bidder shall install flow meter at pump discharge/ main header for measurement of water consumption.
- B. Design of solar PV module cleaning system shall be designed such that complete solar plant can be cleaned with fresh water **twice in a month**. Module cleaning system piping network shall be **close looped pipe network configuration** consists of Main pipe, sub- main and branches in the main plot. In array layout, if solar blocks is separated from main plot due to natural water body, nallah, roads, etc; Module cleaning system piping network may be design for **dead end/tree pipe network configuration**. Cut-off valves shall be provided at suitable junction points so that the repair works may be conducted at a particular area without disturbing the whole area.

The water used for cleaning should be of appropriate quality fit for cleaning purpose as per the recommendations of module manufacturer.

- C. Bidder shall provide the piping and the instrumentation diagram (P&ID) of water washing arrangement including the physical sequence of branches, reducers, valves, pressure gauge, cleaning points with location of pump(s) and water storage tanks and submit for approval during detailed engineering.
- D. The HDPE pipe shall be suitably protected against any impact load. The HDPE pipes shall be covered higher diameter GI pipe / NP3 Hume pipe at roads crossing for protection against any heavy loads etc. at roads section. The same protection shall also be provided wherever higher loads are expected. The bidder may also propose some other protection system for HDPE pipes.
- E. Maximum length of hose pipe shall be 50 meters from tapping point.
- F. The entire water washing system shall be tested for minimum 0.5 N/mm² or double the maximum working pressure, whichever is greater.
- G. End of the branch pipes/tapping points to be bent horizontal/downward to avoid entry of foreign materials like, earth, sand leaf, gravels, etc.
- H. Bidder to ensure interconnection between the sub-systems of module washing system through isolating valve, so as module cleaning may be continued in case of outage of any sub-system.

TECHNICAL SPECIFICATIONS

- I. Bidder shall ensure that the complete module washing system is integrated suitably with bore wells, check dam, motor and water pipe-line coming at the periphery of the respective plant i.e. near central PSS.

2. Robotic Cleaning System (As applicable)

- A. The Module mounting structure/ table shall be designed and modelled considering connection details for robotic cleaning for travelling from one table to another. Crossing of overhead lines, cables through trays & pedestals, connecting approach road between the rows of MMS/Table in layouts shall be avoided for optimum use of dry/robotic cleaning system. Model of working shall be automatic cleaning, IP65 protection level, self-powered system with battery backup (without external supply), it should be compatibility & integrated with SCADA.
- B. Each plot Bidder shall supply the complete robotic cleaning system at site as per approved Array/Plant layout drawings, and supervision of installation & commissioning by supplier along with owner O&M team, all other activities related to dry/robotic cleaning including storage, loading, unloading, transportation within site, its supply including start end docking station, bridge material required complete in all aspect, nuts and bolts, fasteners, installation, coordination, commissioning and any other activity not specified herein but required for successful commissioning of dry/robotic cleaning system is included in the scope of Bidder.

3. Water Supply and Purification

- A. Raw Water would be available by Solar Park Developer through HDPE pipe line in nearby vicinity of Plots. The raw water is expected to be highly saline in nature.
- B. Raw water would be provided after desalination and suitable tapping point would be made available to all the bidders at a given location in the vicinity of Plots/ PSS. Exact location would be intimated to the bidders during detailed Engg. stage.
- C. Water after desalination shall be tapped and transported by the bidders through permanent pipe network as detailed above in preceding paras.
- D. Desalinated water as would be provided by the Owner, would be tested for its final suitability, by the bidder before using the same for module cleaning. Any further treatment of water if required for module cleaning as per technical requirements of modules, would be in Bidder's Scope only.
- E. Accordingly, if required, Suitable capacity water softening / purification or RO system, as decided by the Bidder, shall be installed by the bidder for their respective scope of project(s), to make the supplied water as well as any rainwater stored through pits or RWH system, suitable for module cleaning and O&M purposes.

TECHNICAL SPECIFICATIONS

- F. Suitable Earthing shall be provided as per I.E Rule/Act. Mandatory permission for bore well drilling shall be arranged by contractor if required from local competent.

4. Main Road Crossing

- A. Permanent Main Road along with side drains passing horizontally through the park in East- West Direction is envisaged to be built by the Owner.
- B. Few Culverts are being provided to interconnect the Drains / Plots on N-S side of the Roads (**Refer Roads, Drain and Tr. Line Layout Drawing**).
- C. Pipe / Cabling etc. where-ever required to pass the main road, would be suitably routed preferably through such culvert. However, it may be noted that because such culverts would be subject to water ingress during monsoons, bidders would be required to plan their pipe /cable routing and overall system design in a manner that all pipes, cables, equipment, panels etc., are safe for operation, during design life of plant.

TECHNICAL SPECIFICATIONS

D-4: PROJECT COMMISSIONING AND OTHER GENERAL REQUIREMENTS

1. PART CAPACITY COMMISSIONING:

Owner/ Company shall accept part capacity commissioning of Solar plant subject to the following conditions:

- i. If acceptable to the solar power buying entity as per power sale conditions.
- ii. Minimum capacity for acceptance of first and subsequent part(s) commissioning shall be subject to acceptance of RLDC/other statutory bodies in compliance with grid code and other regulations/power sale conditions as mentioned above.

General conditions for Part/Final commissioning

- i. All strings as per approved design shall be connected to inverter DC side.
- ii. Corresponding AC side works shall be completed for arranging dispatchable power to Grid along with data communication till RLDC.
- iii. The commissioning clearances shall be obtained from statutory authorities.

Scheduled Commissioning date will not get altered due to part commissioning.

Part Capacity/Final Commissioning and Trial run shall be carried out in compliance with the all-applicable statutory regulations (Latest) like Indian Electricity Grid Code, SLDC/RLDC, MNRE, CEA, STU/CTU requirements.

SPV Plant shall be deemed to be successfully commissioned only after commissioning acceptance/approval by RLDC for such capacity.

2. INSURANCE

The bidder's insurance liabilities pertaining to the scope of works are detailed out in Clauses titled Insurance in NIT.

TECHNICAL SPECIFICATIONS

D-5: OPERATION AND MAINTENANCE

1. The successful bidder shall carryout Operation and maintenance of complete SPV Plant along with power evacuation system till point of grid interconnection (including grid substation bays) from date of commissioning of full project capacity. Additionally, bidder to refer commercial portion of bidding document for details regarding O&M of part capacity commissioned. During O&M period, Owner/ Company personnel shall have unrestricted entry to the solar plant and Control Room any time. Owner/ Company may suitably depute its personals to associate with O&M activities. Contractor shall assist them in developing expertise through their day to day O&M activities. All records of maintenance must be maintained by the contractor which can be accessed by Owner/ Company on demand. These records are to be handed over to Owner/ Company after the O&M period of contract.
2. The bidder shall be responsible for supply of all spare parts, repairs / replacement of any defective equipment at his own cost as required from time to time during the O&M period.
3. The contractor shall be responsible for the Operation and Maintenance of the entire Solar PV plant during the O&M period. The brief scope of works is listed below. The details shall be further elaborated by the bidder in the O&M manual to be submitted to Owner/ Company for approval.
 - (a) Ensuring successful operation of SPV Plant for optimum energy generation.
 - (b) Ensuring Breakdown maintenance, Preventive maintenance overhauls, arranging visit of O&M experts (when required) to maximize the availability of the solar plant.
 - (c) Daily work of the operators involves logging the voltage, current, power factor, power and energy output of the SPV plant, temperature, logging down individual array output data once a day
 - (d) The operator shall record monthly energy output of each array and transformer and reports shall be prepared on performance of SPV plant
 - (e) Submission of periodical reports to the owner on the energy generation & operating conditions of the SPV plant.
 - (f) Ensuring Safety and protection of the plant by deputing sufficient security personals
 - (g) Monitoring, controlling, troubleshooting, maintaining of records, registers.
 - (h) Supply of all type of maintenance spares, consumables and fixing / application of the same. In order to meet the emergent requirements, contractor, with the permission of Employer can utilize the mandatory spares being supplied under the contract. However, the used spares shall be replenished by the contractor within reasonable time.

TECHNICAL SPECIFICATIONS

- (i) Cleaning of the plant including array yard on regular basis and as and when required.
- (j) Cleaning of drains, cable trenches, box culverts etc.
- (k) Module washing as per as per approved schedule.
- (l) Herbicide spray and grass cutting on a periodic basis
- (m) The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
- (n) The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his employees or his Co-contractor's employees
- (o) The Contractor shall immediately report the accidents, if any, to the Engineer In charge & to all the concerned authorities as per prevailing laws of the state.
- (p) 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, Employees State Insurance Act 1948, Contract Labor (Regulations & Abolishment) Act 1970 or any modification thereof or any other law relating whereto and rules made there under from time to time.
- (q) In order to ensure longevity, safety of the core equipment and optimum performance of the system the contractor should use only genuine spares of high-quality standards.
- (r) Deployment of Plant in Charge, adequate number of technical support staff and other supporting personnel during the O&M period
- (s) Bidder is required to maintain adequate O&M spare during the O&M contract period of the Solar PV plant with the view to maximize availability and generation of the plant. In case, Contractor uses mandatory spares, provided by Owner/ Company, the contractor shall have to return/replenish the spare(s) of the matching quality, quantity and rating within shortest possible time.
- (t) At the time handing over of the plant by the contractor to Owner/ Company, the contractor shall handover equipment and spares in healthy condition.
- (u) Bidder has to take Comprehensive Annual Maintenance Contract (AMC) from Original Equipment Manufacturer (OEM) **or OEM authorized service provider** for a period of 10 years for the following components:
 - PCU System
 - Replacement of spares like inductors, capacitors, electronic cards as per OEM recommendations
 - SCADA & PPC
 - Tracker System

TECHNICAL SPECIFICATIONS

Replacement of spares as per OEM recommendations

Comprehensive AMC shall include all preventive maintenance and breakdown maintenance including replacement of any component to ensure that equipment is working satisfactorily as per design/system requirement. During AMC period, the OEM or its representative are required to visit at least once a year or as per OEM recommendation cycle for periodic maintenance. During AMC period, the OEM is required to respond within one working day through telecom or any electronic mean. In case of breakdown of the system, OEM has to send their representative within 72 hours. For the minor faults not hampering the generation e.g. communication, display etc., the OEM has to get the fault rectified within 7 working days.

Failure from the OEM to adhere the activity and the time schedule may lead to BG encashment.

- (v) Replacement of equipment/spare parts/ updating of software's being phased out or not being supported by OEM's is also included in bidder's scope.
- (w) Contractor shall be responsible to carry out all test and work as required by statutory regulation in effect as on date of Techno-commercial bid opening during O&M period.

4. Insurance

As Per NIT

5. LD for shortfall in Generation during O&M

Refer special condition of contract section-III

Calculation of LD and Proposal for 50 MW Sample Project

As per clause 2.0 APPENDIX 3A of TECHNICAL SPECIFICATIONS

Contractors' liability during AMC period.

As per this chapter and Chapter 1-A (Appendix – 3B)

6. Handing over of the Plant

- (a) At the end of the contract period, the contractor shall hand over the plant and equipment back to the owner in completely safe and healthy condition and without any pending defect.
- (b) The items supplied by Owner/ Company on returnable basis, such as spares parts (from mandatory spares or through procurement)), consumables, tools and plants, documents etc. shall be returned back to Owner/ Company. Else suitable recoveries shall be made from the Contractor's bills.

TECHNICAL SPECIFICATIONS

7. After O&M period, Owner/ Company may at its discretion decide to extend the existing O&M contract on mutually acceptable terms & conditions or undertake the O&M of the SPV Plant on its own.

TECHNICAL SPECIFICATIONS

D-7: SAFETY MANAGEMENT

1. Bidder shall submit the Safety Plan and the Safety Coordination Procedure as per the requirement of relevant Attachments of the bidding documents.
2. During the execution of the contract, the bidder and its sub-vendor (if any) shall follow safety procedures for the safety of the personnel and the equipment during erection, testing, commissioning, operation and the maintenance during the contract period as per the regulatory requirements and the as per the original equipment manufacturer's recommendations.
3. All the expenses, charges towards compliance of the safety norms by the bidder as per the Safety Plan, Safety Policy, and the Safety Coordination Procedures are deemed to be included in the bid price. No additional claims shall be entertained towards meeting the safety requirements. Minimum price to be quoted for 'Safety Aspects/ compliance to Safety Rules' shall be as per relevant clause of bidding document.
4. Safety sign board to be provided near outdoor transformer yard, HT switchgear and all

TECHNICAL SPECIFICATIONS

PART-E: QUALITY ASSURANCE

TECHNICAL SPECIFICATIONS

E-1: QUALITY ASSURANCE ELECTRICAL

COMPONENTS	
1	PCU
2	Switchgear & LT Busduct
3	Cabling, Earthing, Lightning Protection.
4	Control Cables
5	LT Power Cables
6	MV (3.3kV/ 6.6 kV/ 11kV/ 33kV) Cables
7	HT Switchgear
8	SCADA and Accessories
9	DC System a. Battery b. Battery Charger c. DC Health Monitoring System
10	Station Lighting
11	Transformer
12	Switchyard/Substation
13	Energy Meter
14	Module cleaning System and Ventilation

Components wise QA Chapter has been furnished below.

Indicative list of Vendors Approved for Electrical Components & Civil works are enclosed below.

TECHNICAL SPECIFICATIONS

1. PCU (Inverter)

PCU quality plan should include the following:

- A. Incoming Quality Checks on bought out items as per relevant standard as mentioned in Technical Specifications (TS)
- B. In-process quality checks
- C. Routine tests as per following on the assembled PCU:
 - i. Check of Dimension, Paint shade, Paint Adhesion, Thickness, make, rating, degree of protection, doors.
 - ii. Uploading of Software to control board and checking of general parameter setting including protection settings (Manufacturer to perform on 100% Panel)
 - iii. Control Circuit functional check including operation of contactors, relay and Circuit breakers (Manufacturer to perform on 100% Panel)
 - iv. Display Panel functionality including Digital Input/Output check, Direction of rotation and ON-OFF control of the fans, Protection function check (by simulation or direct method), Abnormal voltage and frequency, DC ground fault, DC reverse polarity, AC & DC Over voltage, Calibration test (DC Voltage, AC Voltage and Frequency), Testing of wake up / auto start and stop with grid connectivity, Manual ON/OFF from PCU MMI with grid connectivity, IR test on main and control circuit, HV test on main and control circuit. (Manufacturer to perform on 100% Panel)
- D. Following sample tests on the assembled PCU: (1 Panel per offered lot)
 - i. Sample testing to include measurement of phase currents, efficiencies, harmonic content and power factor at four points preferably 25%, 50%, 75% and 100% of the rated nominal power.
 - ii. Maximum power point tracking (MPPT) functional check

TECHNICAL SPECIFICATIONS

2. LT SWITCHGEAR & BUS DUCT

LT SWITCHGEAR

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERISTICS														
SUB SYSTEM ASSEMBLY ITEMS/ COMPONENTS/	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per Owner/ Company Spec.	Item to conform to relevant Standards	Pre-treatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per Owner/ Company spec	All Routine tests as per Owner/ Company spec.
Sheet Steel (IS :513)	Y	Y		Y	Y		Y							
Aluminium Bus bar Material (IS: 5082)	Y	Y	Y	Y	Y		Y							
Copper Bus bar Material (IS: 613)	Y	Y	Y	Y	Y		Y							
Support Insulator	Y	Y	Y	Y			Y							
Air Circuit Breaker (IS:13947)	Y	Y				Y	Y			Y	Y			Y
Energy Meters (IS: 13010,13779)	Y	Y				Y	Y			Y				Y
Power & Aux. Contactors (IS: 13947)	Y	Y				Y	Y			Y				
Protection & Aux. Relays (IS: 3231) (IEC 60255/ IEC61850)	Y	Y				Y	Y			Y				Y
Control & Selector Switches (IS: 13947)	Y	Y				Y	Y			Y				
CT's & PT's (IS 2705 /3156)	Y	Y					Y							Y

TECHNICAL SPECIFICATIONS

MCCB (IS: 13947)	Y	Y					Y			Y				
Indicating Meters (IS: 1248)	Y	Y				Y	Y			Y				Y
Indicating Lamps (IS: 13947)	Y	Y				Y	Y			Y				
Air Break Switches (IS: 13947)	Y	Y				Y	Y			Y				
Control Terminal Blocks	Y	Y				Y	Y							

TECHNICAL SPECIFICATIONS

LT SWITCHGEAR																
(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)																
ATTRIBUTES CHARACTERISTICS		↓ ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLY	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per Owner/	Item to conform to relevant Standards	Pre-treatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per Owner/ Company spec	All Routine tests as per Owner/ Company spec. & IS
Fuse (IS 13703)		Y	Y					Y	Y							
Control Transformer (IS: 12021)		Y	Y					Y	Y			Y				Y
Push Buttons (IS: 4794)		Y	Y					Y	Y			Y				
Transducer (IEC: 60688)		Y	Y					Y	Y			Y				Y
CB (IS: 8828)		Y	Y					Y	Y			Y				
Breaker Handling Trolley		Y	Y					Y			Y	Y				Y
Synthetic Rubber Gasket (IS: 11149)		Y	Y			Y	Y		Y							
LT SWITCHGEAR IS: 8623		Y	Y					Y	Y	Y	Y	Y		Y	Y	Y
Notes:																
- This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents. - Makes of all major Bought Out Items will be subject to Owner/ Company approval.																

TECHNICAL SPECIFICATIONS

ELECTRICAL ACTUATOR WITH INTEGRAL STARTER

Test/Attributes Characteristics ITEM/ COMPONENT / SUB SYSTEM ASSEMBLY/ TESTING	RPM ®	No Load Current ®	IR & HV Test®	Mounting Dimension®	All routine Test as per Standard & Specification®	Correct Phase Sequence®	Operation & Setting of limit Switch/Torque Switch®	Stall Torque/Current (A)	Hand Wheel operation/ Auto de clutch function (A)	Function of Aux. like Potentiometer, space heater, position indicator ®	EPT output ®	Grease leakage ®	Local/ Remote (Open-Stop-Close) Operation® Safety check (Single phasing, Phase correction, Tripping etc.) (A)
ELECTRIC A L ACTUATO R WITH INTEGRA L STARTER(I S_9334)													
Motor	Y	Y	Y	Y	Y								
Final Testing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Note: 1) This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the practices and procedure adopted along with relevant supporting documents. ® - Routine Test (A) - Acceptance Test Y - Test applicable													

TECHNICAL SPECIFICATIONS

LT BUSDUCT															
ITEM, COMPONENTS, SUB SYSTEM ASSEMBLY	Dimension & Surface Finish	Make, Type, Rating & TC	Electrical Properties	Mechanical Properties	Chemical Properties	Item to conform to relevant IS	WPS Approval, Welder Qualification	Weld Quality Check (DP test & x-ray Test)	Paint Shade, Thickness, Adhesion & Finish	Tightness by Torque measurement	Electrical Clearances	Galvanizing Test as per IS 2629/2633/ 4759	IR – HV – IR Test	Phase Sequence Check	Degree of Protection routine test as per Owner/ Company spec.
Aluminium Sheets / Plates / Strips/Flexibles / tubes (IS : 5082/ 737)	Y	Y		Y	Y	Y	Y	Y							
CRCA Flats / ISMC (IS 2062)	Y	Y		Y	Y	Y									
Neoprene / Synthetic Rubber Gaskets (IS 11149 / 3400)	Y	Y		Y	Y										
Rubber Bellows (IS :3400)	Y	Y		Y	Y										
Support Insulator (BS : 2782, IEC : 660, IS : 10912)	Y	Y	Y	Y											
Galvanized Structure & GI Earthing Flat (IS : 2629 / 2633 / 4749)	Y	Y				Y						Y			
Space Heater & Thermostat		Y	Y										Y		
LT Busduct (IS : 8623 PART 2)	Y	Y				Y	Y	Y	Y	Y	Y		Y	Y	Y
Notes:															
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.															
2. Makes of all major Bought Out Items will be subject to Owner/ Company approval.															

TECHNICAL SPECIFICATIONS

3. CABLING, EARTHING, LIGHTNING PROTECTION

TECHNICAL SPECIFICATIONS

ATTRIBUTES/CHARACTERISTICS	ITEMS/COMPONENTS / SUBSYSTEMS	Dimension	Panel shape, paint/thickness adhesion	Pre-treatment of sheet	IP protection	Proof Load	Surface finish	Detection test*	HV & IR	Galvanise Test (if Applicable)	Functional	Bought out items/Bill of material	Routine tests as per relevant standard & specification		
Wall Mounted-Lighting Panel (IS-513, IS:2629, 6745)		Y	Y	Y	Y		Y		Y		Y	Y	Y	Y	Y
Switch box/junction box/ Receptacles Panel (IS-513, IS:2629, 6745)		Y	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y
Cable glands (IS-8121)		Y													Y
Cable lug		Y													Y
Lighting wire (IS-694)		Y											Y		Y
Flexible conduits (Galvanise & Epoxy) (IS-9537 & IS:2629, 2633, 6745)		Y		Y						Y			Y		Y

TECHNICAL SPECIFICATIONS

RCC Hume Pipe (IS-458)												Y		Y
Cable termination & straight through joint (IS 13573)	Y											Y	Y	Y
Cable Trays, bends, tees, crosses, Flexible supports system & accessories IS-513, IS:2629, 2633, 6745	Y		Y		Y	Y	Y		Y			Y		Y
Trefoil clamp	Y													Y
GI flats for earthing & lighting protection (IS 2062, 2629, 2633, 6745, 2833)	Y		Y						Y			Y		Y
GI Wire	Y											Y		Y
Fire sealing system (BS-476)												Y	Y	Y

Note:

1. This is an indicative list of tests /checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. *Deflection Test on cable trays and Proof Load test on cable trays support system will be as per details given in the Owner/ Company technical specification & approved MQP. The above acceptance tests shall be done only on one sample from each size of offered lot. This test is not applicable on bends, tees & crosses.
3. Make of all items will be subject to Owner/ Company approval.

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

4. CONTROL CABLES

CONTROL CABLES															
ITEM, COMPONENTS, SUB SYSTEM ASSEMBLY	Make, Type & T.C as per relevant standard	Dimension/surface finish	Mechanical properties	Chemical Composition	Spark Test(as applicable)	Electrical properties	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal stability	Anti termite coating on wooden drums	Constructional requirements feature as per CIL specification	Routine & Acceptance Tests as per relevant standard & CIL specification	FRLS Tests
Copper (IS-8130)	Y	Y	Y	Y		Y									
PVC insulation Compound (IS:5831)	Y		Y			Y				Y	Y				
FRLS PVC Compound (IS-5831,ASTMD2843, IS:10810(Part 58), IEC-60754 Part-1)	Y		Y							Y	Y				Y
Extrusion & curing /Manufacturing of Core		Y			Y						Y				
Core Laying							Y								
Armour wire/strip	Y	Y	Y												
Inner sheath	Y	Y													
Armouring		Y						Y							
Outer Sheathing		Y							Y						
Finished Cable (IS- 5831, ASTM- D2843, IS10810 (Part 58), IEC- 60754 Part-1, IEC 60332 part III cat B)								Y	Y	Y	Y		Y	Y	Y
Wooden drum(IS- 10418) /Steel Drum		Y										Y	Y		
Notes:															
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.															
2. Makes of all major Bought Out Items will be subject to Owner/ Company approval.															

TECHNICAL SPECIFICATIONS

ROUTINE TESTS		Following routine tests shall be carried out on each drum of finished cables for all sizes.
1)		Conductor Resistance test
2)		High voltage test
ACCEPTANCE TESTS		Following Acceptance tests shall be carried out on each size of cables, in the offered lot.
A) For Conductor (as per sampling plan mentioned in IS: 1554)		
	1)	Annealing test (Copper)
	2)	Resistance test
B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IS: 1554)		
	1.	Measurement of Dimensions
	2.	Tensile Tests
	3.	Elongation Test
	4.	Torsion Test For Round wires only
	5.	Wrapping Test
	6.	Resistance Test
	7.	Mass of Zinc coating test For G S wires / Formed wires only
	8.	Uniformity of Zinc coating For G S wires / Formed wires only
	9.	Adhesion test For G S wires / Formed wires only
	10.	Freedom from surface defects
C) For PVC insulation & PVC Sheath (as per sampling plan mentioned in IS: 1554)		
	1)	Test for thickness
	2)	Tensile strength & Elongation before ageing (for tests after ageing see "D")

D) Ageing test:

TECHNICAL SPECIFICATIONS

If the compound manufacturer is carrying out Ageing test, test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch).

E) Following tests will be carried out on completed cables as per IS on each size:

	1)	Insulation resistance test (Volume resistivity method)
	2)	High voltage test

F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes):

	1)	Thermal stability test on PVC insulation and outer sheath
	2)	Oxygen index test on outer sheath
	3)	Smoke density rating test on outer sheath
	4)	Acid gas generation test on outer sheath

G) Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable will be carried out as per following sampling plan:

		This test will be carried out using composite sampling i.e. irrespective of size; cables of one particular type (i.e. armoured, unarmoured) will be bunched together, as per calculations in line with the IEC. All sizes of armoured & unarmoured cables shall be covered.

H) Following tests shall be carried on one length of each size (armoured & unarmoured) of offered lot:

	1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, drum / outer sheath extrusion's batch number marking
	2)	Measurement of Eccentricity & Ovality

GENERAL NOTE:

TECHNICAL SPECIFICATIONS

(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre: - Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis.

(b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre: - Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.

1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.

TECHNICAL SPECIFICATIONS

5. LT POWER CABLES

Attributes/Characteristics Item / Components / Sub System Assembly	Make, Type & T.C as per relevant standard	Dimension/surface finish	Mechanical properties	Chemical Composition	Spark Test(as applicable)	Electrical properties	Hot Set Test/ Eccentricity & Ovality	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal stability	Anti termite coating on wooden drums	Constructional requirements feature as per Owner/ Company specification	Routine & Acceptance Tests as per relevant standard & Owner/ Company specification	FRLS Tests
Aluminum (IS-8130)	Y	Y	Y	Y		Y										
XLPE Compound (IS-7098)	Y		Y			Y	Y				Y					
PVC insulation Compound (IS: 5831)	Y		Y			Y					Y	Y				
FRLS PVC Compound (IS-5831, ASTM-D2843, IS10810(Part 58), IEC-60754 Part-1)	Y		Y								Y	Y				Y
Extrusion & curing /Manufacturing of Core (PVC / XLPE)		Y			Y		Y					Y				
Core Laying								Y								
Armour wire/strip	Y	Y	Y													
Inner sheath	Y	Y														
Armouring		Y							Y							
Outer Sheathing		Y								Y						
Power Cable (Finished) (IS-5831, ASTM-D2843, IS10810(Part 58), IEC-60754 Part-1, IEC 60332 part III cat B)								Y	Y	Y	Y	Y		Y	Y	Y
Wooden drum(IS-10418) /Steel Drum		Y											Y	Y		

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought out items will be subject to Owner/ Company approval.

TECHNICAL SPECIFICATIONS

ROUTINE TESTS	Following routine tests shall be carried out on each drum of finished cables for all types (PVC / XLPE insulated) & sizes.	
3)	Conductor Resistance test	
4)	High voltage test	
ACCEPTANCE TESTS	Following Acceptance tests shall be carried out on each size of each type (PVC / XLPE insulated) of cables, in the offered lot.	
A) For Conductor (as per sampling plan mentioned in IS: 1554 / 7098)		
	1)	Annealing test (Copper)
	2)	Tensile Test (Aluminum)
	3)	Wrapping Test (Aluminum)
	4)	Resistance test
B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IS: 1554 / 7098)		
	1.	Measurement of Dimensions
	2.	Tensile Tests
	3.	Elongation Test
	4.	Torsion Test For Round wires only
	5.	Wrapping Test
	6.	Resistance Test
	7.	Mass of Zinc coating testFor G S wires / Formed wires only
	8.	Uniformity of Zinc For G S wires / Formed coating wires only
	9.	Adhesion test For G S wires / Formed wires only
	10.	Freedom from surface defects
C) For PVC / XLPE insulation & PVC Sheath (as per sampling plan mentioned in IS: 1554 / 7098)		
	1)	Test for thickness
	2)	Tensile strength & Elongation before ageing (for tests after ageing see “D”)
	3)	Hot set test (For XLPE insulation)

TECHNICAL SPECIFICATIONS

D) Ageing test:

If the compound manufacturer is carrying out Ageing test, test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch)

E) Following tests will be carried out on completed cables as per IS on each size of each type (PVC / XLPE insulated)

	1)	Insulation resistance test (Volume resistivity method)
	2)	High voltage test

F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes & types)

	1)	Thermal stability test on PVC insulation and outer sheath
	2)	Oxygen index test on outer sheath
	3)	Smoke density rating test on outer sheath
	4)	Acid gas generation test on outer sheath

G) Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cables as per following sampling plan:

		This test will be carried out using composite sampling i.e. irrespective of size; cables of one particular type (i.e. armoured PVC insulated, unarmoured PVC insulated, armoured XLPE insulated, unarmoured XLPE insulated) will be bunched together, as per calculations in line with the IEC. All sizes of PVC & XLPE insulated, armoured & unarmoured cables shall be covered. For one particular type, cables with OD less than or equal to 30 mm shall be clubbed together in touching formation while cables with OD greater than 30 mm shall be clubbed together leaving a gap equal to OD of cable having least diameter. Cable OD shall be taken as nominal overall diameter as per Owner/ Company approved datasheet.

H) Following tests shall be carried on one length of each size of each type (PVC / XLPE insulated) of offered lot:

	1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, drum / Batch (outer sheath extrusion batch)number marking on sheath
	2)	Measurement of Eccentricity & Ovality

TECHNICAL SPECIFICATIONS

GENERAL NOTE:		

(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis.

(b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on

10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.

1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.

TECHNICAL SPECIFICATIONS

6. MV (3.3 KV / 6.6. KV / 11 KV / 33 KV) CABLES

Attributes/Characteristics	Item / Components / Sub System Assembly	Make, Type & T.C as per relevant standard	Dimension/surface finish	Mechanical properties	Chemical Composition	Spark Test(as applicable)	Electrical properties	Hot Set Test/ Eccentricity & Ovality	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal stability on outer sheath	Metallic (Cu) Screening If applicable	Anti termite coating on wooden drums	Constructional requirements feature as per Owner/ Company specification	Routine & Acceptance Test as per relevant standard & Owner/ Company specification	FRLS Test
Aluminum (IS-8130)		Y	Y	Y	Y		Y											
Semiconducting Compound		Y		Y			Y											
XLPE Compound (IS-7098 Part-II)		Y		Y			Y					Y						
FRLS PVCCompound (IS-5831, ASTM- D2843, IS10810(Part 58) ,IEC-60754 Part-1)		Y		Y								Y	Y					Y
Triple Extrusion & curing /Manufacturing of Core			Y			Y	Y											
Copper Tape		Y	Y	Y			Y											
Polyster tape		Y	Y															
Core Laying									Y									
Armour wire/strip		Y	Y	Y														
Copper tapping		Y	Y											Y				
Inner sheath		Y	Y															
Armouring			Y							Y								
Outer Sheathing			Y								Y							
Power Cable (Finished)									Y	Y	Y	Y	Y			Y	Y	Y
Wooden drum(IS-10418) /Steel Drum			Y												Y	Y		

Notes: 1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

Make of all major Bought out items will be subject to Owner/ Company approval.

TECHNICAL SPECIFICATIONS

ROUTINE TESTS	Following routine tests shall be carried out on each drum of finished cables for all types & sizes.	
1)	Conductor Resistance test	
2)	High voltage test	
3)	Partial discharge test (for Screened cables only)	
ACCEPTANCE TESTS	Following Acceptance tests shall be carried out on each size of each type (voltage rating) of cables, in the offered lot.	
A) For Conductor (as per sampling plan mentioned in IS: 7098 Part II)		
	1)	Annealing test (Copper)
	2)	Tensile Test (Aluminum)
	3)	Wrapping Test (Aluminum)
	4)	Resistance test
B) For copper tape / Wires (as per sampling plan mentioned in IS: 7098 Part II)		
	1)	Measurement of Dimensions
	2)	Conductivity check
B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IS: 7098 Part II)		
	1.	Measurement of Dimensions
	2.	Tensile Tests
	3.	Elongation Test
	4.	Torsion Test For Round wires only
	5.	Wrapping Test
	6.	Resistance Test
	7.	Mass of Zinc coating test For G S wires / Formed wires only
	8.	Uniformity of Zinc coating For G S wires / Formed wires only
	9.	Adhesion test For G S wires / Formed wires only
	10.	Freedom from surface defects
C) For XLPE insulation & PVC Sheath (as per sampling plan mentioned in IS: 7098 Part II)		
	1)	Test for thickness
	2)	Tensile strength & Elongation before ageing (for tests after ageing see “D”)
	3)	Hot set test (For XLPE insulation)
D)	Ageing test:	

2

TECHNICAL SPECIFICATIONS

If the compound manufacturer is carrying out Ageing test , test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch)

(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate

Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis.

(b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100%

basis.

1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.

E) Following tests will be carried out on completed cables as per IS on each size of each type

1)	Insulation resistance test (Volume resistivity method)
2)	High voltage test
3)	Partial discharge test (for Screened cables only)

F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes & types)

1)	Thermal stability test on outer sheath
2)	Oxygen index test on outer sheath
3)	Smoke density rating test on outer sheath
4)	Acid gas generation test on outer sheath
5)	Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable

G) Following tests shall be carried on one length of each size of each type of offered lot:

1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking,

TECHNICAL SPECIFICATIONS

		marking of drum no. / Batch number of outer sheath extrusion
	2)	Measurement of Eccentricity & Ovality
GENERAL NOTE:		
(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis. (b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through		
Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.		
1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.		

TECHNICAL SPECIFICATIONS

7. HT SWITCHGEAR

ATTRIBUTES CHARACTERISTICS															
	ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLY	Make, Model, Type, Rating & TC	Electrical properties	Mechanical Properties	Chemical properties	Dimensions & Finish	Constructional, Functional & Operational Features as per Company/Owner Spec.	Item to conform to relevant Standards	Pre-treatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	IR – HV – IR Test	Degree of Protection Routine test as per Owner/ Company spec	CB Operation timing check	All Routine tests as per Owner/ Company spec. & IS
	CRCA steel sheet/ Aluzinc*/ Zinalum*/ Galvalum*	Y	Y	Y	Y	Y									
	Aluminum Bus bar material (IS : 5082)	Y	Y	Y	Y	Y	Y								
	Copper Bus bar material (IS : 613)	Y	Y	Y			Y								
	Bus bar Support Insulator	Y	Y	Y			Y					Y			
	HT Circuit Breaker (IEC-62271-100)	Y				Y	Y	Y			Y			Y	Y
	HT Contactors (IS : 9046 / IEC 60470)	Y				Y	Y	Y			Y				Y
	Protection & Auxilliary Relays	Y				Y	Y	Y			Y				Y
	HT CT's & PT's (IS : 2705 / 3156)	Y				Y		Y							Y
	HT Fuses (IS : 9385)	Y				Y	Y	Y							
	Surge Arrester (IEC : 99 –4)	Y				Y		Y							Y

TECHNICAL SPECIFICATIONS

LT Contactors (IS : 13947)	Y				Y	Y	Y			Y				
Control & Selector Switches (IS : 6875)	Y				Y	Y	Y			Y				
Indicating Meters (IS : 1248)	Y				Y	Y	Y			Y				Y
Indicating Lamps (IS : 13947)	Y				Y	Y	Y			Y				
Push Buttons (IS : 4794)	Y				Y	Y	Y			Y				
Control Transformer (IS : 12021)	Y				Y	Y	Y			Y				Y
LT Fuses (IS : 13703)	Y				Y	Y	Y							
Energy Meters (IS : 722)	Y				Y	Y	Y			Y				Y
Transducers (IEC : 60688)	Y				Y	Y	Y			Y				Y
Diodes	Y	Y				Y	Y			Y				
Terminal Blocks	Y	Y				Y	Y							
Synthetic Rubber Gasket (IS : 11149 / 3400)	Y	Y			Y		Y							
Breaker Handling Trolley	Y				Y	Y			Y	Y				
HT Switchgear Panel IEC-62271-200)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
 2. Make of all major Bought Out Items will be subject to Company approval
 3. Temperature rise test reports for diode plates with actual heat sink will be verified.
- *. CRCA Galvanized steel with metal coating composed of Al (55%), Zn (43.4%) & Si (1.6%),

TECHNICAL SPECIFICATIONS

8. SCADA & ACCESSORIES

PROGRAMMABLE LOGIC CONTROLLER																
Items	Tests	Visual ®	GA, BOM, Lay Out of components ®	Dimensions ®	Paint Shade/ Thickness/Adhesi	Alignment of Section ®	Component Rating/ Make / Type ®	Wiring ®	IR & HV ®	Review of TC for instruments/ Devices/ Recorders, Indicators/ Mosaic Items/	Accessibility of TBS/ Devices ®	Illumination ®	Functional Check for Control Element , Annunciation ®	Mimic ®	Test as per IEC 1131 ® *	Test as per Std ® & (A)
PLC Panel		Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	Y
Control Desk with PLC		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Note: 1. This is an indicative list of test/ checks. The manufacturer is to furnish a detailed quality plan indicating the Practice and Procedure along with relevant supporting documents. *Applicable for PLC Y - Test Applicable, ® - Routine Test (A) – Acceptance Test																

TECHNICAL SPECIFICATIONS

CONTROL DESK, PLC PANEL, SMOKE DETECTOR, FIRE ALARM & CONTROL SYSTEM																
ITEMS	TESTS															
		Visual ®	GA, BOM, Lay Out of components ®	Dimensions ®	Paint Shade/Thickness/Adhesion ®	Alignment of Section ®	Component Rating/ Make / Type ®	Wiring ®	IR & HV ®	Review of TC for instruments/ Devices/ Recorders, Indicators/ mosaic Items/ Transducers ®	Accessibility of TBS/ Devices ®	Illumination ®	Functional Check for Control Element , Annunciation	Mimic ®	Test as per IEC 1131 ® *	Test as per Std ® & (A)
1. Control Desk		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
2. Annunciation/ Control/ PLC Panel		Y	Y	Y	Y		Y	Y	Y	Y	Y			Y	Y	
3. Smoke Detectors (UL-268, EN-54 PT-7), Heat Detectors (UL-521/EN 54 PT-5) Annunciation/ Control Panel (UL -864, EN- 54, PT-2)															Y	
Note: 1) Detailed procedure of Environmental Stress Screening test shall be as per Quality Assurance Programme in General Technical Conditions 2) This is an indicative list of test/ checks. The manufacturer is to furnish a detailed quality plan indicating the Practice and Procedure along with relevant supporting documents. • *Applicable for PLC • Y - Test Applicable, ® - Routine Test (A) - Acceptance Test																

TECHNICAL SPECIFICATIONS

INSTRUMENTATION CABLE

TESTS	ITEMS	Conductor Resistance @ & (A)	High Voltage @ & (A)	Insulation Resistance @ & (A)	Constructional detail, dimensions (A)	Outer-Sheath/core marking, end sealing (A)	Thermal Stability (A) +	Visual, Surface finish (A) +	Electrical Parameters ** (A) +	Persulphate Test (A) +	Overall/Coverage/Continuity (A)	Swedish chimney Test (SS-4241475) (A) ++	FRLS Test (A) ++	Tensile & Elongation before & after aging (A) ++	Vol. Resistivity, at room & Elevated Temp. (A) ++	Spark test report review @
Instrument cable twisted and shielded																
Conductor (IS-8130)	Y			Y			Y									
Insulation (VDE-207)				Y	Y	Y	Y							Y		Y
Pairing/Twisting				Y	Y		Y									
Shielding				Y			Y			Y						
Drain wire	Y			Y			Y		Y	Y						
Inner Sheath				Y	Y	Y	Y					Y	Y			
Outer Sheath				Y	Y	Y	Y					Y	Y			
Over all cable	Y	Y	Y	Y	Y		Y	Y			Y			Y		
Cable Drums (IS-10418)				Y			Y									

Note: High Temp. cables shall be subjected to tests as per VDE-207(Part-6) Compensating cables shall be checked for Thermal EMF/Endurance test as per IS 8784.

Note: This is an indicative list of tests/checks. The manufacture is to furnish a detailed Quality Plan indicating his practice & Procedure along with relevant supporting documents during QP finalization for all items.

Note: ® - Routine Test A - Acceptance Test Y - Test Applicable

Note: Sampling Plan for Acceptance test shall be as per IS 8784 (As applicable)

- * FRLS Tests: Oxygen / Temp Index (ASTM D-2863), Smoke Density Rating (ASTM – D 2843), HCL Emission (IEC-754-1)

- ** Characteristic Impedance, Attenuation, Mutual Capacitance, Cross Talk (As applicable)

+ Sample size will be One No. of each size/type per lot.

++ Sample size will be One No. sample for complete lot offered irrespective of size/type.

TECHNICAL SPECIFICATIONS

POWER SUPPLY FOR C&I SYSTEMS (UPS/BATTERY/BATTERY CHARGER/ACDB/DCDB)

TESTS	ITEMS	Visual/ dimension/rating/Paint Adhesion/ Thickness (R)	General arrangement/BOM/make of components (R)	Efficiency/ regulation (A)	Input voltage variation (A)	Output voltage and frequency adj. range (A)	Preliminary light load test (R)	Load transfer and return test (R)	AC input failure and return test (R)	Partial operation and current division (R)	Relative harmonic content (R)	Restart with PRI, AC and battery (separately)(R)	System transfer and retransfer (R)	Asynchronous transfer (R)	Ripple content (R)	Load limiter operation (R)	IR/HV (R)	Tests as per standard & specification (R & A)
	UPS/ CONVERTER (IEC 146 PT4)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	VOLTAGE STABILISER	Y	Y	Y	Y	Y					Y		Y				Y	
	LEAD ACID BATTERY (TUBULAR) - IS-1651																	Y
	LEAD ACID BATTERY (PLANTE) - IS-1652																	Y
	NICKEL CADMIUM BATTERY (IS-10913)(IEC-623)																	Y
	SMF BATTERY																	Y
	ACDB/DCDB																Y	Y
	BATTERY CHARGER	Y	Y	Y	Y	Y				Y					Y	Y	Y	Y

TECHNICAL SPECIFICATIONS

9. DC SYSTEM

LEAD ACID BATTERY								
ATTRIBUTES CHARACTERISTICS	Dimensions & Finish	Conformance to relevant part drg. & Manufacturer' s standards	Chemical composition	Lead Coating Thickness (min. 25 microns, IS: 6848 App.F) & Adhesion Check	Conformance to CPWD Spec. for Teak Wood	Paint Process checks, Paint Shade, Thickness, Adhesion & Finish	Constructional requirements as per Owner/ Company Spec.	Routine & acceptance tests as per relevant standard
ITEMS, COMPONENTS, SUB SYSTEM ASSEMBLY								
Container & Lids (IS : 1146)	Y	Y						
Vent Plugs	Y	Y						
Sealing Compound (IS : 3116)		Y	Y					
Positive & Negative Plates		Y	Y					
Separators (IS : 6071)	Y	Y						
Electrolyte (Water / Sulphuric Acid) (IS : 1069 / 266)		Y	Y					
Inter-cell Connectors & Fasteners	Y	Y		Y				
Battery Stand	Y	Y			Y	Y		
Cell Insulators	Y	Y						
Stack Assembly	Y	Y						
Lead Acid Battery (IS : 1652)	Y						Y	Y
Note: This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.								

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Ni- Cd BATTERY									
ATTRIBUTES CHARACTERISTICS	/	Dimensions & Finish	Impact Strength	Conformance to relevant part drg. & Manufacturer' s standards	Resistance to Alkali	Chemical composition	Nickel Plating thickness	Paint Shade, Thickness, Adhesion & Finish	Routine & acceptance tests as per relevant standard
Container & Lids		Y	Y	Y	Y				
Vent Plugs		Y		Y	Y				
Perforated Steel Strips		Y		Y	Y		Y		
Active Material for Positive & Negative Plates				Y		Y			
Separators		Y		Y	Y				
Electrolyte				Y		Y			
Inter-cell Connectors & Fasteners		Y		Y	Y		Y		
Battery Stand		Y			Y			Y	
Cell Insulators		Y		Y	Y				
Stack Assembly		Y		Y					
Ni-Cd Battery (IS : 10918)		Y							Y
Notes:									
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.									
2. Makes of all major Bought Out Items will be subject to Owner/ Company approval.									

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Attributes / Characteristics														
Items / Components / Sub- assembly	Make, Model, Type, Rating & Finish	Verification of Routine test reports as per relevant IS	Sheet Steel Pretreatment & Painting process checks	Conform to relevant Standard & Owner/ Company spec	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per Owner/ Company approved drgs & specification	Temperature Rise Test	Ripple Content Test, Load Limiter & AVR Operation Test	Dynamic Response Test	Operational & Functional Checks	HV & IR Test	Burn-In Test at 50°C for 48 hrs in energised condition	Alternating current measurement test	Degree of Protection Test as per Owner/ Company Spec.
Rectifier Transformer and Reactors IS : 4540, 2026)	Y	Y		Y			Y				Y			
Electronic Components including Potentiometer (Vernier Type)	Y			Y		Y								
Electronic Cards	Y			Y								Y		
PCB & racks for electronic cards	Y					Y								
Control & Selector Switches (IS : 6875)	Y			Y						Y				
Indicating Meters (IS : 1248)	Y			Y						Y				
Indicating Lamps (IS: 13947)	Y			Y						Y				
Air Break Switches / Fuses (IS : 13947 / 13703)	Y			Y						Y				
Control Terminal Blocks (IS : 13947)	Y			Y										
Control Transformer (IS : 12021)	Y			Y						Y				

TECHNICAL SPECIFICATIONS

Push Buttons (IS : 4794)	Y			Y						Y				
MCB (IS : 8828)	Y			Y						Y				
PVC insulated Copper control wires (IS : 694)	Y			Y										
Sheet Steel (IS : 513)	Y		Y	Y										
Synthetic Rubber Gaskets	Y			Y										
Annunciator	Y									Y		Y		
Battery Charger	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to Owner/ Company approval.

TECHNICAL SPECIFICATIONS

BATTERY CHARGER

(of capacity up to 24 V / 48 V, 150 A DC)

Attributes / Characteristics											
Items / Components / Sub- assembly	Make, Model, Type, Rating	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per approved drgs	Ripple Content Test, Load Limiter operation & AVR Operation Test	Operational & Functional Checks of aux. Devices like annunciator, switches, indicators etc.	HV & IR Test	Burn-In Test	Dynamic response test	AC input current measurement test	Temperature rise test	
Battery Charger	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Note - This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents. - Makes of all major Bought Out Items will be subject to Owner/ Company approval.											

TECHNICAL SPECIFICATIONS

DC HEALTH MONITORING SYSTEM

Attributes / Characteristics Items / Components / Sub- assembly										
	Make, Model, Type, Rating & Finish	Verification of Routine test reports as per relevant IS	Sheet Steel Pretreatment & Painting process checks	Conform to relevant Standard & Owner/ Company spec	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per Owner/ Company approved drgs & specification	Operational & Functional Checks	HV & IR Test	Burn-In Test at 50°C for 48 hrs in 303energized condition	Degree of Protection Test as per Owner/ Company Spec.
Enclosure	Y		Y	Y	Y					Y
Synthetic Rubber Gaskets	Y			Y						
Control & Selector Switches ,Indicating Meters, Indicating Lamps	Y			Y			Y			
Control Terminal Blocks ,Push Buttons, MCB	Y			Y			Y			
MCB	Y			Y			Y			
PVC insulated Copper control / signal cables	Y	Y		Y						
Transducers / detectors	Y	Y		Y			Y			
PCB & racks for electronic cards	Y									
Electronic Cards	Y						Y		Y	
Microprocessor Based Controller	Y						Y		Y	
SCADA	Y						Y			
Software	Y						Y			
DC Health Monitoring System	Y			Y	Y	Y	Y	Y	Y	Y
Notes:										
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.										
2. Makes of all major Bought Out Items will be subject to Owner/ Company approval.										

TECHNICAL SPECIFICATIONS

10. STATION LIGHTING

Item Components Sub System Assembly	Attributes Characteristic	Make, Type , Rating/ TC	Dimension	Pre-Treatment of sheat	Paint Shade Thickness Adhesion & Finish	Galvanization Tests	IP Test	Bought Out Items/ Bill of Material	HV & IR	Functional Check as per spec.	Constructional Feature as per NTP spec	Routine Test as per relevant std and spec	Acceptance Test as per relevant std and spec	Item to conform to relevant standard
Luminaries (IS- 10322 Part-5 Sec.1 (non –LED type)		Y					Y		Y			Y	Y	Y
Electronic Ballast		Y										Y	Y	Y
Lighting Wire (IS-694)		Y										Y		
Fans (IS-374)		Y										Y		
Pole (IS-2713)		Y			Y						Y	Y	Y	
Lamps (IS-9800, IS-9974)		Y										Y	Y	
Lighting Mast (with raise & lower lantern type)		Y	Y			Y					Y	Y	Y	
Wall Mounted Lighting Panel (IS-513, IS-5)		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Switch Box/ Junction Box/Receptacles/ Local Push Button Station / Lighting Panel (IS-513, 2629, 2633, 4759,6745)		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Cable Gland (BS-6121)		Y	Y									Y		
Cable Lug (IS-8309)		Y	Y									Y		
Flexible Conduit		Y										Y		
Lighting Transformer (IS-11171)		Y									Y	Y		
Epoxy & Galvanised Conduit (IS-9537, 2629, 2633, 4759, 6745)		Y	Y									Y		Y

TECHNICAL SPECIFICATIONS

LED Luminaire Quality Requirements

- 1) LED modules to conform to IS: 16103 part 2. Manufacturer to issue a certificate of compliance for the same.
- 2) Control gear to conform to IS 15885-part 2 section 13. Manufacturer to issue a certificate of compliance for the same.
- 3) LED luminaire to conform to IS 16107-part 2 section 1. Manufacturer to issue a certificate of compliance for the same.
- 4) LED luminaire marking to be as per IS 16107-part 2 section 1. Manufacturer to issue a certificate of compliance for the same.
- 5) Acceptance tests as per IS 16107-part 2 section 1 to be carried out on LED luminaire except long duration tests i.e. a) Chromaticity coordinates & correlated color temperature (CCT); b) Color rendering index (CRI). Manufacturer will submit a COC for above tests i.e. CCT & CRI
- 6) LED driver make, model, type & rating may be as per recommendations of LED module manufacturer.

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

Make of all major Bought Out Items will be subject to Owner/ Company approval

TECHNICAL SPECIFICATIONS

11. TRANSFORMER

Oil Filled Transformer

Attributes / Characteristics	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	NDT / DPT / MPI / UT	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make / Type / Rating / Model / TC / General Physical Inspection.	Functional check	WPS & PQR	Routine Test as per relevant standard / Owner/ Company Specification
Items/Components Sub Systems													
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y					Y	
Conservator / Radiator / Cooler / Pipes	Y	Y					Y						
Copper Conductor (IS:191)	Y	Y	Y		Y								
Insulating Material	Y	Y	Y	Y	Y	Y							
CRGO Lamination & Built Core	Y	Y	Y		Y	Y				Y			
Bushing/Insulator (IS:2544 / 5621)	Y	Y								Y			Y
Gasket	Y	Y			Y	Y		Y		Y			Y
Transformer Oil (IEC296)			Y										Y
OLTC / Off-Circuit Tap Changer	Y									Y			Y
Core Coil Assembly & Pre-tanking	Y								Y	Y			
Marshalling Box	Y									Y	Y		Y
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Buchholz Relay, Valves	Y									Y	Y		
Welding (ASME Sect-IX)	Y						Y					Y	
Complete Transformer (IS:2026/ IEC-60076)	Y												Y
Note: 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents. 2) All major Bought Out Items will be subject to Owner/ Company approval.													

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

LT INDOOR TRANSFORMER (DRY TYPE TRANSFORMER)

Attributes / Characteristics Items/ Components Sub Systems	Visual & Dimensional check	Mechanical properties	Electrical strength	Thermal Properties	Chemical Properties	NDT / DP / MPI	Voltage Ratio, Vector Group & Polarity	Make / Type / Rating / Model / TC / General Physical Inspection	Routine Test as per relevant standard / Owner/ Company Specification
Enclosure door, H.V. & L.V. Cable Box / Flange Throat	Y	Y						Y	
Copper Conductor	Y	Y	Y		Y				
Insulating Material	Y			Y	Y				
CRGO Lamination & Built Core	Y							Y	
Porcelain Bushing /Insulator (IS:2544 / 5621)	Y	Y	Y					Y	Y
Gasket (IS 2712)	Y	Y						Y	Y
Off-Circuit Tap Changer	Y							Y	Y
Core Coil Assembly	Y						Y		
Marshalling Box	Y								Y
WTI, Thermistor, Terminal Connector	Y							Y	
Complete Transformer (IS:11171 / IEC 60076)	Y								Y
Notes: 1) This is an indicative List of test/checks. The manufacturer is to furnish a detailed Quality Plan indicating his practice and procedure along with relevant supporting documents during QP finalization for all item. 2) All major Bought out Items will be subject to Owner/ Company approval.									

TECHNICAL SPECIFICATIONS

AUXILIARY / LT TRANSFORMER

Attributes / Characteristics Items/Component Sub Systems	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	NDT / DPT / MPI / UT	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make / Type / Rating / Model / TC / General Physical Inspection.	Functional check	WPS & PQR	Routine Test as per relevant standard / Owner/ Company
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y					Y	
Conservator / Radiator / Cooler / Pipes	Y	Y					Y						
Copper Conductor (IS:191)	Y	Y	Y		Y								
Insulating Material	Y	Y	Y	Y	Y	Y							
CRGO Lamination & Built Core	Y	Y	Y		Y	Y				Y			
Bushing / Insulator (IS:2544 / 5621)	Y	Y								Y			Y
Gasket	Y	Y			Y	Y		Y		Y			Y
Transformer Oil (IEC296)			Y										Y
OLTC / Off-Circuit Tap Changer	Y									Y			Y
Core Coil Assembly & Pre-tanking	Y								Y	Y			
Marshalling Box	Y									Y	Y		Y
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Valves	Y									Y	Y		
Welding (ASME Sect- IX)	Y						Y					Y	
Complete Transformer (IS:2026/ IEC-60076)	Y												Y

Note:

- This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents
- All major Bought Out Items will be subject to Owner/ Company approval.

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

12. SWITCHYARD/SUBSTATION (If Applicable)

Attributes / Characteristics Items/ Components Sub Systems	Make, model, Type & Rating, Test Certificate	Routine & Acceptance Test as per IS / IEC	Functional requirements as per Owner/ Company Specification
Energy meter	Y	Y	Y
Circuit Breaker (IEC:62271-100)	Y	Y	Y
Isolator (IEC:62271-102)	Y	Y	Y
Current Transformer (IEC:60044/BS:3938/IS2705/ IEC: 61869)	Y	Y	Y
Potential Transformer (IEC:186A / 358/IS3156/IEC60044/ IEC: 61869)	Y	Y	Y
Bus Post Insulator (IEC:168 / 815 / IS:2544)	Y	Y	Y
Disc, Pin & String Insulator (IEC:383 / IS:731)	Y	Y	Y
Surge Arrestor (IEC:99-4/IS:3070)	Y	Y	Y
Spacers, Clamps & Connector (IS:10162 / 5561/ 617)	Y	Y	Y
Galvanized Steel Structures (IS:2062/2629/4759/6745)	Y	Y	Y
Vibration Damper (IS:9708)	Y	Y	Y
Sag Compensating Spring DIN:2089/2096 IS:3195 / 7906	Y	Y	Y
SF6 Gas filling & evacuating plant	Y	Y	Y
SF6 Gas Leak Detector	Y	Y	Y
Leakage Current Analyser	Y	Y	Y
Protection Relays	Y	Y	Y
Relay Test Kit	Y	Y	Y
Surge Monitor	Y	Y	Y

Notes : 1) This is an indicative list of test/checks. The manufacture is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents during QP finalization for all items.

2) All major Bought Out Items will be subject to Owner/ Company approval.

Portable FIRE EXTINGUISHERS

- All fire extinguishers shall be tested as per relevant standard.
- Performance / function test shall be carried out on sampling basis as per relevant code / standard.

TECHNICAL SPECIFICATIONS

13. ENERGY METER

ENERGY METER						
Attributes / Characteristics						
Items / Components / Sub-assembly	Make, Model, Type, Rating & Finish	Conform to relevant Standard & Owner/ Company spec	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per Owner/ Company approved drgs & specification	Burn-In Test and Elevated Temperature Test as per specification	All routine & acceptance tests as per IS 13779
Electronic Components	Y	Y				
PCB for electronic cards	Y					
Electronic Cards	Y	Y		Y	Y	
Terminal Blocks as per IS 13779	Y	Y				
Instrument Transformer CTs & PTs (IS : 2705 & IS 3156)	Y	Y				
Sheet Steel (IS : 513)	Y	Y				
Synthetic Rubber Gaskets IS 11149	Y	Y				
Energy meter IS 13779	Y		Y	Y	Y	Y
Notes: 1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents. 2. Makes of all major Bought Out Items will be subject to Owner/ Company approval.						

TECHNICAL SPECIFICATIONS

14. MODULE CLEANING AND VENTILATION QUALITY REQUIREMENTS

A. Module Cleaning System:

Pipes, Valves, Pumps etc shall be tested as per requirements of relevant standard.

MODULE WASHING SYSTEM: PUMP													
	TEST / CHECKS												
	ITEMS/ COMPONENTS	Material Test	WPS/PQR/Welder Qualification	DPT/MPI	Assembly Fit Up	Visual & Dimensional Check	UT	RT	Hydraulic / Water Fill	Balancing	Type Test	Performance Test	Other Test
A	PUMP				Y	Y						Y ⁶	
A.1	Casing	Y ¹		Y ²		Y			Y ⁴				
A.2	Impeller	Y ¹		Y ²		Y				Y ⁵			
A.3	Shaft	Y ¹		Y ²		Y	Y ³			Y ⁵			

Notes :

- 1 One per heat / HT batch
- 2 100% DPT shall be carried out on machined surfaces.
- 3 UT Shall be done on shaft / tie rod with diameter above 40 mm.
- 4 All pressure retaining parts shall be hydrostatically tested at 200% of pump rated head or 150% of shut – off head whichever is higher, for at least 30 minutes. No leakage is allowed.
- 5 Static and Dynamic Balancing shall be carried out on complete rotor assembly.
- 6 All pumps shall be tested at rated speed, for head, flow capacity, efficiency and power consumption for the entire operating range i.e. from shut off head to maximum flow. A minimum of 7 readings shall be taken to curve, plot the with one reading at design flow. Testing standard shall be HIS (Hydraulic Institute Standard) of USA

Performance test shall be carried out with contract motor, wherever Liquidated Damages are to be ed ascertain based on performance test at shop.

TECHNICAL SPECIFICATIONS

MODULE WASHING SYSTEM: PIPES, FITTINGS, VALVES,

Tests/Checks Items/Components	Material Test	DPT/MPI/RT	Ultrasonic Test	WPS/WQS/PQR	Hydraulic/Water Fill Test	Pneumatic Test	Assembly Fit up	Dimensions	Functional/Operational Test	Other Tests	all Tests as per relevant Std	Remarks
Pipes & Pipe Fittings	Y ^a		Y ^b					Y			Y	
Gate/ Globe/ Check valve	Y ^a		Y ^b	Y ^c		Y	Y	Y	Y	Y ³		
Nozzles	Y ^a							Y				
Strainers	Y ^a		Y ^b					Y		Y ⁵		
HDPE Pipes	Y ^a							Y				
Site Welding		Y ⁴		Y	Y ¹							

NOTES (MEANING OF SUPERSSCRIPTS)

- a One per heat/heat treatment batch/lot.
- b On machined surfaces only for castings and on butt welds.
- c For shaft/spindles > or = 40 mm
- 1 100% Hydraulic test shall be carried out at 1.5 time design pressure or 2 times of working pressure or as per Technical specification/Data sheet/ governing standard.
- 2 Seat Leakage Test for Actuator Operated Valves, shall be done with by closing the valves with actuator.
- 3 Blue matching, wear travel for gates, valves, pneumatic seat leakage, and reduced pressure test for check valves shall be done as per relevant standard. Maximum allowable vacuum loss is 0.5 mm of Hg abs. for valves to be tested for vacuum operation for internal pressure 25 mm of Hg abs. for a period of 15 minutes. Functional checks of the valves for smooth opening and closing shall also be done. Valves shall be offered for hydro test in unpainted condition. Anti-corrosive protection shall be tested as per applicable code.
- 4 10% of welds (Root and finished welds) shall be subjected to DPT.
- 5 Pressure drop across the strainer for each type and size as a special test shall be carried out. In case of already carried out, the test report shall be submitted for review as applicable.

B. VENTILATION SYSTEM

- Split/Window Cassette Air conditioner less than 10 TR will be accepted on the basis of Manufacturer Standard Guarantee and Warrantee certificate.
- Fans, Filters etc. shall be tested as per requirements of relevant standard.

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

E-2: QUALITY ASSURANCE CIVIL WORKS

1. SAMPLING AND TESTING OF CONSTRUCTION MATERIALS

- a) Before execution of any civil work the contractor shall conduct full-scale suitability tests on various construction and building material such as soil, fine and coarse aggregates, cement, construction chemicals, supplementary cementitious materials and construction water to ascertain their suitability for use and the concrete mix designs conducted from reputed institutes such as NCCBM-Ballabgarh, CSMRS-Delhi, selected IIT's, nearby NABL Lab centre etc. as agreed by the Employer. The test samples for such full-scale testing shall be jointly sampled and sealed by the Employer and contractor, thereafter these shall be sent to the concerned laboratory through the covering letter signed by field quality assurance department (FQA)/EIC representative of the Employer. Format for sampling and testing of cement, coarse aggregate, fine aggregate, chemical admixture, fly ash, water, concrete mix design is enclosed at Annexure-I.
- b) The contractor shall timely initiate the action with regard to the evaluation of aggregates and other building material including concrete mix design, so as to ensure completion of these tests before start of civil works at site, thereby not affecting any project work. The test reports and recommendations for suitability of the materials including concrete mix design shall be promptly submitted by the contractor to the Engineer-in-charge (EIC)/Head of Field Quality Assurance (FQA) Department of Employer.

2. LABORATORY AND FIELD TESTING

- a) The field laboratory for QA activities shall be established and installed with the adequate facilities to meet the requirement of envisaged day to day tests during execution of the work. Temperature and humidity controls shall be available wherever necessary during testing of samples. The contractor shall furnish a comprehensive list of testing equipment/ instrument required to meet the planned/scheduled tests for the execution of works for EIC acceptance/ approval. The contractor shall mobilize the requisite laboratory equipment and QA manpower in well advance prior to the planned test activity. The tests which cannot be carried out/do not have facilities for testing in the field laboratory shall be done at Employer acceptable third-party testing laboratory.
- b) All equipment and instruments in the 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 EIC. 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 NABL or such accrediting agency complying with ISO/IEC-17025 accreditation and the calibration reports shall be submitted to EIC for their review and acceptance.
- c) The QA activities (include all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality

TECHNICAL SPECIFICATIONS

assurance requirements) in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / relevant standard codes / contract documents shall be carried out at no extra cost to the Employer

- d) 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 EIC.

3. FIELD QUALITY PLAN

- a) Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans (FQP) and obtain approval of Employer. This document 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. This FQP shall cover for all the items / activities required as per the contract / schedule of items, right from material procurement to completion of the work at site. An Indicative Field Quality Plan for civil works is enclosed at Annexure II for reference purpose.

4. PURCHASE AND SERVICE

- A. To facilitate advance planning of material testing/ approval of bought out items (BOI), well before the start of activity as per L-2 network, representative samples shall be procured by the contractor from approved sub-vendors and submitted to the EIC for his approval before bulk procurement. In case of manufacturers test certificate (MTC) is submitted for acceptance, it shall be clearly traceable and correlated with the consignment received at site. MTC of all bought out items (BOI) shall essentially contain all the test parameters / characteristics specified in the technical specifications / standards / codes. In case the manufacturer's test certificate does not mention these details, sample from each lot shall be tested at the Employer acceptable third-party lab. Approval of material / sample by the Employer shall not relieve the contractor of his responsibility, for their conformance to the specification, as well as the requisite performance and quality of material.
- B. Structural steel (plates and rolled sections i.e. channels, beams & angles) conforming to IS 2062 and Reinforcement steel conforming to IS 1786 supply if in the scope of the contractor shall be procured directly from Primary Steel Producers (Refer NOTE below). Any procurement route, other than direct procurement from primary steel producer, shall require prior approval of Owner/ Company. Currently, Primary Steel Producers acceptable are as below:
 - i. SAIL
 - ii. JSW Steel Ltd
 - iii. Jindal Steel & Power
 - iv. Tata steel Ltd. (for Reinforcement steel/TMT bars)

TECHNICAL SPECIFICATIONS

- v. RINL (for long products/Rolled sections and Reinforcement steel/TMT bars)
- vi. Arcelormittal Nippon Steel India Ltd. (for Flat products/ Steel Plates)
- vii. ESL Steel Ltd. (for Reinforcement steel/TMT bars)
- viii. JSW Ispat Special Products Ltd. (for long products/Rolled sections and Reinforcement steel/TMT bars).

Subsequently, if any new Primary Steel Producer/s are proposed during execution of contract, the same may be considered for acceptance subject to meeting the following qualifying requirements:

- i) The proposed supplier should be a Primary Steel Producer, having a minimum production capacity of one million tons per annum (MTPA).
- ii) The proposed supplier should be a regular manufacturer of Steel Plates and / or Rolled Sections and / or Reinforcement Steel for the last two years as on date of submission of proposal.
- iii) The proposed supplier should also be a registered licensee with Bureau of Indian Standards for BIS:1786/2062 at the time of submission of proposal.

NOTE: The “Primary Steel Producer” shall mean Steel Producer of any capacity, irrespective of process route, starting their operations from iron making using iron ore, virgin or processed, with necessary refining facilities and rolling/processing facilities, at a single location or else in multiple locations provided that the entire gamut of iron and steel production, from iron making to finished steel production, is owned by the same company or its subsidiary company(ies). Provided that the iron making capacity is sufficiently matching the steel making capacity. Further, downstream units should use material from the upstream units of the same company or its subsidiaries.

- i. In case of non-availability of certain steel section/s i.e. Angles, MS flats, rounds, square bars and chequered plate from all of the above acceptable primary steel producers (non-availability to be established by supporting documents), the Main contractor may source these sections directly from SAIL approved Conversion/Wet Leasing agent subject to the conditions given below:
 - a. Main Contractor to ensure continuity of BIS license of the manufacturer for the sections being manufactured for Employer supply.
 - b. Billets shall be procured from Employer approved Main Steel Producers. Proper records for traceability from raw material to final product shall be maintained.
 - c. Testing of one sample per 40 MT for each type of section/size or part thereof shall be carried out as per IS:2062 on finished product for physical and chemical properties. The sampling and testing for physical and chemical tests on finished product at Conversion/Wet Leasing agent shall be

TECHNICAL SPECIFICATIONS

mandatorily witnessed by main contractor and all reports shall be presented during final inspection by Owner/ Company.

- d. Each lot of delivery of finished product shall be accompanied with co-relatable Manufacturer's Test Certificate (MTC). MTC of finished sections shall be correlated with original MTC for Billets received from Main Steel Producer. MTC of finished sections shall include the reference of MTC for Billets from Main Steel Producer.
 - e. Employer will have access to carry out the surveillance checks for in-process stage.
 - f. In case of any defects are seen in the material at any stage, Main Contractor will replace the material without any cost implication to Employer.
- ii. In case of non-availability of certain size/s of steel tubes conforming to IS:1161 and Hollow (square and rectangular) steel sections conforming to IS: 4923 from above acceptable primary steel producers, the same may be sourced from BIS approved sources having valid BIS license subject to the conditions given below:
- a. Main Contractor to ensure continuity of BIS license of the manufacturer for the sections being manufactured for Employer supply.
 - b. Raw materials shall be procured from Employer approved Main Steel Producers.
 - c. 100% chemical analysis of the raw material (steel) shall be carried out as per IS:
 - d. 228. Testing of samples of steel tubes and hollow sections from each lot shall be carried out as per IS: 1161 & IS: 4923 respectively on finished product.
 - e. Each lot of delivery of finished product shall be accompanied with co-relatable Manufacturer's Test Certificate (MTC).
 - f. Employer will have access to carry out the surveillance checks for in-process stage.
 - g. In case of any defects are seen in the material, Main Contractor will replace the material without any cost implication to Employer.
- C. **For Module Mounting Structure**, the structural steel (other than those specified at 'b' above) may be procured from main contractor approved sources, subject to condition that they otherwise meet the requirement of technical specification.

The specific methodology to be followed for above procurement through conversion route/ BIS approved sources route shall be subject to approval by Employer in advance.

TECHNICAL SPECIFICATIONS

PART-F: GENERAL TECHNICAL REQUIREMENTS

TECHNICAL SPECIFICATIONS

F-1: GENERAL TECHNICAL REQUIREMENTS

1. INTRODUCTION

This part covers technical requirements which will form an integral part of the Contract. The following provisions shall supplement all the detailed technical requirements brought out in the Technical Specifications and the Technical Data Sheets.

2. BRAND NAME

Whenever a material or article is specified or described by the name of a particular brand, manufacturer or vendor, the specific item mentioned shall be understood to be indicative of the function and quality desired, and not restrictive; other manufacturer's products may be considered provided sufficient information is furnished to enable the Employer to determine that the products proposed are equivalent to those named.

3. BASE OFFER & ALTERNATE PROPOSALS

The Bidder's proposal shall be based upon the use of equipment and material complying fully with the requirements specified herein. It is recognized that the Contractor may have standardized on the use of certain components, materials, processes or procedures different than those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice may also be considered, provided the base offer is in line with technical specifications and such proposals meet the specified design standards and performance requirement and are acceptable to the Employer. Sufficient amount of information for justifying such proposals shall be furnished to Employer along with the bid to enable the Employer to determine the acceptability of these proposals.

4. COMPLETENESS OF FACILITIES

- a) Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant shall be engineered and designed in accordance with the specification requirement. All engineering and associated services are required to ensure that a completely engineered plant is provided.
- b) All equipment furnished by the Contractor shall be complete in every respect, with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or those needed for erection, completion and safe operation & maintenance of the equipment and for the safety of the operating personnel, as required by applicable codes, though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.

TECHNICAL SPECIFICATIONS

All similar standard components/ parts of similar standard equipment provided, shall be interchangeable with one another.

5. CODES & STANDARDS

A. In addition to the codes and standards specifically mentioned in the relevant technical specifications for the equipment / plant / system, all equipment parts, systems and works covered under this specification shall comply with all currently applicable statutory regulations and safety codes of the Republic of India as well as of the locality where they will be installed, including the following:

- a) Bureau of Indian Standards (BIS)
- b) Indian electricity act
- c) Indian electricity rules
- d) Indian Explosives Act
- e) Indian Factories Act and State Factories Act
- f) Indian Boiler Regulations (IBR)
- g) Regulations of the Central Pollution Control Board, India
- h) Regulations of the Ministry of Environment & Forest (MoEF), Government of India
- i) Pollution Control Regulations of Department of Environment, Government of India
- j) State Pollution Control Board.
- k) Rules for Electrical installation by Tariff Advisory Committee (TAC).
- l) Any other statutory codes / standards / regulations, as may be applicable.

B. Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications, the latest editions (as applicable as on date of bid opening), of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS)
- b) American National Standards Institute (ANSI)
- c) American Society of Testing and Materials (ASTM)
- d) American Society of Mechanical Engineers (ASME)
- e) American Petroleum Institute (API)

TECHNICAL SPECIFICATIONS

- f) Standards of the Hydraulic Institute, U.S.A.
 - g) International Organization for Standardization (ISO)
 - h) Tubular Exchanger Manufacturer's Association (TEMA)
 - i) American Welding Society (AWS)
 - j) National Electrical Manufacturers Association (NEMA)
 - k) National Fire Protection Association (NFPA)
 - l) International Electro-Technical Commission (IEC)
 - m) Expansion Joint Manufacturers Association (EJMA)
 - n) Heat Exchange Institute (HEI)
- C. Other International/ National standards such as DIN, VDI, BS, GOST etc. shall also be accepted for only material codes and manufacturing standards, subject to the Employer's approval, for which the Bidder shall furnish, along with the offer, adequate information to justify that these standards are equivalent or superior to the standards mentioned above. In all such cases the Bidder shall furnish specifically the variations and deviations from the standards mentioned elsewhere in the specification together with the complete word to word translation of the standard that is normally not published in English.
- D. As regards highly standardized equipment National /International standards such as JIS, DIN, VDI, ISO, SEL, SEW, VDE, IEC & VGB shall also be considered as far as applicable for Design, Manufacturing and Testing of the respective equipment. In addition, these standards shall be referred for the design of machine foundations, wherever specifically mentioned in the specifications. However, for those of the above equipment not covered by these National / International standards, established and proven standards of manufacturers shall also be considered.
- E. In the event of any conflict between the codes and standards referred to in the above clauses and the requirement of this specification, the requirement of Technical Specification shall govern.
- F. Two (2) English language copies of all-national and international codes and/or standards which are not available with Owner/ Company and same is used in the design of the plant, equipment, civil and structural works shall be provided by the Contractor to the Employer within two calendar months from the date of the Notification of Award.

TECHNICAL SPECIFICATIONS

- G. In case of any change in codes, standards & regulations between the date of bid opening and the date when vendors proceed with fabrication, the Employer shall have the option to incorporate the changed requirements or to retain the original standard. It shall be the responsibility of the Contractor to bring to the notice of the Employer such changes and advise Employer of the resulting effect.

6. EQUIPMENT FUNCTIONAL GUARANTEE

- a) The functional guarantees of the equipment under the scope of the Contract is given elsewhere in the technical specification. These guarantees shall supplement the general functional guarantee provisions covered under General Conditions of Contract.
- b) Liquidated damages for shortfall in meeting functional guarantee(s) during the performance guarantee tests shall be assessed and recovered from the Contractor as specified elsewhere in this specification.

7. DESIGN OF FACILITIES/ MAINTENANCE & AVAILABILITY CONSIDERATIONS

a) Design of Facilities

All the design procedures, systems and components proposed shall have already been adequately developed and shall have demonstrated good reliability under similar conditions elsewhere.

The Contractor shall be responsible for the selection and design of appropriate equipment to provide the best co-ordinated performance of the entire system. The basic requirements are detailed out in various clauses of the Technical Specifications. The design of various components, assemblies and subassemblies shall be done so that it facilitates easy field assembly and dismantling. All the rotating components shall be so selected that the natural frequency of the complete unit is not critical or close to the operating range of the unit.

b) Maintenance and Availability Considerations

Equipment/facilities offered shall be designed for high availability, low maintenance and ease of maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability/availability and ease of maintenance. The Bidder shall also furnish details of availability records in the reference plants stated in his experience list.

- c) Bidder shall state in his offer the various maintenance intervals, spare parts and man-hour requirement during such operation. The intervals for each type of maintenance namely the minor and major overhauls shall be specified in terms of fired hours, clearly defining the spare parts and man-hour requirement for each stage.

TECHNICAL SPECIFICATIONS

Lifting devices i.e. hoists and chain pulley jacks, etc. shall be provided by the contractor for handling of any equipment or any of its part having weight in excess of 500 kgs during erection and maintenance activities.

Lifting devices like lifting tackles, slings, etc. to be connected to hook of the hoist / crane shall be provided by the contractor for lifting the equipment and accessories covered under the specification.

8. DOCUMENTS, DATA AND DRAWINGS TO BE FURNISHED BY CONTRACTOR

- a) Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant and equipment shall be fully integrated, engineered and designed to perform in accordance with the technical specification. All engineering and technical services required ensuring a completely engineered plant shall be provided in respect of mechanical, electrical, control & instrumentation, civil & structural works as per the scope.
- b) The Contractor shall furnish engineering data/drgs. for entire equipment covered under this specification in accordance with the schedule of information as specified in Technical Specification and Data sheets.. This documentation shall include but not be limited to the following:

A. INSTRUCTION MANUALS

The Contractor shall submit to the Employer, draft Instruction Manuals for all the equipment covered under the Contract by the end of one year from the date of his acceptance of the Letter of Award. The Instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. After finalization and approval of the Employer the Instruction Manuals shall be submitted. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals have been supplied to the Employer. The Instruction Manuals shall comprise of the following.

(a) Erection & Commissioning Manuals/Checklists

The erection & Commissioning Manuals/Checklists shall be submitted atleast three (3) months prior to the commencement of erection activities of particular equipment/system. The erection manual should contain the following as a minimum.

- i. Erection strategy.
- ii. Sequence of erection.
- iii. Erection instructions.

TECHNICAL SPECIFICATIONS

- iv. Critical checks and permissible deviation/tolerances.
- v. List of tool, tackles, heavy equipment like cranes, dozers, etc.
- vi. Bill of Materials
- vii. Procedure for erection.
- viii. General safety procedures to followed during erection/installation.
- ix. Procedure for initial checking after erection.
- x. Procedure for testing and acceptance norms.
- xi. Procedure / Check list for pre-commissioning activities.
- xii. Procedure / Check list for commissioning of the system.
- xiii. Safety precautions to be followed in electrical supply distribution during erection

(b) Operation & Maintenance Manuals

- i. The operating and maintenance instructions together with drawings (other than shop drawings) of the equipment, as completed, shall be in sufficient detail to enable the Employer to operate, maintain, dismantle, reassemble and adjust all parts of the equipment. They shall give a step by step procedure for all operations likely to be carried out during the life of the plant / equipment including, operation, maintenance dismantling and repair including periodical activities such as chemical cleaning of the generator. Each manual shall also include a complete set of drawings together with performance/rating curves of the equipment and test certificates wherever applicable. The contract shall not be considered to be completed for purposes for taking over until these manuals have been supplied to the Employer.
- ii. If after the commissioning and initial operation of the plant, the manuals require any modification / additions / changes, the same shall be incorporated and the updated final instruction manuals shall be submitted to the Employer for records.
- iii. A separate section of the manual shall be for each size/ type of equipment and shall contain a detailed description of construction and operation, together with all relevant pamphlets and drawings.
- iv. The manuals shall include the following :
 - a. List of spare parts along with their drawing and catalogues and procedure for ordering spares.
 - b. Lubrication Schedule including charts showing lubrication checking, testing and replacement procedure to be carried daily, weekly, monthly & at longer intervals to ensure trouble free operation.

TECHNICAL SPECIFICATIONS

- c. Where applicable, fault location charts shall be included to facilitate finding the cause of mal-operation or break down.
- v. Detailed specifications for all the consumables including lubricant oils, greases, chemicals etc. system/equipment/assembly/sub-assembly - wise required for the complete plant.
- vi. On completion of erection, a complete list of bearings / equipment giving their location, and identification marks etc. shall also be furnished to the Employer indicating lubrication method for each type/category of bearing.

B. Project Completion Report

The Contractor shall submit a Project Completion Report at the time of handing over the plant. After final acceptance of individual equipment /system by the Employer, the Contractor will update all original drawings and documents for the equipment/ system to "as built" conditions and submit.

C. ENGINEERING INFORMATION SUBMISSION SCHEDULE

Prior to the award of Contract, a Detailed Engineering Information Submission Schedule shall be tied up with the Employer. For this, the bidder shall furnish a detailed list of engineering information alongwith the proposed submission schedule. This list would be a comprehensive one including all engineering data / drawings / information for all bought out items and manufactured items. The information shall be categorised into the following parts.

- a. Information that shall be submitted for the approval of the Employer before proceeding further, and
- b. Information that would be submitted for Employer's information only. The Engineering Information Schedule shall be updated month-wise.

The schedule should allow adequate time for proper review and incorporation of changes/ modifications, if any, to meet the contract without affecting the equipment delivery schedule and overall project schedule. The early submission of drawings and data is as important as the manufacture and delivery of equipment and hardware and this shall be duly considered while determining the overall performance and progress.

D. ENGINEERING PROGRESS AND EXCEPTION REPORT

Report giving the status of each engineering information including

- (a) A list of drawings/engineering information which remains unapproved for more than four (4) weeks after the date of first submission
- (b) Drawings which were not submitted as per agreed schedule.

TECHNICAL SPECIFICATIONS

The draft format for this report shall be furnished to the Employer within four (4) weeks of the award of the contract, which shall then be discussed and finalised with the Employer.

E. TECHNICAL CO-ORDINATION MEETING

- The Contractor shall organize and attend at least one monthly progress Meetings with the Employer/Employer's representatives during the period of Contract at mutually agreed venues for review of progress & resolving technical clarifications, if any. The Contractor shall attend such meetings at his own cost and fully co- operate with such persons and agencies involved during the discussions.
- The Contractor shall ensure availability of the concerned experts / consultants/ personnel who are empowered to take necessary decisions during these meetings. The Contractor shall be equipped with necessary tools and facilities so that, if required, the drawings/documents can be resubmitted after incorporating necessary changes and approved during the meeting itself.
- The Contractor shall furnish monthly progress report to the Employer detailing out the progress achieved on all erection activities as compared to the schedules. This shall be supplemented by printed colour photographs and video in VCD/DVD indicating various stages of erection and the progress of the work done at Site. The report shall also indicate the reasons for the variance between the scheduled and actual progress and the action proposed for corrective measures, wherever necessary.

F. DESIGN IMPROVEMENTS

The Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the parties agree upon any such changes the specification shall be modified accordingly.

If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any changing the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

G. EQUIPMENT BASES

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer. Each base plate which support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

H. PROTECTIVE GUARDS

TECHNICAL SPECIFICATIONS

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards shall be designed for easy installation and removal for maintenance purpose.

I. LUBRICANTS, SERVO FLUIDS AND CHEMICALS

The Bidder's scope includes all the first fill and one year's topping, requirements of consumables such as oils, lubricants including grease, servo fluids, gases and essential chemicals etc. Consumption of all these consumables during the initial operation and final filling after the initial operation shall also be included in the scope of the Bidder.

As far as possible lubricants marketed by reputed companies shall be used. The variety of lubricants shall be kept to a minimum possible.

Detailed specifications for the lubricating oil, grease, gases, servo fluids, control fluids, chemicals etc. required for the complete plant covered herein shall be furnished. On completion of erection, a complete list of bearings/ equipment giving their location and identification marks shall be furnished to the Employer alongwith lubrication requirements.

Lubrication

Equipment shall be lubricated by systems designed for continuous operation. Lubricant level indicators shall be furnished and marked to indicate proper levels under both standstill and operating conditions.

J. Material of Construction

All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilized for various components shall be those which have established themselves for use in such applications.

K. RATING PLATES, NAME PLATES & LABELS

Each main and auxiliary item of plant including instruments shall have permanently attached to it in a conspicuous position, a rating plate of non-corrosive material upon which shall be engraved manufacturer's name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Employer.

Such nameplates or labels shall be of white non-hygroscopic material with engraved black lettering or alternately, in the case of indoor circuit breakers, starters, etc. of transparent plastic material with suitably coloured lettering engraved on the back. The name plates shall be suitably fixed on both front and rear sides.

L. Hanger/ support numbers shall be marked on all pipe supports, anchors, hangers, snubbers and restraint assemblies. Each constant and variable spring support shall

TECHNICAL SPECIFICATIONS

also have stamped upon it the designed hot and cold load which it is intended to support. Suitable scale shall also be provided to indicate load on support/hanger.

Nameplates shall be as per best practices of the industry

All such plates, instruction plates, etc. shall be bilingual with Hindi inscription first, followed by English. Alternatively, two separate plates one with Hindi and the other with English inscriptions may be provided.

All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system

M. TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles and other instruments required for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software). These special tools will also include special material handling equipment, jigs and fixtures for maintenance and calibration / readjustment, checking and measurement aids etc. A list of such tools and tackles shall be submitted by the Bidder along with the offer.

The price of each tool / tackle shall be deemed to have been included in the total bid price. These tools and tackles shall be separately packed and sent to site. The Contractor shall also ensure that these tools and tackles are not used by him during erection, commissioning and initial operation. For this period the Contractor should bring his own tools and tackles. All the tools and tackles shall be of reputed make acceptable to the Employer.

9. Welding

- a) If the manufacturer has special requirements relating to the welding procedures for welds at the terminals of the equipment to be performed by others the requirements shall be submitted to the Employer in advance of commencement of erection work.

QUALITY ASSURANCE PROGRAMME

The Contractor shall adopt suitable quality assurance programme to ensure that the equipment and services under the scope of contract whether manufactured or performed within the Contractor's works or at his sub-contractor's premises or at the Employer's site or at any other place of work are in accordance with the specifications. Such programmes shall be outlined by the Contractor and shall be finally accepted by the Employer/authorised representative after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001. A quality assurance programme of the contractor shall generally cover the following:

TECHNICAL SPECIFICATIONS

- (a) His organisation structure for the management and implementation of the proposed quality assurance programme
- (b) Quality System Manual
- (c) Design Control System
- (d) Documentation and Data Control System
- (e) Qualification data for bidder's key personnel.
- (f) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- (g) System for shop manufacturing and site erection controls including process, fabrication and assembly.
- (h) Control of non-conforming items and system for corrective actions and resolution of deviations.
- (i) Inspection and test procedure both for manufacture and field activities.
- (j) Control of calibration and testing of measuring testing equipment.
- (k) System for Quality Audits.
- (l) System for identification and appraisal of inspection status.
- (m) System for authorising release of manufactured product to the Employer.
- (n) System for handling, storage and delivery.
- (o) System for maintenance of records, and
- (p) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

b) GENERAL REQUIREMENTS - QUALITY ASSURANCE

- i. All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. An indicative programme of inspection/tests to be carried out by the contractor for some of the major items is given in the respective technical specification. This is, however, not intended to form a comprehensive programme as it is the contractor's responsibility to draw up and implement such programme duly approved by the Employer. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Employer for approval. Schedule of finalisation of such quality plans will be finalised before award on enclosed format No. QS- 01-QAI-P-01/F3. If bidder

TECHNICAL SPECIFICATIONS

wishes to appoint a TPIA for inspection on his behalf, same shall be intimated during finalisation of Quality plans. Such agency and their representative's credential would be reviewed and approved by Owner/ Company as per applicable procedures.

- ii. Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Contractor's/ Sub-contractor's/ sub-supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted on electronic media e.g. CD Rom or E-mail in addition to hard copy, for review and approval. After approval the same shall be submitted in compiled form on CD-ROM.
- iii. Field Quality Plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Contractor's "Site Quality Control Organisation", during various stages of site activities starting from receipt of materials/equipment at site.
- iv. The Bidder shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with Quality Plans. These Quality Plans and reference documents/standards etc. will be subject to Employer's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Employer shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Employer's Project Manager or his authorised representative along with Contractor's QA representative or an Owner/ Company approved TPIA on behalf of Contractor and beyond which the work will not proceed without consent of Employer in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Employer along with technical justification for approval and dispositioning.
- v. No material shall be dispatched from the manufacturer's works before the same is accepted, subsequent to predispatch final inspection in presence of Contractor's QA representative or an Owner/ Company approved TPIA on behalf of Contractor, including verification of records of all previous tests/inspections by Employer's Project Manager/Authorised representative and duly authorised for dispatch by issuance of Material Despatch Clearance Certificate (MDCC).

TECHNICAL SPECIFICATIONS

- vi. All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.
- vii. The contractor shall submit to the Employer Field Welding Schedule for field welding activities in the enclosed format No.: QS-01-CQA-W-11/F1. The field welding schedule shall be submitted to the Employer along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site.
- viii. All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Employer.

All welding/brazing procedures shall be submitted to the Employer or its authorised representative for approval prior to carrying out the welding/brazing.

- i. All brazers, welders and welding operators employed on any part of the contract either in Contractor's/sub-contractor's works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Employer.
- ii. Welding procedure qualification & Welder qualification test results shall be furnished to the Employer for approval. However, where required by the Employer, tests shall be conducted in presence of Employer/authorised representative.
- iii. For all pressure parts and high pressure piping welding, the latest applicable requirements of the IBR (Indian Boiler Regulations) shall also be essentially complied with. Similarly, any other statutory requirements for the equipment/systems shall also be complied with. On all back-gauged welds MPI/LPI shall be carried before seal welding.
- iv. Unless otherwise proven and specifically agreed with the Employer, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- v. No welding shall be carried out on cast iron components for repair.
- vi. All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.
- vii. All non-destructive examination shall be performed in accordance with written procedures as per International Standards, The NDT operator shall be

TECHNICAL SPECIFICATIONS

qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.

All plates of thickness above 40mm & all bar stock/Forging above 40mm dia shall be ultrasonically tested. For pressure parts, plate of thickness equal to or above 25mm shall be ultrasonically tested.

- i. The Contractor shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-contractors (BOI). All the sub-contractor proposed by the Contractor for procurement of major bought out items including castings, forging, semi-finished and finished components/equipment etc., list of which shall be drawn up by the Contractor and finalised with the Employer, shall be subject to Employer's approval on enclosed format No. QS-01-QAI-P-01/F3. The contractor's proposal shall include vendor's facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-contractors enclosed and shall be submitted to the Employer for approval within the period agreed at the time of pre-awards discussion and identified in "DR" category prior to any procurement. Such vendor approval shall not relieve the contractor from any obligation, duty or responsibility under the contract.
- ii. For components/equipment procured by the contractors for the purpose of the contract, after obtaining the written approval of the Employer, the contractor's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-contractor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organisation, the relevant reference documents/standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalised with the Employer and such approved Quality Plans shall form a part of the purchase order/contract between the Contractor and sub-contractor. Within three weeks of the release of the purchase orders /contracts for such bought out items /components, a copy of the same without price details but together with the detailed purchase specifications, quality plans and delivery conditions shall be furnished to the Employer on the monthly basis by the Contractor along with a report of the Purchase Order placed so far for the contract. **

TECHNICAL SPECIFICATIONS

- iii. Employer reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Contractor's or their sub-contractor's quality management and control activities. The contractor shall provide all necessary assistance to enable the Employer carry out such audit and surveillance.
- a. The contractor shall carry out an inspection and testing programme during manufacture in his work and that of his sub-contractor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials parts and equipment. Contractor shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.
- iv. Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Employer to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Contractor in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.
- v. For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.
- vi. Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Employer/ authorised representative.

Environmental Stress Screening

- i. Environmental stress screening test process / procedure for eliminating infant mortile components for DDCMIS / PLC based system & for other systems having substantial electronics components (as determined by employer) like Electronic transmitter, CCTV components, PA systems etc. shall be necessarily furnished for any sub vendors proposed for vendor assessment and approval for this contract. For other approved sub vendors of above mentioned systems, contractor shall furnish the test procedure for eliminating infant mortile components in case, if it is asked for by the employer before these items are offered for inspection / dispatched to site.

Software Reliability / Quality Certification

- i. Certification from OEM's authorized signatory that software offered with DDCMIS, PLC, CCTV, PA, Pyrometer, CEMS, AAQMS, EQMS, BHMS

TECHNICAL SPECIFICATIONS

etc. declaring that the all the offered software(s) had gone through the established software quality test and offered software is not of β -version and offered software is also free from all known bugs as on date of approval of systems documents by Owner/ Company as a part of quality documentation review and approval process during detail engineering.

Owner/ Company follows a well defined sub-contractor's/sub-vendor assessment and approval process, the broad contours of which are also defined at Owner/ Company website [www.Owner/ Companytender.com](http://www.Owner/Companytender.com) alongwith a FAQ which answers most of the queries on the subject.

An indicative list of sub-vendors which has been accepted by Owner/ Company in the past for Corporate Awarded similar packages based on the respective Technical Specifications are enclosed in the tender specification for reference purpose only. The purpose of this list is to provide general guidance to the prospective Bidders / Main Contractors for this package only. Further, this list is indicative in nature and may undergo revision for future packages based on the performance feedback received from Owner/ Company sites / other agencies about the supplier / sub vendors / supplied material. However, it is not the intention to limit the sub-vendor to only such names appearing in the above list and Main contractor is free to propose additional sub-vendors in his bid offer which will be subject to Owner/ Company sub- vendor assessment system upon receipt of requisite details in a time bound mutually agreed schedule. . Moreover listed suppliers may or may not be able to supply the material as per current Tech Specifications for the present package. Bidder is required to enquire before finalizing the suppliers / sub vendors for the present contract to meet provisions of the current Tech Specs.

Standard Manufacturing Quality Plan (SQP)/Indicative Manufacturing Quality Plan(IQP)/ Standard Field Quality Plan (SFQP)/ Indicative Field Quality Plan(IFQP) are enclosed for the major items, which can be used as a reference purpose for item under consideration.

The contractor's proposal shall include vendor's facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified subcontractors and shall be submitted to the Employer for approval within a time bound schedule drawn during detailed engineering process. Such sub-vendor proposed in his bid offer shall be deemed to be identified in DR category and upon final acceptance by Owner/ Company in writing, contractor can place order on such accepted sub-vendor only.

Monthly progress reports on sub-contractor detail submission / approval shall be furnished as per Engineering Co-ordination Procedure. Such vendor approval shall not relieve the contractor from any obligation, duty or responsibility under the

TECHNICAL SPECIFICATIONS

contract. Sub- vendor whose details are not submitted within the agreed cut-off date, shall be deemed to be withdrawn by the contractor.

c) QA DOCUMENTATION PACKAGE

- a) The Contractor shall be required to submit the QA Documentation in two hard copies and two CD ROMs, as identified in respective quality plan with tick mark.
- b) Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Supplier's sub-supplier to allow regular reviews by all parties during the manufacturing.

The final quality document will be compiled and issued at the final assembly place of equipment before dispatch. However CD-Rom may be issued not later than three weeks.

- Typical contents of QA Documentation is as below:-

a) Quality Plan

Material mill test reports on components as specified by the specification and approved Quality Plans.

- c) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- d) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
- e) Heat Treatment Certificate/Record (Time- temperature Chart)
- f) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
- g) CHP / Inspection reports duly signed by the Inspector of the Employer and Contractor for the agreed Customer Hold Points.
- h) Certificate of Conformance (COC) wherever applicable.
- i) MDCC

- Similarly, the contractor shall be required to submit two sets (two hard copies and two CD ROMs), containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.
- Before dispatch / commissioning of any equipment, the Supplier shall make sure that the corresponding quality document or in the case of protracted phased

TECHNICAL SPECIFICATIONS

deliveries, the applicable section of the quality document file is completed. The supplier will then notify the Inspector regarding the readiness of the quality document (or applicable section) for review.

- (a) If the result of the review carried out by the Inspector is satisfactory, the Inspector shall stamp the quality document (or applicable section) for release.
- (b) If the quality document is unsatisfactory, the Supplier shall endeavor to correct the incompleteness, thus allowing to finalize the quality document (or applicable section) by time compatible with the requirements as per contract documents. When it is done, the quality document (or applicable section) is stamped by the Inspector.
- (c) If a decision is made dispatch, whereas all outstanding actions cannot be readily cleared for the release of the quality document by that time. The supplier shall immediately, upon shipment of the equipment, send a copy of the quality document Review Status signed by the Supplier Representative to the Inspector and notify of the committed date for the completion of all outstanding actions & submission. The Inspector shall stamp the quality document for applicable section when it is effectively completed. The submission of QA documentation package shall not be later than 3 weeks after the dispatch of equipment.

d) Project Manager's Supervision

To eliminate delays and avoid disputes and litigation, it is agreed between the parties to the Contract that all matters and questions shall be referred to the Project Manager and without prejudice to the provisions of 'Arbitration' clause in Section GCC of Vol.I, the Contractor shall proceed to comply with the Project Manager's decision.

The work shall be performed under the supervision of the Project Manager. The scope of the duties of the Project Manager pursuant to the Contract, will include but not be limited to the following:

- (a) Interpretation of all the terms and conditions of these documents and specifications:
- (b) Review and interpretation of all the Contractor's drawing, engineering data, etc:
- (c) Witness or his authorised representative to witness tests and trials either at the manufacturer's works or at site, or at any place where work is performed under the contract :
- (d) Inspect, accept or reject any equipment, material and work under the contract :
- (e) Issue certificate of acceptance and/or progressive payment and final payment certificates

TECHNICAL SPECIFICATIONS

- (f) Review and suggest modifications and improvement in completion schedules from time to time, and
- (g) Supervise Quality Assurance Programme implementation at all stages of the works.

e) INSPECTION, TESTING AND INSPECTION CERTIFICATES

- The word 'Inspector' shall mean the Project Manager and/or his authorised representative and/or an outside inspection agency acting on behalf of the Employer to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- The Project Manager or his duly authorised representative and/or an outside inspection agency acting on behalf of the Employer shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Contractor shall obtain for the Project Manager and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works.
- The Contractor shall give the Project Manager/Inspector fifteen (15) days written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector's. The Project Manager/Inspector, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within fifteen (15) days of the date on which the equipment is noticed as being ready for test/inspection failing which the contractor may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the inspector duly certified copies of test reports in two (2) copies.
- The Project Manager or Inspector shall within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, or any objection to any drawings and all or any equipment and workmanship which is in his opinion not in accordance with the contract. The Contractor shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Project Manager/Inspector giving reasons therein, that no modifications are necessary to comply with the contract.

When the factory tests have been completed at the Contractor's or sub-contractor's works, the Project Manager /Inspector shall issue a certificate to this effect fifteen (15)

days after completion of tests but if the tests are not witnessed by the Project Manager /Inspectors, the certificate shall be issued within fifteen (15) days of the receipt of the Contractor's test certificate by the Project Manager

TECHNICAL SPECIFICATIONS

/Inspector. Project Manager /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the works. The completion of these tests or the issue of the certificates shall not bind the Employer to accept the equipment should it, on further tests after erection be found not to comply with the contract.

- In all cases where the contract provides for tests whether at the premises or works of the Contractor or any sub-contractor, the Contractor, except where otherwise specified shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Project Manager /Inspector or his authorised representatives to carry out effectively such tests on the equipment in accordance with the Contractor and shall give facilities to the Project Manager/Inspector or to his authorised representative to accomplish testing.
- The inspection by Project Manager / Inspector and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Programme forming a part of the contract.
- To facilitate advance planning of inspection in addition to giving inspection notice as specified at clause no 9.05.03- of this chapter, the Contractor shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.
- All inspection, measuring and test equipment used by contractor shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Contractor shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by Owner/ Company. Wherever asked specifically, the contractor shall re-calibrate the measuring/test equipment in the presence of Project Manager / Inspector.

f) ASSOCIATED DOCUMENT FOR QUALITY ASSURANCE PROGRAMME:

- c) List of items requiring quality plan and sub supplier approval. Format No.:QS-01- QAI-P-01/F3-R0.
- d) Manufacturing Quality Plan Format No.: QS-01-QAI-P-09/F1-R1
- e) Field Quality Plan Format No.: QS-01-QAI-P-09/F2-R1.

10. PRE-COMMISSIONING AND COMMISSIONING FACILITIES

3

TECHNICAL SPECIFICATIONS

The Contractor upon completion of installation of equipments and systems, shall conduct pre-commissioning and commissioning activities, to make the equipment/systems ready for safe, reliable and efficient operation on sustained basis. During commissioning the Contractor shall carry out system checking and reliability trials on various parts of the facilities. All pre-commissioning/commissioning activities considered essential for such readiness of the equipment/systems including those mutually agreed and included in the Contractor's quality assurance programme as well as those indicated in clauses elsewhere in the technical specifications shall be performed by the contractor.

The pre-commissioning and commissioning activities of the equipment/systems furnished and installed by the contractor shall be the responsibility of the Contractor. The Contractor shall provide, in addition, temporary instrumentation and other measuring devices, test instruments, calibrating devices etc. and labour required for successful performance of these operations. If it is anticipated that the above test may prolong for a long time, the Contractor's workmen required for the above test shall always be present at site during such operations.

All erection & commissioning checks shall be as per manufacturer's manual on mutually agreed terms

- (a) As soon as the facilities or part thereof has been completed operationally and structurally and before start-up, each item of the equipment and systems forming part of facilities shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness of and completeness of facility or part thereof and acceptability for initial pre-commissioning tests, commissioning and start-up at Site. The list of pre-commissioning tests to be performed shall be as mutually agreed and included in the Contractor's quality assurance programme as well as those included elsewhere in the Technical Specifications.
- (b) The Contractor's pre-commissioning/ commissioning/start-up engineers, specially identified as far as possible, shall be responsible for carrying out all the pre- commissioning tests at Site. On completion of inspection, checking and after the pre-commissioning tests are satisfactorily over, the commissioning of the complete facilities shall be commenced during which period the complete facilities, equipments shall be operated integral with sub-systems and supporting equipment as a complete plant.
- (c) The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.
- (d) The check outs during the pre - commissioning period should be programmed to follow the construction completion schedule. Each equipment/system, as it is completed in construction and turned over for

TECHNICAL SPECIFICATIONS

commissioning (start-up), should be checked out and cleaned. The checking and inspection of individual systems should then follow a prescribed commissioning documentation [SCL (Standard Check List) / TS (Testing Schedule) / CS (Commissioning Schedule)] to be furnished by the manufacturer/supplier.

The Contractor shall conduct vibration testing to determine the 'base line' of performance of all plant rotating equipment. These tests shall be conducted when the equipment is running at the base load, peak load as well as lowest sustained operating condition as far as practicable.

11. SAFETY ASPECTS DURING CONSTRUCTION AND ERECTION

In addition to the requirements given in Erection Conditions of Contract (ECC) the following shall also cover:

- (a) Working platforms should be fenced and shall have means of access.
- (b) Ladders in accordance with Employer's safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

12. PACKAGING AND TRANSPORTATION

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

13. ELECTRICAL ENCLOSURE

All electrical equipment and devices, including insulation, heating and ventilation devices shall be designed for ambient temperature and a maximum relative humidity as specified elsewhere in the specification.

14. INSTRUMENTATION AND CONTROL

TECHNICAL SPECIFICATIONS

All instrumentation and control systems/ equipment/ devices/ components, furnished under this contract shall be in accordance with the requirements stated herein, unless otherwise specified in the detailed specifications.

All instrument scales and charts shall be calibrated and printed in metric units and shall have linear graduation. The ranges shall be selected to have the normal reading at 75% of full scale.

All scales and charts shall be calibrated and printed in Metric Units

All instruments and control devices provided on panels shall be of miniaturized design, suitable for modular flush mounting on panels with front draw out facility and flexible plug-in connection at rear.

All electronic modules shall have gold plated connector fingers and further all input and output modules shall be short circuit proof. These shall also be tropicalised & components shall be of industrial grade or better.

15. ELECTRICAL NOISE CONTROL

The equipment furnished by the Contractor shall incorporate necessary techniques to eliminate measurement and control problems caused by electrical noise. Areas in Contractor's equipment which are vulnerable to electrical noise shall be hardened to eliminate possible problems. Any additional equipment, services required for effectively eliminating the noise problems shall be included in the proposal. The equipment shall be protected against ESD as per IEC-801- 2. Radio Frequency interference (RFI) and Electro Magnetic Interference (EMI) protection against hardware damage and control system mal- operations/errors shall be provided for all systems.

16. ELECTRONIC MODULE/COMPONENT DETAILS

The Bidder shall have to furnish all technical details including circuit diagrams, specifications of components, etc., in respect of each and every electronic card/module as employed on the various solid state as well as microprocessor based systems and equipment including conventional instruments, peripherals etc.

It is mandatory for the Bidder to identify clearly the custom built ICs used in the package. The Bidder shall also furnish the details of any equivalents of the same.

TECHNICAL SPECIFICATIONS

Annexure-1 of GTR

S. N.	Description Of Documents	No of Prints (Sets)	NO. OF CD-ROMs
1	Drawings for Initial Submission (Either "FOR APPROVAL" or "FOR INFORMATION Category) and re-submissions after review by Owner/ Company (including Data sheets/ Calculations, all Equipment/instrument schedule, BOM etc)	8	1 Soft Copy (through 1 no of CD-Rom or through E-Mail)

3

TECHNICAL SPECIFICATIONS

2	Final Approved Drawings (Cat-I & Cat – IV Approved) (As referred in Sl no: 1 above)	3	4 CD-Roms or through E-Mail
3	Documents / Drawings "AS BUILT"	4	4 CD-Roms or through E-Mail
4	Type test reports (Initial)	8	1 Soft Copy (through 1 no of CD-Rom or through E-Mail)
5	Type test reports (Final)	1	2 CD-Roms or through E-Mail
6	Erection manual "Final"	4 sets	1 CD-ROM or through E-Mail
7	Operation & Maintenance manual "FINAL"	4 sets	4 CD-ROMs or through E-Mail
8	Commissioning Procedure (if applicable) (FINAL)	4 sets	1 CD-ROM or through E-Mail

S. N.	Description Of Documents	No of Prints (Sets)	NO. OF CD-ROMs
9	Performance and Guarantee test Procedure (Final)	8	1 Soft Copy (2 Floppy or 1 no of CD-Rom or through E-Mail)
10	Progress Reports	1	Through Mail

3

TECHNICAL SPECIFICATIONS

11	Project completion report	3	3 CD-ROMs or through E-Mail
12	QA programme including Organisation for implementation and QA system manual (with revision-servicing)	1	1 CD-ROM or through E-Mail
13	Vendor details in respect of proposed vendors including contractor's evaluation report.	1	1 CD-ROM or through E-Mail
14	Manufacturing QPs, Field QPs, Field welding schedules and their reference documents like test procedures, WPS, POR etc.		
	i) For review/comment	-	3 sets of soft copy
	ii) For final approval	1 set floppies	4
15	Monthly Vendor Approval /QP approval status	2 sets	1 FLOPPY or through E-Mail
16	QA Documentation Package for field activities on equipment / systems at site	2 sets	2 CD-ROMs or through E-Mail
17	QA Documentation Package for field activities on equipment / systems at site	2 sets	2 CD-ROMs or through E-Mail

TECHNICAL SPECIFICATIONS

PART-G ERECTION CONDITIONS OF CONTRACT

TECHNICAL SPECIFICATIONS

G-1: ERECTION CONDITIONS OF CONTRACT

1. GENERAL

The following provisions shall supplement the conditions already contained in the other parts of these specifications and documents and shall govern that portion of the work of this contract which is to be performed at site. The erection requirements and procedures not specified in these documents shall be in accordance with the recommendations of the equipment manufacturer, or as mutually agreed to between the Employer and the Contractor prior to commencement of erection work.

The Contractor upon signing of the Contract shall, in addition to a Project Coordinator, nominate another responsible officer as his representative at Site suitably designated for the purpose of overall responsibility and co-ordination of the Works to be performed at Site. Such a person shall function from the Site office of the Contractor during the pendency of Contract.

2. CODE REQUIREMENTS

The erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Government of India Rules & Codes, accepted good practices in the industry and shall fulfill all statutory requirements.

3. ELECTRICAL SAFETY REGULATIONS

The contractor shall ensure that entire electrical installation work is executed by adopting applicable statutory safety regulations and best practices in the industry. The Contractor shall employ the necessary number of qualified, full time electricians to maintain his temporary electrical installation.

4. INSPECTION AND TESTING INSPECTION CERTIFICATES

The provisions of the clause entitled Inspection and Testing in the Technical Specification, shall also be applicable to the erection portion of the Works. The Employer shall have the right to re-inspect any equipment though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site. If by the above inspection, the Employer rejects any equipment, the Contractor shall make good for such rejections either by replacement or modification/ repairs as may be necessary to the satisfaction of the Employer. Such replacements will also include the replacements or re- execution of such of those works of other Contractors and/or agencies, which might have got damaged or affected by the replacements or re-work done to the Contractor's work.

5. CONTRACTOR'S SITE OFFICE ESTABLISHMENT

TECHNICAL SPECIFICATIONS

The Contractor shall establish an Office at the Site and keep posted an authorized representative for the purpose of the Contract. Any written order or instruction of the Employer or his duly authorized representative shall be communicated to the said authorized resident representative of the Contractor and the same shall be deemed to have been communicated to the Contractor at his legal address.

6. CONTRACTOR'S FIELD OPERATION

The Contractor shall keep the Employer informed in advance regarding his field activity plans and schedules for carrying out each part of the works. Any review of such plan or schedule or method of work by the Employer shall not relieve the Contractor of any of his responsibilities towards the field activities. Such reviews shall also not be considered as an assumption of any risk or liability by the Employer or any of his representatives and no claim of the Contractor will be entertained because of the failure or inefficiency of any such plan or schedule or method of work reviewed. The Contractor shall be solely responsible for the safety, adequacy and efficiency of plant and equipment and his erection methods.

The Contractor shall have the complete responsibility for the conditions of the Work-Site including the safety of all persons employed by him or his Sub-Contractor and all the properties under his custody during the performance of the work. This requirement shall apply continuously till the completion of the Contract and shall not be limited to normal working hours. The construction review by the Employer is not intended to include review of Contractor's safety measures in, on or near the Work-Site, and their adequacy or otherwise.

7. PROTECTION OF WORK

The Contractor shall have total responsibility for protecting his works till it is finally taken over by the Employer. No claim will be entertained by the Employer or the representative of the Employer for any damage or loss to the Contractor's works and the Contractor shall be responsible for complete restoration of the damaged works to original conditions to comply with the specification and drawings. Should any such damage to the Contractor's Works occur because of any other agency/individual not being under his supervision or control, the Contractor shall make his claim directly with the party concerned. The Contractor shall not cause any delay in the repair of such damaged Works because of any delay in the resolution of such disputes. The Contractor shall proceed to repair the Work immediately and no cause thereof will be assigned pending resolution of such disputes.

8. FACILITIES TO BE PROVIDED BY THE CONTRACTOR

TECHNICAL SPECIFICATIONS

A. Contractor's site office Establishment

The Contractor shall establish a site office at the site and keep posted an authorized representative for the purpose of the contract, pursuant to GCC.

B. Tools, tackles, and scaffoldings

The Contractor shall provide all the construction equipment, tools, tackles, and scaffoldings required for pre-assembly, installation, testing, commissioning and conducting Guarantee tests of the equipment covered under the Contract. The Contractor shall arrange machinery & equipment such as Dozer, Hydra, Cranes, Trailer, etc. wherever required for the purpose of fabrication, erection, and commissioning.

C. Testing Equipment and Facilities:

The contractor shall provide the necessary testing equipment and facilities.

D. Testing of construction material at the site:

Contractor shall make arrangements for the testing of construction material at the site wherever required, under the scope of services of the contract.

E. First-aid

The Contractor shall provide necessary first-aid facilities for all his employees, representatives and workmen working at the Site. Enough number of Contractor's personnel shall be trained in administering first-aid.

F. Water

Contractor shall make all arrangements himself for the supply of construction water as well as potable water for labour and other personnel at the worksite/colony.

9. FIRE PROTECTION

The work procedures that are to be used during the erection shall be those which minimize fire hazards to the extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the Site regularly. Fuels, oils and volatile or flammable materials shall be stored away from the construction and equipment and materials storage areas in safe containers. Untreated canvas, paper, plastic or other flammable flexible materials shall not at all be used at Site for any other purpose unless otherwise specified. If any such materials are received with the equipment at the Site, the same shall be removed and replaced with acceptable material before moving into the construction or storage area.

All materials used for storage or for handling of materials shall be of water proof and flame resistant type. All the other materials such as working drawings, plans etc. which are combustible but are essential for the works to be executed shall be

TECHNICAL SPECIFICATIONS

protected against combustion resulting from welding sparks, cutting flames and other similar fire sources.

All the Contractor's supervisory personnel and sufficient number of workers shall be trained for fire-fighting and shall be assigned specific fire protection duties. Enough of such trained personnel must be available at the Site during the entire period of the Contract.

The Contractor shall provide suitable quantity & type fire protection equipment for the warehouses, office, temporary structures etc.

10. SECURITY

The Contractor shall have total responsibility for all equipment and materials in his custody stores, loose, semi-assembled and/or erected by him at Site. The Contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

11. PACKAGING AND TRANSPORTATION

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling, and storage due to improper packing. The Contractor shall ascertain the availability of Railway wagon sizes from the Indian Railways or any other agency concerned in India well before effecting dispatch of equipment. Before dispatch it shall be ensured that complete processing and manufacturing of the components is carried out at shop, only restricted by transport limitation, in order to ensure that site works like grinding, welding, cutting & preassembly to bare minimum. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

12. CRATING

All equipment and materials shall be suitably coated, wrapped, or covered and boxed or crated for moist humid tropical shipment and to prevent damage or deterioration during handling and storage at the site.

Equipment shall be packed with suitable desiccants, sealed in water proof vapour-proof wrapping and packed in lumber of plywood enclosures, suitably braced, tied and skidded. Lumber enclosures shall be solid, not slatted.

TECHNICAL SPECIFICATIONS

Desiccants shall be either silica gel or calcium sulphate, sufficiently ground to provide the required surface area and activated prior to placing in the packaging. Calcium sulphate desiccants shall be of a chemical nature to absorb moisture. In any case, the desiccant shall not be of a type that will absorb enough moisture to go into solution. Desiccants shall be packed in porous containers, strong enough to withstand handling encountered during normal shipment. Enough desiccant shall be used for the volumes enclosed in wrapping.

Packaging or shipping units shall be designed within the limitations of unloading facilities and the equipment which will be used for transport. Complications involved with ocean shipment and the limitations of ports, railways and roads shall be considered. It shall be the Contractor's responsibility to investigate these limitations and to provide suitable packaging to permit safe handling during transit and at the job site.

Electrical equipment, control and instrumentation shall be protected against moisture and water damage. All external gasket surfaces and flange faces, couplings, motor pump shafts, bearing and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection.

Equipment having antifriction or sleeve bearings shall be protected by weather tight enclosures.

Coated surfaces shall be protected against impact, abrasion, discolouration and other damage. Surfaces which are damaged shall be repaired.

All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors. All female threaded openings shall be closed with forged steel plugs. All pipings, tubing, and conduit equipment and other equipment openings shall be sealed with metallic or other rough usage covers and tapped to seal the interior of the equipment piping, tubing, or conduit.

Provisions shall be made to ensure that water does not enter any equipment during shipment or in storage at the plant site.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Contractor's expense.

While packaging the material, care shall be taken for the limitation from the point of view of availability of railway wagon sizes in India.

13. MATERIALS HANDLING AND STORAGE

- A. All the equipment furnished under the Contract and arriving at Site shall be promptly received, unloaded and transported and stored in the storage spaces by the Contractor.
- B. Contractor shall be solely responsible for any shortages or damage in transit, handling and / or in storage and erection of the equipment at Site. Any demurrage,

TECHNICAL SPECIFICATIONS

wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

- C. The equipment stored shall be properly protected to prevent damage either to the equipment or to the floor where they are stored. The equipment from the store shall be moved to the actual location at the appropriate time to avoid damage of such equipment at Site.
- D. All electrical panels, controls gear, motors and such other devices shall be properly dried by heating before they are installed and energised. Motor bearings, slip rings, commutators and other exposed parts shall be protected against moisture ingress and corrosion during storage and periodically inspected. Heavy rotating parts in assembled conditions shall be periodically rotated to prevent corrosion due to prolonged storage.
- E. All the electrical equipment such as motors, etc. shall be periodically tested for insulation resistance from the date of receipt till the date of commissioning and a record of such measured insulation values maintained by the Contractor. Such records shall be open for inspection by the Employer.
- F. The Contractor shall ensure that all the packing materials and protection devices used for the various equipment during transit and storage are removed before the equipment are installed.
- G. The consumables and other supplies likely to deteriorate due to storage must be thoroughly protected and stored in a suitable manner to prevent damage or deterioration in quality by storage.
- H. All the materials stored in the open or dusty location must be covered with suitable weatherproof and flameproof covering material wherever applicable.

14. CONSTRUCTION MANAGEMENT

Contractor shall be responsible for performance of his works in accordance with the specified construction schedule. If at any time, the Contractor is falling behind the schedule, he shall take necessary action to make good for such delays by increasing his work force or by working overtime or otherwise accelerate the progress of the work to comply with the schedule and shall communicate such actions in writing to the Employer, satisfying that his action will compensate for the delay. The Contractor shall not be allowed any extra compensation for such action.

The Employer shall however not be responsible for provision of additional labour and/or materials or supply or any other services to the Contractor.

TECHNICAL SPECIFICATIONS

15. FIELD OFFICE RECORDS

The Contractor shall maintain at his Site Office up-to- date copies of all drawings, specifications and other Contract Documents and any other supplementary data complete with all the latest revisions thereto. The Contractor shall also maintain in addition the continuous record of all changes to the above Contract Documents, drawings, specifications, supplementary data, etc. effected at the field and on completion of his total assignment under the Contract shall incorporate all such changes on the drawings and other Engineering data to indicate as installed conditions of the equipment furnished and erected under the Contract. Such drawings and Engineering data shall be available for inspection & review to the Employer.

16. PROTECTION OF PROPERTY AND CONTRACTOR'S LIABILITY

- A. The Contractor shall be responsible for any damage resulting from his operations. He shall also be responsible for protection of all persons including members of public and employees of the Employer and his own employees and all public and private property including structures, building, other plants and equipment and utilities either above or below the ground.
- B. The Contractor will ensure provision of necessary safety equipment such as barriers, sign boards, warning lights and alarms, etc. to provide adequate protection to persons and property.

17. PAINTING

All exposed metal parts of the equipment including pipings, structure railings, etc. wherever applicable, after installation unless otherwise surface protected, shall be first painted in accordance with relevant codes & standards, after thoroughly cleaning all such parts of all dirt, rust, scales, greases, oils and other foreign materials by wire brushing, scraping or sand blasting.

18. UNFAVOURABLE WORKING CONDITIONS

The Contractor shall confine all his field operations to those works which can be performed without subjecting the equipment and materials to adverse effects during inclement weather conditions, like monsoon, storms, etc. and during other unfavourable construction conditions. No field activities shall be performed by the Contractor under conditions which might adversely affect the quality and efficiency thereof, unless special precautions or measures are taken by the Contractor in a proper and satisfactory manner in the performance of such Works and with the concurrence of the Employer. Such unfavourable construction conditions will in no way relieve the Contractor of his responsibility to perform the Works as per the schedule.

19. PROTECTION OF MONUMENTS AND REFERENCE POINTS

TECHNICAL SPECIFICATIONS

The Contractor shall ensure that any finds such as relic, antiquity, coins, fossils, etc. which he may come across during the course of performance of his Works either during excavation or elsewhere, are properly protected and handed over to the Employer.

20. FOUNDATION DRESSING & GROUTING FOR EQUIPMENT/ EQUIPMENT BASES

The surfaces of foundations shall be dressed to bring the top surface of the foundations to the required level, prior to placement of equipment/equipment bases on the foundations.

All the equipment/ equipment bases shall be grouted and finished as per these specifications unless otherwise recommended by the equipment manufacturer.

The concrete foundation surfaces shall be properly prepared by chipping, grinding as required to bring the top of such foundation to the required level, to provide the necessary roughness for bondage and to assure enough bearing strength.

A. GROUT

The grout shall be high strength grout having a minimum characteristic compressive strength of 60 N/mm² at 28 days. The grout shall be chloride - free, cement based, free flowing, non-metallic grout.

The Grout shall have good flowability even at very low water/ grout powder ratio.

The Grout shall have characteristics of controlled expansion to be able to occupy its original volume to fill the voids and to compensate for shrinkage. Grout shall be of pre-mix variety so that only water needs to be added before use.

The mixing of the Grout shall conform to the recommendations of the manufacturer of the Grout.

B. PLACING OF GROUT

After the base has been prepared, its alignment and level has been checked and approved and before actually placing the grout, a low dam shall be set around the base at a distance that will permit pouring and manipulation of the grout. The height of such dam shall be at least 25mm above the bottom of the base. Suitable size and number of chains shall be introduced under the base before placing the grout, so that such chains can be moved back & forth to push the grout into every part of the space under the base.

The grout shall be poured either through grout holes if provided or shall be poured at one side or at two adjacent sides to make the grout move in a solid mass under the base and out in the opposite side. Pouring shall be continued until the entire space below the base is thoroughly filled and the grout stands at least 25 mm higher all around than the bottom of the base. Enough care should be taken to avoid any air or water pockets beneath the bases.

TECHNICAL SPECIFICATIONS

In addition to the above, recommendations of Grout manufacturer shall also be followed.

C. FINISHING OF THE EDGES OF THE GROUT

The poured grout should be allowed to stand undisturbed until it is well set. Immediately thereafter, the dam shall be removed and grout which extends beyond the edges of the structural or equipment base plates shall be cut off, flushed and removed. The edges of the grout shall then be pointed and finished with 1:2 cement mortar pressed firmly to bond with the body of the grout and smoothened with a tool to present a smooth vertical surface. The work shall be done in a clean and scientific manner and the adjacent floor spaces, exposed edges of the foundations, and structural steel and equipment base plates shall be thoroughly cleaned of any spillage of the grout.

21. SHAFT ALIGNMENTS

All the shafts of rotating equipment shall be properly aligned to those of the matching equipment to as perfect accuracy as practicable. The equipment shall be free from excessive vibration to avoid overheating of bearings or other conditions which may tend to shorten the life of the equipment. The vibration level of rotating equipment measured at bearing housing shall conform to VDI 2056. All bearings, shafts and other rotating parts shall be thoroughly cleaned and suitably lubricated before starting.

22. DOWELLING

All the motors and other equipment shall be suitably doweled after alignment of shafts with tapered machined dowels as per the direction of the Employer.

23. CABLING

All cables shall be supported by conduits or cable tray run in air or in cable channels. These shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turn made of symmetrical bends or fittings. When cables are run on cable trays, they shall be clamped at a minimum intervals of 2000mm.

Each cable, whether power or control, shall be provided with a metallic or plastic tag of an approved type, bearing a cable reference number indicated in the cable and conduit list (prepared by the Contractor), at every 5 meter run or part thereof and at both ends of the cable adjacent to the terminations. Cable routing is to be done in such a way that cables are accessible for any maintenance and for easy identification.

Sharp bending and kinking of cables shall be avoided. Installation of other cables like high voltage, coaxial, screened, compensating, mineral insulated shall be in accordance with the cable manufacturer's recommendations. Wherever cables

TECHNICAL SPECIFICATIONS

cross roads and water, oil, sewage or gas lines, special care should be taken for the protection of the cables in designing the cable channels.

In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop fault at a later date.

Control cable terminations shall be made in accordance with wiring diagrams, using identifying codes subject to the Employer's approval. Multicore control cable jackets shall be removed as required to train and terminate the conductors. The cable jacket shall be left on the cable, as far as possible, to the point of the first conductor branch. The insulated conductors from which the jacket is removed shall be neatly twined in bundles and terminated. The bundles shall be firmly but not tightly tied utilizing plastic or nylon ties or specifically treated fungus protected cord made for this purpose. Control cable conductor insulation shall be securely and evenly cut.

The connectors for control cables shall be covered with a transparent insulating sleeve so as to prevent accidental contact with ground or adjacent terminals and shall preferably terminate in Elmex terminals and washers. The insulating sleeve shall be fire resistant and shall be long enough to over pass the conductor insulation. All control cables shall be fanned out and connection made to terminal blocks and test equipment for proper operation before cables are corded together.

24. EQUIPMENT INSTALLATION

A. GENERAL

REQUIREMENTS

The Contractor shall furnish all construction materials, tools and equipment and shall

perform all work required for complete installation of all control and instrument equipment furnished under this specification.

Contractor shall prepare detailed installation drawings for each equipment furnished under this specification. Installation of all equipment/systems furnished by this specification shall be as per installation drawings.

Erection procedures not specified herein shall be in accordance with the recommendations of the equipment manufacturers. The procedures shall be acceptable to the Employer.

The Contractor shall coordinate his work with other suppliers where their instruments and devices are to be installed under specifications.

B. INSTALLATION MATERIALS

All materials required for installation, testing and commissioning of the equipment shall be furnished by the Contractor.

TECHNICAL SPECIFICATIONS

C. REGULATORY REQUIREMENTS

All installation procedures shall confirm with the accepted good engineering practice and with all applicable governmental laws, regulations and codes.

D. CLEANING

All equipment shall be cleaned of all sand, dirt and other foreign materials immediately after removal from storage and before the equipment is installed.

E. INSTALLATION OF FIELD MOUNTED INSTRUMENTS/DEVICES AND NON-FREE

Standing Equipment

The installation drawings for all field mounted equipment/instrument/devices furnished under this specification shall meet the requirements of this specification, applicable codes and standards and recommendations of manufacturers of instruments/devices. In addition to above relevant Portion as specified elsewhere in technical specification may be referred.

Field mounted instruments and accessories shall be bracket or sub panel mounted on the nearest suitable firm steel work or masonry. The brackets, stands, supports and other miscellaneous hardware required for mounting instruments and accessories such as receiver gauge, air set, valve manifold, purge-meter etc. shall be furnished and installed. No field mounted instruments shall be installed such that it depends for support or rigidity on the impulse piping or on electrical connection to it.

All free standing instrumentation cabinets and panels shall be located within the construction tolerances of +/- 3 mm of the location dimensions indicated on the plant arrangement drawings.

Non-free standing local enclosures and cabinets shall be mounted in accessible locations on columns, walls, or stands. Bracket and stands shall be fabricated as required to install the local enclosures and cabinets in a workman like manner. Rough edges and welds on all fabricated supports shall be ground smooth. The supports shall be finished with two coats of primer and two coats of paint as specified in this part.

F. DEFECTS

All defects in erection shall be corrected to the satisfaction of the Employer and the Project Manager. The dismantling and reassembly of Contractor furnished equipment to remove defective parts, replace parts, or make adjustments shall be included as a part of the work under these specifications.

The removal of control and instrument equipment in order to allow bench calibration, if required, and the re-installation of the said equipment after calibration shall also be included as a part of the work under these specifications.

G. EQUIPMENT PROTECTION

TECHNICAL SPECIFICATIONS

All equipment to be erected under these specifications shall be protected from damage of any kind from the time of contract award until commissioning of each unit.

The equipment shall be protected during storage as described herein.

Equipment shall be protected from weld spatter during construction.

Suitable guards shall be provided for protection of personnel on all exposed rotating or moving machine parts. All such guards with necessary spares and accessories shall be designed for easy removal and maintenance.

Equipment having glass components such as gauges, or equipment having other easily breakable components, shall be protected during the construction period with plywood enclosures or other suitable means. Broken, stolen, or lost components shall be replaced by the Contractor.

Machine finished surfaces, polished surfaces, or other bare metal surfaces which are not to be painted, such as machinery shafts and couplings shall be provided temporary protection during storage and constructional periods by a coating of a suitable non-drying, oily type, rust preventive compound.

25. DEVIATIONS DISPOSITIONING:

Any deviation to the contract and employer approved documents shall be properly recorded in the format prescribed by Owner/ Company. All the deviations shall be brought to the knowledge of employer's representative for suitable dispositioning.

26. STATUTORY REQUIREMENTS

In addition to the local laws and regulations, the Contractor shall also comply with the Minimum Wages Act and the Payment of Wages Act (both of the Government of India) and the rules made there under in respect of its labour and the labour of its sub-contractors currently employed on or connected with the contract.

All registration and statutory inspection fees, if any, in respect of his work pursuant to this Contract shall be to the account of the Contractor. However, any registration, statutory inspection fees lawfully payable under the provisions of any statutory laws and its amendments from time to time during erection in respect of the plant equipment ultimately to be owned by the Employer, shall be to the account of the Employer. Should any such inspection or registration need to be re-arranged due to the fault of the Contractor or his Sub-Contractor, the additional fees for such inspection and/or registration shall be borne by the Contractor.

27. EMPLOYMENT OF LABOUR

TECHNICAL SPECIFICATIONS

- A. Contractors are to employ, to the extent possible (as per policy decision of the company valid from time to time), local project affected people and pay wages not less than the minimum wages as per minimum Wages Act or such other legislations or award of the minimum wage fixed by respective State Govt. or Central Govt. as may be in force. No female labour shall be employed after darkness. No persons below the age of eighteen years shall be employed.
- B. All traveling expenses including provisions of all necessary transport to and from site lodging allowances and other payments to contractor's employees shall be the sole responsibility of the contractor.
- C. The hour of work on the site shall be decided by the owner and the contractor shall adhere to it. Working hours will normally be eight (8) hours per day Monday to Saturday.
- D. Contractor's employees shall wear identification badges while on work at site.
- E. Payment of Provident Fund for the workmen employed by him for the work as per the Law prevailing under provision of CMPF/EPF and allied scheme valid from time to time shall be responsibility of the Contractor which shall be in accordance with the given guidelines:
 - i. The Contractor must be mandatorily registered as employer under the CMPF Act and allied scheme and shall submit details of their workers with the CMPF number, wherever required. The contractor shall submit CMPF registration certificate before signing of agreement.
 - ii. If any employee of a Contractor is not a member of any Provident Fund, he shall be required to become a member of CMPF scheme immediately, for availing benefits therefrom.
 - iii. Where the employees of a Contractor are members of EPF scheme, the Contractor shall provide appropriate facilitation to those employees who voluntarily opt for conversion from EPF Schemes to CMPF Schemes. In addition to the above, the Contractor shall provide a copy of the updated passbook having entry made in the CMPF/EPF or Allied Scheme(s) of Provident fund as the case may be, to the Competent Authority annually or as and when asked. Bidder shall also submit copies of statutory returns. The contractor shall also comply with the provisions of the CMPF/ EPF and regularly deposit the contributions in accordance with the same. The Company shall have no liability whatsoever in this regard.
- F. The Contractor shall comply with statutory requirements of various acts including Child Labour (Prohibition & Regulation) Act, 1986 as amended from time to time

TECHNICAL SPECIFICATIONS

and all rules, regulations and schemes framed there under from time to time in addition to other applicable labour laws.

- G. The payment to the contractor's labourers has to be made through Bank only.
- H. Bonus is to be paid to the contract workers engaged by the Contractors as per the provisions of Payment of Bonus Act, 1965 as amended from time to time.
- I. The contractors shall register themselves on the Contract Labour Payment Management Portal (CLPMP) of Owner/ Company within 30 days of issue of Letter of Acceptance/work order and will have to enter and update periodically the following details in the portal:
 - i. LOA/Work Order details
 - ii. Details of Contractor workers and payment of wages in respect of each Work Order each month.
- J. All the contract workers shall be covered with the Bio-metric attendance system for payment of wages.
- K. Contractors should deploy suitably experienced workers as mentioned in relevant Govt. circular.

28. WORK & SAFETY REGULATIONS

The Contractor shall ensure proper safety of all the workmen, materials, plant and equipment belonging to him or to Employer or to others, working at the Site. The Contractor shall also be responsible for provision of all safety notices and safety equipment required both by the relevant legislation and the Employer as he may deem necessary.

Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the contractor shall be responsible for carrying-out such provision and/or storage in accordance with the rules and regulations laid down in petroleum act 1934, explosives act, 1948, and petroleum and carbide of calcium manual published by the chief inspector of explosives of India. All such storage shall have prior approval of the employer. In case, any approvals are necessary from the chief inspector (explosives) or any statutory authorities, the contractor shall be responsible for obtaining the same.

TECHNICAL SPECIFICATIONS

Where explosives are to be used, the same shall be used under the direct control and supervision of an expert, experienced, qualified and competent person strictly in accordance with the Code of Practices/Rules framed under Indian Explosives Act pertaining to handling, storage and use of explosives.

All equipment used in construction and erection by Contractor shall meet Indian/International Standards and where such standards do not exist, the Contractor shall ensure these to be absolutely safe. All construction and erection equipment shall be strictly operated and maintained by the Contractor in accordance with statutory safety regulations. Periodical Examinations and all tests for all lifting/hoisting equipment & tackles shall be carried-out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity Act 1910 and associated Laws/Rules in force from time to time.

The Contractor shall provide suitable safety equipment of prescribed standard to all employees and workmen according to the need, as may be directed by Employer who will also have right to examine these safety equipments to determine their suitability, reliability, acceptability and adaptability.

- (a) Working platforms should be fenced and shall have means of access.
- (b) Ladders in accordance with statutory safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

The Contractor shall provide safe working conditions to all workmen and employees at the Site including safe means of access, railings, stairs, ladders, scaffoldings etc. The scaffoldings shall be erected under the control and supervision of an experienced and competent person. For erection, good and standard quality of material only shall be used by the Contractor.

The Contractor employing workmen whether temporary, casual, probationer, regular or permanent or on contract, shall employ at least one full time officer exclusively as **Safety Steward** to supervise safety aspects of the equipment and workmen, who will co- ordinate with the Employer's Safety Officer. In case of work being carried out through sub- Contractors, the Sub-Contractor's workmen/employees will also be considered as the Contractor's employees/workmen for the above purpose

In case any accident occurs during the construction/ erection or other associated activities undertaken by the Contractor thereby causing any minor or major or fatal injury to his employees due to any reason, whatsoever, it shall be the responsibility of the Contractor to promptly inform the same to the Employer and also to all the authorities envisaged under the applicable laws.

The Contractor shall follow and comply with relevant provisions of applicable laws pertaining to the safety of workmen, employees plant and equipment as may be prescribed from time to time without any demur, protest or contest or reservation

TECHNICAL SPECIFICATIONS

PART-H: MANDATORY SPARES

TECHNICAL SPECIFICATIONS

H-1: MANDATORY SPARES

1. GENERAL

- A. The general requirements pertaining to the supply of mandatory spares is as under. The bidder shall indicate the prices for each and every item (except for items not applicable to the bidders design) in the 'Schedule of mandatory Spares' whether or not he considers it necessary for the Owner to have such spares. If the bidder fails to comply with the above or fails to quote the price of any spare item, the cost of such spares shall be deemed to be included in the contract price. The bidder shall furnish the population per unit of each item in the Bid Forms and Price Schedules. Whenever the quantity is mentioned in "sets" the bidder has to give the item details and prices of each item.
- B. Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the station (project), unless specified otherwise, and the fraction will be rounded off to the next higher whole number.
- C. Wherever the requirement has been specified as a 'set' it will include the total requirement of the item for a unit, module or the station or as specified. Where it is not specified a 'set' it will include the total requirement of the item for a unit, module or the station or as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also one set for the particular equipment. e.g. 'set' of bearings for a pump would include the total number of bearings in a pump. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.
- D. The Owner reserves the right to buy any or all the mandatory spares parts.
- E. The prices of mandatory spares indicated by the Bidder in the Bid Proposal sheets shall be used for bid evaluation purposes.
- F. All mandatory spares shall be delivered at site at least two months before scheduled commissioning of the solar plant. However, spares shall not be dispatched before dispatch of corresponding main equipment.
- G. Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise.
- H. The Mandatory Spares shall be handed over to the Bidder during O&M Period for use in the Plant Capacity Block through an Indemnity Bond (Format Attached). The spares shall be replenished by the bidder as and when it is used.
- I. The spares in total quantity shall be returned to the Employer in working condition at the end of the O&M Period.

TECHNICAL SPECIFICATIONS

PART-I – TENDER DRAWINGS & ATTACHMENTS

TECHNICAL SPECIFICATIONS

I-1 : TENDER DRAWINGS & ATTACHMENTS

1.	Attachment-1	Geotechnical Investigation Report
2.	Attachment-2	Plot Map
3.	Attachment-3	Hydrology & Hydrogeological Study Report
4.	Attachment-4	Tentative layout of Park pooling substation (SLD)



Report No.: GM/22/198B

Date: 25/08/2022

To

M/s TUV SUD South Asia Pvt Ltd.

C/o

M/s Geomin solution pvt ltd

Name of Client: Rajasthan Rajya Vidyut Utpaadan Nigam Ltd (RRVUNL)

Subject: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Please find enclosed herewith the bearing capacity report of soil for the above said project.

Er. I.S. Bath
Geo Media Engineering &
Consultancy Services Pvt. Ltd.,
Bathinda



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

INDEX

Description	Page No.
1.0 Introduction	03
2.0 Field Investigation	03
2.1 Bore hole Location	03
2.2 Standard penetration test	03
3.0 Laboratory Investigations	03
3.1 Index Properties	03
3.2 Engineering Properties	03
4.0 Calculation of bearing capacity	04
4.1 Bearing capacity based on shear criteria	04
4.2 Bearing capacity based on settlement criteria	05
5.0 Net Allowable bearing capacity	10
6.0 Recommendations	10
7.0 Bore log charts	16
8.0 Observed SPT 'N'-Value and Corrected 'N'-value Graph	27
9.0 Appendix-I (Notations)	34
10.0 Appendix-II (IS Codes)	36



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

I. Discipline: Mechanical Testing**Group:** Soil & Rock (Field Testing)**1.0 INTRODUCTION**

Geo-Media Engineering and Consultancy Services (Geo-Media) Pvt. Ltd. presents herein our Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan. The purpose of this report is to assess subsurface conditions in order to provide geotechnical comments and recommendations for soil characteristics, bearing capacity and earth pressure. Attachments to this report include soil bore-logs.

2.0 FIELD INVESTIGATIONS**2.1 BORE HOLE LOCATION:**

The locations of bore holes were given by Mr. Ashok Solanki. Eighteen bore holes designated as BH-1 and BH-18 were done to carry out the desired investigations. This report contains BH-1 to BH-12 only.

2.2 STANDARD PENETRATION TEST

According to IS code 2131-1981 Standard penetration test was conducted at each bore hole and samples were collected at an interval of 1.5m or at a depth where there is change in strata. N values were recorded at required depths as per the code up to significant depth. N values observed in the field are corrected for both the corrections

- Overburden Pressure Correction $N_n = C_n \times N$

Where C_n is correction for overburden pressure, N = Observed no of blows.

- Dilatancy Correction : This correction is required for fine sands below water table
 $N_c = 15 + (N_n - 15) / 2$ When $N_n > 15$ N_c = corrected value.

3.0 LABORATORY INVESTIGATIONS**3.1 INDEX PROPERTIES**

Following Index Properties of the soil samples collected from various depths are determined for the classification of soil.

- Particle size distribution
- Relative density
- Atterbergs limits

3.2 ENGINEERING PROPERTIES

Following Engineering Properties are determined in the laboratory from the tests mentioned against them.

- Shear Strength (c' and Φ' from direct shear test and triaxial shear test)
- Permeability (k from constant and variable head permeability test)
- Compressibility (Compaction and Consolidation test)



Page 3 of 36

**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

4.0 CALCULATION OF BEARING CAPACITY

The soil can fail either in shear or settlement. Net allowable bearing capacity will be determined with both the cases. The criteria, with minimum value will govern the bearing capacity of soil.

4.1 BEARING CAPACITY BASED ON SHEAR

Net ultimate bearing capacity q_{nu} as per IS code 6403--1981.

$$q_{nu} = 2/3 c' N'_c S_c d_c i_c + \gamma D_f (N_q' - 1) S_q d_q i_q + 0.5 \gamma B N'_\gamma S_\gamma d_\gamma i_\gamma W' \quad (\text{local shear failure})$$

$$q_{nu} = c N_c S_c d_c i_c + \gamma D_f (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W' \quad (\text{General shear failure})$$

$$\text{Net safe bearing capacity } q_{ns} = q_{nu} / 2.5 \quad \Phi' = \tan^{-1} (2/3 \tan \Phi)$$

N'_c, N'_q, N'_γ are bearing capacity factors for local shear failure.

N_c, N_q, N_γ are bearing capacity factors for general shear failure

d_c, d_q, d_γ are the depth factors

i_c, i_q, i_γ are the Inclination factors

S_c, S_q, S_γ are the Shape factors

Assumed data of Foundation	Size (m)	1.00 x 1.00					
	Type	Square					
	Depth (m) w.r.t. NSL	1.00					
Properties↓		BH-1	BH-2	BH-3	BH-4	BH-5	BH-6
w'		1.00	1.00	1.00	1.00	1.00	1.00
c' (t/m ²)		0.00	0.00	0.00	0.00	0.00	0.00
γ (g/cc)		1.85	1.81	1.74	1.74	1.62	1.62
Φ°		30.50	30.25	29.75	29.75	26.00	26.00
Φ'°		21.44	21.24	20.86	20.86	18.01	18.01
Nc		19.78	18.90	17.32	17.32	13.30	13.30
Nq		10.26	9.54	8.29	8.29	5.42	5.42
Nγ		10.82	9.77	7.99	7.99	4.30	4.30
Sc		1.300	1.300	1.300	1.300	1.300	1.300
Sq		1.200	1.200	1.200	1.200	1.200	1.200
Sr		0.800	0.800	0.800	0.800	0.800	0.800
dc		1.294	1.292	1.290	1.290	1.274	1.274
dq=dγ		1.147	1.146	1.145	1.145	1.137	1.137
qu (t/m ²)		32.76	29.36	23.80	23.80	12.94	12.94
qns (t/m ²)		13.11	11.75	9.52	9.52	5.18	5.18





Report No.: GM/22/198B

Date: 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

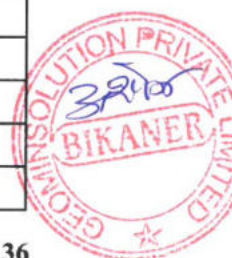
Assumed data of Foundation	Size (m)	1.00 x 1.00					
	Type	Square					
	Depth (m) w.r.t. NSL	1.00					
Properties↓		BH-7	BH-8	BH-9	BH-10	BH-11	BH-12
w'		1.00	1.00	1.00	1.00	1.00	1.00
$c' (t/m^2)$		0.00	0.00	0.00	0.00	0.00	0.00
$\gamma (g/cc)$		1.62	1.66	1.62	1.64	1.66	1.63
Φ°		26.00	28.50	26.00	28.00	28.50	27.00
Φ°		18.01	19.90	18.01	19.52	19.90	18.76
N_c		13.30	14.75	13.30	14.46	14.75	13.88
N_q		5.42	6.35	5.42	6.16	6.35	5.79
N_γ		4.30	5.34	4.30	5.13	5.34	4.71
S_c		1.300	1.300	1.300	1.300	1.300	1.300
S_q		1.200	1.200	1.200	1.200	1.200	1.200
S_r		0.800	0.800	0.800	0.800	0.800	0.800
d_c		1.274	1.284	1.274	1.282	1.284	1.278
$d_q=d_\gamma$		1.137	1.142	1.137	1.141	1.142	1.139
$q_u (t/m^2)$		12.94	16.22	12.94	15.43	16.22	14.17
$q_{ns} (t/m^2)$		5.18	6.49	5.18	6.17	6.49	5.67

4.2 BEARING CAPACITY BASED ON SETTLEMENT CRITERIA

Both overburden and dilatancy corrections are required to be applied to the observed as per IS2131-1981. Net allowable safe bearing pressure is calculated as the allowable limits given in IS code 8009 part 1 and water table correction factor is taken into consideration.

BH-1 (28°16'52"N 73°04'40"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C_n	N_n	N_c
1.00	15	0.185	1.566	23.49	23.49
1.50	16	0.278	1.430	22.88	22.88
2.00	16	0.371	1.333	21.33	21.33
3.00	18	0.561	1.195	21.51	21.51
4.50	21	0.851	1.056	22.17	22.17
6.00	37	1.155	0.954	35.28	35.28



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-2

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	13	0.181	1.573	20.45	20.45
1.50	15	0.274	1.435	21.53	21.53
2.00	21	0.370	1.334	28.02	28.02
3.00	27	0.569	1.190	32.14	32.14
4.50	31	0.871	1.048	32.49	32.49
6.00	38	1.177	0.947	36.00	36.00

BH-3 (28°15'47"N 73°04'35"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	10	0.174	1.587	15.87	15.87
1.50	12	0.263	1.448	17.38	17.38
2.00	17	0.357	1.346	22.89	22.89
3.00	26	0.555	1.199	31.17	31.17
4.50	31	0.857	1.054	32.66	32.66
6.00	36	1.161	0.952	34.27	34.27

BH-4 (28°16'50"N 73°00'30"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	12	0.178	1.579	18.95	18.95
1.50	15	0.271	1.439	21.59	21.59
2.00	18	0.366	1.338	24.09	24.09
3.00	21	0.559	1.197	25.13	25.13
4.50	31	0.860	1.052	32.62	32.62
6.00	34	1.165	0.951	32.33	32.33



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-5 (28°17'31"N 73°00'29"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	3	0.162	1.610	4.83	4.83
1.50	9	0.248	1.468	13.21	13.21
2.00	12	0.337	1.366	16.39	16.39
3.00	21	0.530	1.214	25.50	25.50
4.50	28	0.832	1.063	29.78	29.78
6.00	32	1.135	0.960	30.71	30.71

BH-6

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	2	0.162	1.610	3.22	3.22
1.50	5	0.244	1.474	7.37	7.37
2.00	10	0.332	1.371	13.71	13.71
3.00	13	0.513	1.225	15.93	15.93
4.50	24	0.807	1.074	25.77	25.77
6.00	27	1.105	0.968	26.15	26.15

BH-7 (28°17'48"N 73°01'25"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	3	0.162	1.610	4.83	4.83
1.50	5	0.244	1.474	7.37	7.37
2.00	12	0.333	1.370	16.43	16.43
3.00	17	0.521	1.220	20.74	20.74
4.50	23	0.814	1.071	24.63	24.63
6.00	28	1.114	0.966	27.04	27.04



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-8 (28°17'37"N 73°01'56"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	6	0.166	1.602	9.61	9.61
1.50	8	0.251	1.464	11.71	11.71
2.00	14	0.343	1.360	19.04	19.04
3.00	20	0.535	1.211	24.23	24.23
4.50	27	0.833	1.063	28.70	28.70
6.00	31	1.135	0.960	29.75	29.75

BH-9 (28°17'20"N 73°03'43"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	3	0.162	1.610	4.83	4.83
1.50	10	0.249	1.467	14.67	14.67
2.00	16	0.342	1.361	21.77	21.77
3.00	22	0.536	1.210	26.63	26.63
4.50	31	0.838	1.061	32.89	32.89
6.00	34	1.141	0.958	32.57	32.57

BH-10 (28°16'49"N 73°04'30"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	5	0.164	1.606	8.03	8.03
1.50	8	0.249	1.467	11.73	11.73
2.00	15	0.342	1.361	20.42	20.42
3.00	22	0.536	1.211	26.63	26.63
4.50	25	0.831	1.064	26.59	26.59
6.00	32	1.133	0.960	30.73	30.73



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-11 (28°27'56"N 73°05'29"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	6	0.166	1.602	9.61	9.61
1.50	8	0.251	1.464	11.71	11.71
2.00	13	0.342	1.361	17.69	17.69
3.00	27	0.541	1.208	32.60	32.60
4.50	30	0.842	1.059	31.78	31.78
6.00	35	1.147	0.956	33.46	33.46

BH-12 (28°17'32"N 73°02'02"E)

Depth from NSL (m)	N	Over Burden Pressure Kg /cm ²	C _n	N _n	N _c
1.00	4	0.163	1.608	6.43	6.43
1.50	9	0.249	1.467	13.20	13.20
2.00	13	0.340	1.363	17.72	17.72
3.00	17	0.528	1.216	20.67	20.67
4.50	23	0.820	1.068	24.57	24.57
6.00	30	1.122	0.963	28.90	28.90

Bore Holes	N _c (Avg)	Net allowable pressure q _{np} (t/m ²)
BH-1	22.28	28.20
BH-2	26.93	35.00
BH-3	23.99	30.71
BH-4	24.47	31.41
BH-5	17.94	21.86
BH-6	13.20	14.92
BH-7	14.80	17.26
BH-8	18.66	22.91
BH-9	20.16	25.10
BH-10	18.68	22.94
BH-11	20.68	25.87
BH-12	16.52	19.77





Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

5.0 NET ALLOWABLE BEARING CAPACITY

The net allowable bearing capacity is the least of the bearing capacity based on above two criteria and its value is given in the following table.

Bore Hole	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net safe bearing capacity q_{ns} (t/m ²) From shear criteria	Net safe pressure q_{np} (t/m ²) From Settlement criteria	Net Allowable Bearing Capacity (t/m ²)
BH-1	1.00	1.00 x 1.00	Square	13.11	28.20	13.11
BH-2	1.00	1.00 x 1.00	Square	11.75	35.00	11.75
BH-3	1.00	1.00 x 1.00	Square	9.52	30.71	9.52
BH-4	1.00	1.00 x 1.00	Square	9.52	31.41	9.52
BH-5	1.00	1.00 x 1.00	Square	5.18	21.86	5.18
BH-6	1.00	1.00 x 1.00	Square	5.18	14.92	5.18
BH-7	1.00	1.00 x 1.00	Square	5.18	17.26	5.18
BH-8	1.00	1.00 x 1.00	Square	6.49	22.91	6.49
BH-9	1.00	1.00 x 1.00	Square	5.18	25.10	5.18
BH-10	1.00	1.00 x 1.00	Square	6.17	22.94	6.17
BH-11	1.00	1.00 x 1.00	Square	6.49	25.87	6.49
BH-12	1.00	1.00 x 1.00	Square	5.67	19.77	5.67

6.0 RECOMMENDATIONS

1) Net allowable bearing capacity is given in following table.

BH-1

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	13.11	14.96
2	1.00	1.50 x 1.50	Square	14.30	16.15

i) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.84	0.56	4.02
2	3.00	0.30	3.13	1.16	3.97
3	4.00	0.30	5.05	2.00	3.05

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

Page 10 of 36



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-2

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	11.75	13.56
2	1.00	1.50 x 1.50	Square	12.80	14.61

i) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	2.01	0.56	4.12
2	3.00	0.30	4.12	1.20	4.30
3	4.00	0.30	6.22	2.09	4.44

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-3

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	9.52	11.26
2	1.00	1.50 x 1.50	Square	10.34	12.08

i) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.93	0.54	3.62
2	3.00	0.30	4.00	1.15	3.92
3	4.00	0.30	6.07	2.01	4.16

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-4

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	9.52	11.26
2	1.00	1.50 x 1.50	Square	10.34	12.08

i) Load Carrying capacity of piles is given in following table:-



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.98	0.55	3.92
2	3.00	0.30	4.03	1.16	4.02
3	4.00	0.30	6.12	2.04	4.21

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-5

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	5.18	6.80
2	1.00	1.50 x 1.50	Square	5.58	7.20

i) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.48	0.49	2.84
2	3.00	0.30	3.77	1.06	3.25
3	4.00	0.30	5.80	1.88	3.57

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-6

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	5.18	6.80
2	1.00	1.50 x 1.50	Square	5.58	7.20

i) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.40	0.47	2.18
2	3.00	0.30	2.56	1.00	2.65
3	4.00	0.30	5.58	1.78	3.08

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-7

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	5.18	6.80
2	1.00	1.50 x 1.50	Square	5.58	7.20

ii) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.41	0.48	2.52
2	3.00	0.30	2.84	1.02	2.96
3	4.00	0.30	5.64	1.81	3.19

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-8

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	6.49	8.15
2	1.00	1.50 x 1.50	Square	6.99	8.65

ii) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.63	0.51	3.08
2	3.00	0.30	3.11	1.09	3.38
3	4.00	0.30	5.10	1.91	3.62

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-9

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	5.18	6.80
2	1.00	1.50 x 1.50	Square	5.58	7.20

ii) Load Carrying capacity of piles is given in following table:-



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.73	0.50	3.08
2	3.00	0.30	3.19	1.08	3.46
3	4.00	0.30	5.64	1.91	3.78

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-10

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	6.17	7.81
2	1.00	1.50 x 1.50	Square	6.65	8.29

ii) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.73	0.51	3.08
2	3.00	0.30	3.20	1.09	3.44
3	4.00	0.30	4.87	1.90	3.62

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

BH-11

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	6.49	8.15
2	1.00	1.50 x 1.50	Square	7.00	8.66

ii) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.73	0.51	3.02
2	3.00	0.30	3.49	1.10	3.57
3	4.00	0.30	5.49	1.94	3.83

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

BH-12

Sr. No.	Depth of Foundation w.r.t NSL (m)	Size of foundation (m)	Type of Foundation	Net Allowable Bearing Capacity (t/m ²)	Gross Safe Bearing Capacity (t/m ²)
1	1.00	1.00 x 1.00	Square	5.67	7.30
2	1.00	1.50 x 1.50	Square	6.11	7.74

ii) Load Carrying capacity of piles is given in following table:-

Sr. No.	Length of Pile (m)	Diameter of Pile (m)	Load carrying capacity of Straight pile (tonne)	Uplift Load carrying capacity of straight pile (tonne)	Lateral load carrying Capacity of straight pile (tonnes)
1	2.00	0.30	1.72	0.50	2.96
2	3.00	0.30	2.90	1.06	3.19
3	4.00	0.30	4.78	1.86	3.41

Note: - Actual load carrying capacity of pile should be verified by conducting pile load test on test pile.

- ii) Ground water table has not been encountered upto the depth exploration.
 iii) Allowable settlement is taken as 50mm for isolated foundation.

Er. I.S. Bath
 Geo Media Engineering &
 Consultancy Services Pvt. Ltd.,
 Bathinda





Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Bore Log Chart

Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022			ULR No. TC748322000000947F		IS: Classification			
Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)		Bulk unit weight Y (t/m ³)	Direct Shear Test				
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L		P.I			C [*] (t/m ²)	φ ^o
1.00	SPT		0.00	53.01	46.99	NP	NP	NP	1.85	0.00	30.50	15	SM
1.50	SPT		0.00	55.12	44.88	NP	NP	NP	1.86	0.00	31.00	16	SM
2.00	SPT		0.00	59.64	40.36	NP	NP	NP	1.86	0.00	31.00	16	SM
3.00	SPT		0.00	68.26	31.74	NP	NP	NP	1.90	0.00	31.25	18	SM
4.50	SPT		0.00	70.49	29.51	NP	NP	NP	1.93	0.00	32.00	21	SM
6.00	SPT		0.00	83.36	16.64	NP	NP	NP	2.03	0.00	34.00	37	SM

		TC-7483	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC748322000000947F	
				Ground water table: - Not encountered		Bore Hole No.: - 01 of 18	

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 06.08.2022		ULR No. TC74832200000094	

SILTY SAND





Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.: - 02 of 18		 TC-7483			
Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight Y (t/m³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C' (t/m²)	φ°		
1.00	SPT		0.00	98.14	1.86	NP	NP	NP	1.81	0.00	30.25	13	SP
1.50	SPT		0.00	97.81	2.19	NP	NP	NP	1.85	0.00	31.00	15	SP
2.00	SPT		0.00	98.28	1.72	NP	NP	NP	1.93	0.00	31.50	21	SP
3.00	SPT		0.00	98.15	1.85	NP	NP	NP	1.99	0.00	33.00	27	SP
4.50	SPT		0.00	98.21	1.79	NP	NP	NP	2.01	0.00	33.50	31	SP
6.00	SPT		0.00	97.84	2.16	NP	NP	NP	2.04	0.00	34.00	38	SP



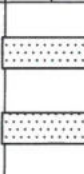
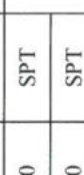
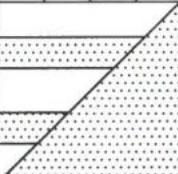
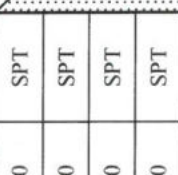
Page 17 of 36



Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A				Ref. Dated: 09.08.2022				Date of Field Testing: 07.08.2022				ULR No. TC748322000000947F		 TC-7483							
Depth from NSL (m)				Symbolic Representation		Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight				Direct Shear Test		S.P.T Value (Observed) (N Value)		IS: Classification	
						Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I	Y (t/m ³)	C' (t/m ²)	φ°							
1.00						0.00	77.78	22.22	NP	NP	NP	1.74	0.00	29.75	10	SM	SILTY SAND				
1.50						0.00	87.19	12.81	NP	NP	NP	1.78	0.00	30.25	12	SM					
2.00						0.00	93.06	6.94	NP	NP	NP	1.88	0.00	31.25	17	SP-SM					
3.00						0.00	88.88	11.12	NP	NP	NP	1.98	0.00	32.00	26	SP-SM	POORLY GRADED SAND – SILTY SAND				
4.50						0.00	94.44	5.56	NP	NP	NP	2.01	0.00	33.00	31	SP-SM					
6.00						0.00	93.96	6.04	NP	NP	NP	2.03	0.00	33.50	36	SP-SM					



Page 18 of 36

GEO MEDIA ENGINEERING AND CONSULTANCY SERVICES PVT. LTD.

Head Office: # 23609-A, Opp. I.T.I., Mansa Road, Bathinda (Punjab) 151001 | Mob. 95696-70700, 78377-26700, Tel.: 0164-5012700

E-mail: geomediapvtltd@gmail.com

Website: www.geomediaengineering.com



Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A		Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 04 of 18		 TC-7483	
Ref. No. SRF/22/805A											

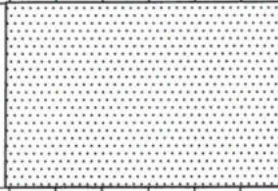




Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022		Date of Field Testing: 07.08.2022		ULR No. TC74832200000947F		Bore Hole No.:- 05 of 18		 TC-7483		
Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight Y (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C' (t/m ²)	φ°		
1.00	SPT		0.00	95.04	4.96	NP	NP	NP	1.62	0.00	26.00	3	SP
1.50	SPT		0.00	95.85	4.15	NP	NP	NP	1.72	0.00	29.50	9	SP
2.00	SPT		0.00	95.14	4.86	NP	NP	NP	1.78	0.00	30.25	12	SP
3.00	SPT		0.00	95.91	4.09	NP	NP	NP	1.93	0.00	32.00	21	SP
4.50	SPT		0.00	95.68	4.32	NP	NP	NP	2.01	0.00	33.00	28	SP
6.00	SPT		0.00	95.78	4.22	NP	NP	NP	2.02	0.00	33.25	32	SP

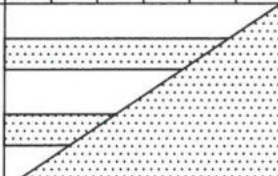




Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F		IS: Classification	
Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)	Bulk unit weight Y (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)		
			Gravel (%)	Sand (%)	Silt & Clay (%)			L.L	P.L		P.I	C' (t/m ²)
1.00	SPT		0.00	93.08	6.92	NP	NP	1.62	0.00	26.00	2	POORLY GRADED SAND – SILTY SAND
1.50	SPT		0.00	92.63	7.37	NP	NP	1.64	0.00	28.00	5	
2.00	SPT		0.00	93.04	6.96	NP	NP	1.75	0.00	30.00	10	
3.00	SPT		0.00	92.99	7.01	NP	NP	1.81	0.00	30.50	13	
4.50	SPT		0.00	92.03	7.97	NP	NP	1.96	0.00	32.00	24	
6.00	SPT		0.00	93.11	6.89	NP	NP	1.99	0.00	32.75	27	



GOVERNMENT ENGINEERING COLLEGE
TIRUNELVELI
-2008-

TC-7483



Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			 TC-7483		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F					
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. Dated: 09.08.2022			Date of Field Testing: 07.08.2022			ULR No. TC748322000000947F			Bore Hole No.:- 07 of 18		
Ref. No. SRF/22/805A			Ref. D											





Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight γ (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C' (t/m ²)	ϕ°		
1.00	SPT		0.00	94.66	5.34	NP	NP	NP	1.66	0.00	28.50	6	SP-SM
1.50	SPT		0.00	94.47	5.53	NP	NP	NP	1.70	0.00	29.25	8	SP-SM
2.00	SPT		0.00	95.91	4.09	NP	NP	NP	1.83	0.00	30.75	14	SP
3.00	SPT		0.00	95.23	4.77	NP	NP	NP	1.92	0.00	31.50	20	SP
4.50	SPT		0.00	96.62	3.38	NP	NP	NP	1.99	0.00	32.50	27	SP
6.00	SPT		0.00	96.55	3.45	NP	NP	NP	2.01	0.00	33.00	31	SP



ULR No. TC748322000000947F

Date of Field Testing: 07.08.2022

Ground water table: - Not encountered

Bore Hole No.: - 08 of 18

Ref. Dated: 09.08.2022

Ref. No. SRF/22/805A



Page 23 of 36

GEO MEDIA ENGINEERING AND CONSULTANCY SERVICES PVT. LTD.

Head Office: # 23609-A, Opp. I.T.I., Mansa Road, Bathinda (Punjab) 151001 | Mob. 95696-70700, 78377-26700, Tel.: 0164-5012700

E-mail: geomediapvtltd@gmail.com

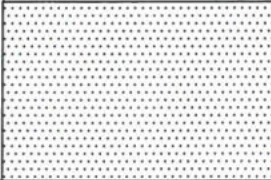
Website: www.geomediaengineering.com



Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A				Ref. Dated: 09.08.2022		Date of Field Testing: 08.08.2022		ULR No. TC748322000000947F		Bore Hole No.:- 09 of 18		 TC-7483	
Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight γ (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C [*] (t/m ²)	ϕ°		
1.00	SPT		0.00	96.96	3.04	NP	NP	NP	1.62	0.00	26.00	3	SP
1.50	SPT		0.00	97.06	2.94	NP	NP	NP	1.74	0.00	29.75	10	SP
2.00	SPT		0.00	97.45	2.55	NP	NP	NP	1.86	0.00	31.25	16	SP
3.00	SPT		0.00	97.96	2.04	NP	NP	NP	1.94	0.00	31.75	22	SP
4.50	SPT		0.00	97.54	2.46	NP	NP	NP	2.01	0.00	33.00	31	SP
6.00	SPT		0.00	97.81	2.19	NP	NP	NP	2.02	0.00	33.50	34	SP



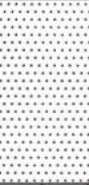
Page 24 of 36



Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A				Ref. Dated: 09.08.2022		Date of Field Testing: 08.08.2022		ULR No. TC748322000000947F		 TC-7483				
						Ground water table: - Not encountered		Bore Hole No.:- 10 of 18						
Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight γ (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification	
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C' (t/m ²)	ϕ°			
1.00	SPT		0.00	94.36	5.64	NP	NP	NP	1.64	0.00	28.00	5	SP-SM	POORLY GRADED SAND – SILTY SAND
1.50	SPT		0.00	93.82	93.05	NP	NP	NP	1.70	0.00	29.25	8	SP-SM	
2.00	SPT		0.00	97.45	95.26	NP	NP	NP	1.85	0.00	31.00	15	SP	POORLY GRADED SAND
3.00	SPT		0.00	97.96	95.95	NP	NP	NP	1.94	0.00	31.75	22	SP	
4.50	SPT		0.00	97.54	2.46	NP	NP	NP	1.97	0.00	32.00	25	SP	
6.00	SPT		0.00	96.56	3.44	NP	NP	NP	2.01	0.00	33.00	32	SP	



Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight γ (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification
			Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C' (t/m ²)	ϕ'°		
1.00	SPT		0.00	98.34	1.66	NP	NP	NP	1.66	0.00	28.50	6	SP
1.50	SPT		0.00	99.01	0.99	NP	NP	NP	1.70	0.00	29.25	8	SP
2.00	SPT		0.00	98.87	1.13	NP	NP	NP	1.81	0.00	30.50	13	SP
3.00	SPT		0.00	98.63	1.37	NP	NP	NP	1.99	0.00	32.50	27	SP
4.50	SPT		0.00	98.36	1.64	NP	NP	NP	2.01	0.00	32.75	30	SP
6.00	SPT		0.00	98.98	1.02	NP	NP	NP	2.03	0.00	33.25	35	SP



ULR No. TC748322000000947F

Date of Field Testing: 08.08.2022

Ref. No. SRF/22/805A

Ref. Dated: 09.08.2022

Ground water table: - Not encountered

Bore Hole No.: - 11 of 18





Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Ref. No. SRF/22/805A	Depth from NSL (m)	Nature of Sample	Symbolic Representation	Grain Size Analysis			Consistency Characteristics (%)			Bulk unit weight γ (t/m ³)	Direct Shear Test		S.P.T Value (Observed) (N Value)	IS: Classification
				Gravel (%)	Sand (%)	Silt & Clay (%)	L.L	P.L	P.I		C [*] (t/m ²)	ϕ°		
	1.00	SPT		0.00	92.46	7.54	NP	NP	NP	1.63	0.00	27.00	4	SP-SM
	1.50	SPT		0.00	93.85	93.05	NP	NP	NP	1.72	0.00	29.50	9	SP-SM
	2.00	SPT		0.00	92.33	95.26	NP	NP	NP	1.81	0.00	30.50	13	SP-SM
	3.00	SPT		0.00	94.68	95.95	NP	NP	NP	1.88	0.00	31.25	17	SP-SM
	4.50	SPT		0.00	94.04	5.96	NP	NP	NP	1.95	0.00	32.00	23	SP-SM
	6.00	SPT		0.00	94.68	5.32	NP	NP	NP	2.01	0.00	32.75	30	SP-SM



ULR No. TC748322000000947F

Date of Field Testing: 08.08.2022

Ground water table: - Not encountered

Bore Hole No.: - 12 of 18

Ref. Dated: 09.08.2022

Amanpreet Singh
Amanpreet Singh
Analyst



Er. I.S. Bath
Er. I.S. Bath
Quality Manager



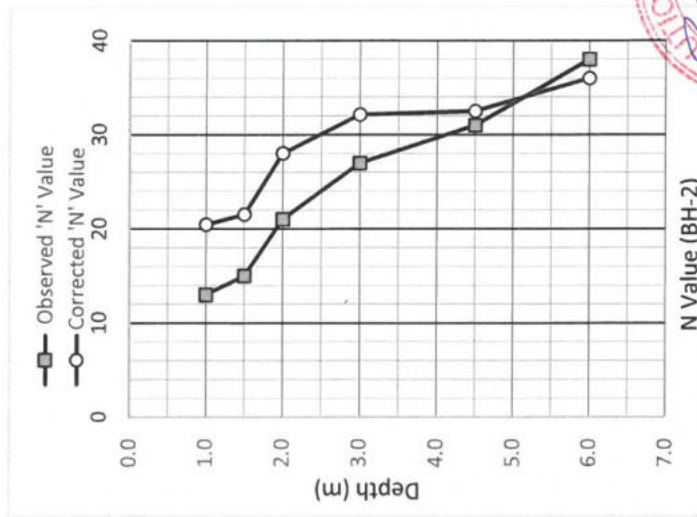
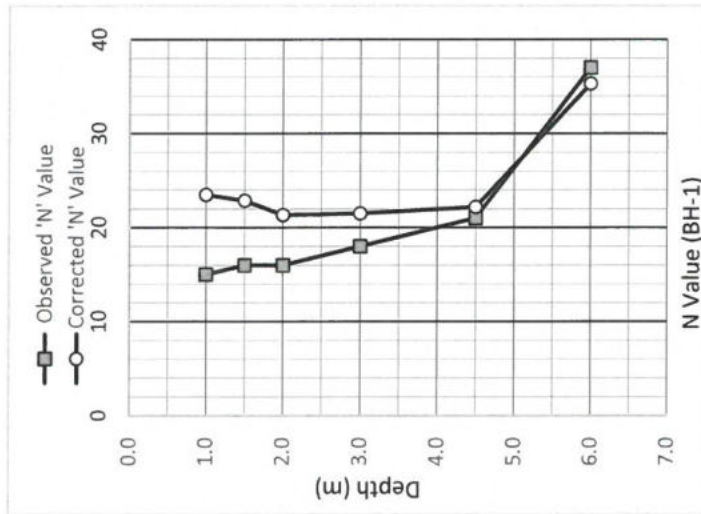
Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Observed SPT 'N'-Value and Corrected 'N'-value Graph

Depth from NSL (m)	Observed 'N' Value		Corrected 'N' Value	
	BH-1	BH-2	BH-1	BH-2
1.00	15	13	23.49	20.45
1.50	16	15	22.88	21.53
2.00	16	21	21.33	28.02
3.00	18	27	21.51	32.14
4.50	21	31	22.17	32.49
6.00	37	38	35.28	36.00



Page 28 of 36

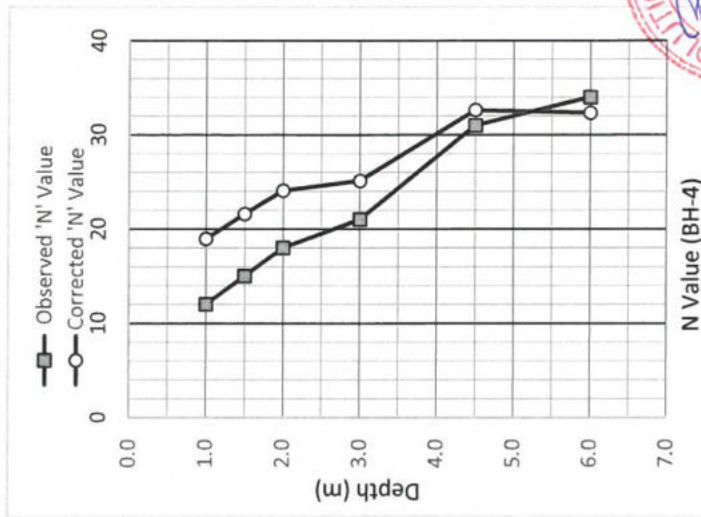
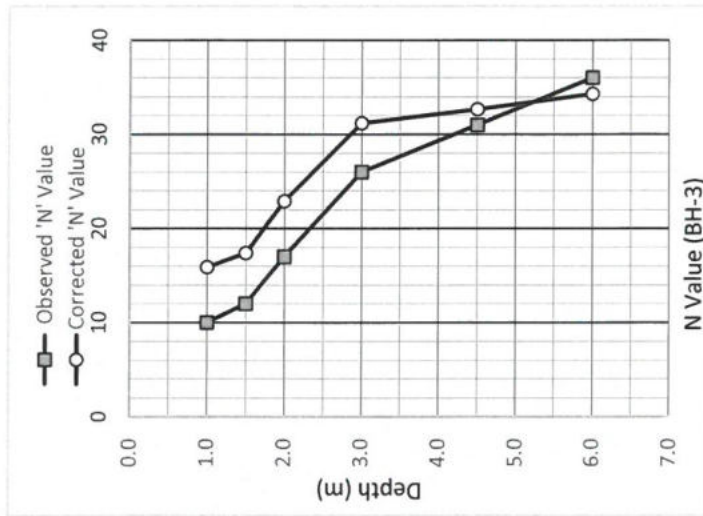


Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Depth from NSL (m)	Observed 'N' Value		Corrected 'N' Value	
	BH-3	BH-4	BH-3	BH-4
1.00	10	12	15.87	18.95
1.50	12	15	17.38	21.59
2.00	17	18	22.89	24.09
3.00	26	21	31.17	25.13
4.50	31	31	32.66	32.62
6.00	36	34	34.27	32.33



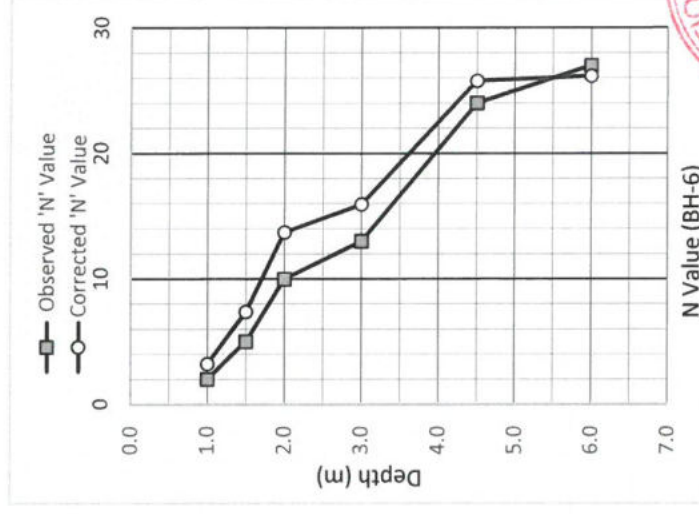
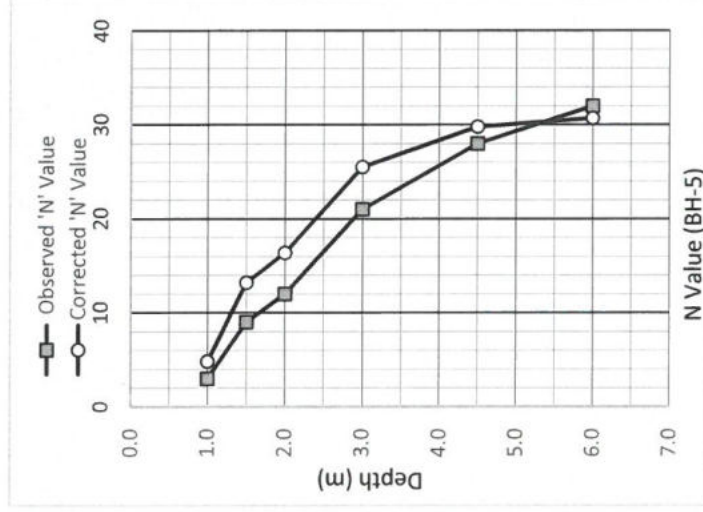


Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Depth from NSL (m)	Observed 'N' Value		Corrected 'N' Value	
	BH-5	BH-6	BH-5	BH-6
1.00	3	2	4.83	3.22
1.50	9	5	13.21	7.37
2.00	12	10	16.39	13.71
3.00	21	13	25.50	15.93
4.50	28	24	29.78	25.77
6.00	32	27	30.71	26.15



Page 30 of 36



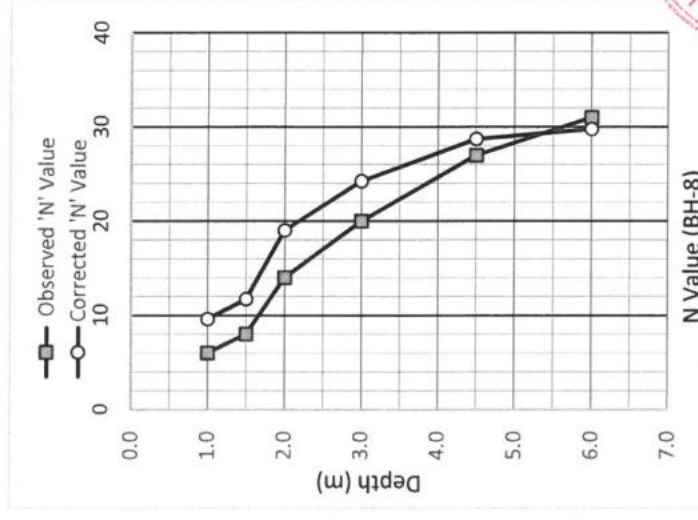
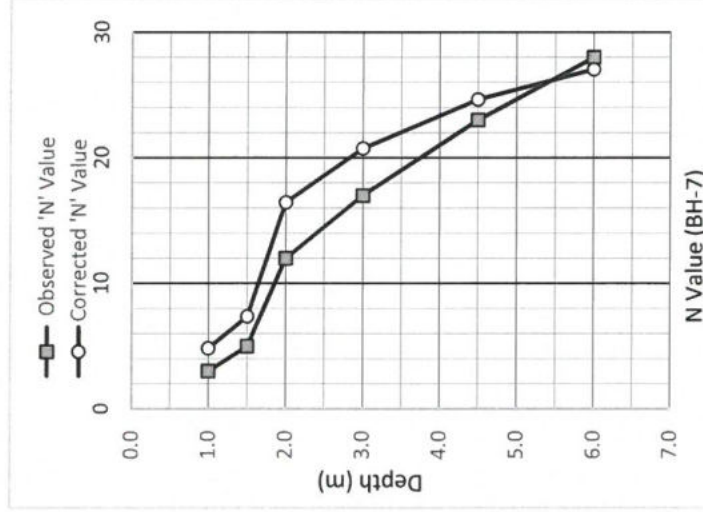
Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Observed SPT 'N'-Value and Corrected 'N'-value Graph

Depth from NSL (m)	Observed 'N' Value		Corrected 'N' Value	
	BH-7	BH-8	BH-7	BH-8
1.00	3	6	4.83	9.61
1.50	5	8	7.37	11.71
2.00	12	14	16.43	19.04
3.00	17	20	20.74	24.23
4.50	23	27	24.63	28.70
6.00	28	31	27.04	29.75



Page 31 of 36

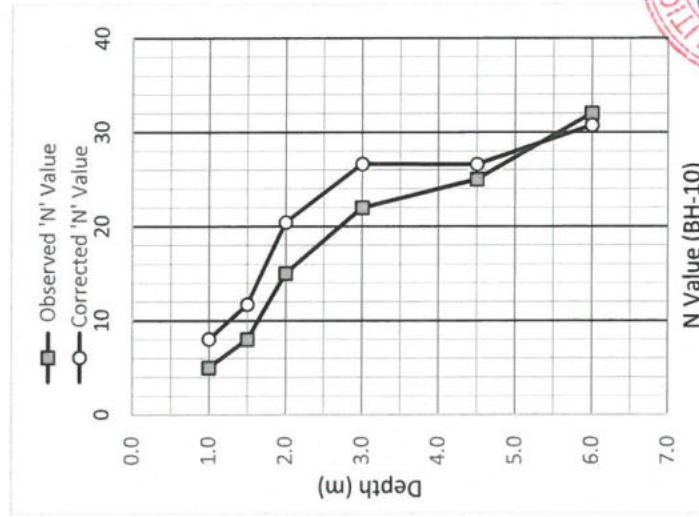
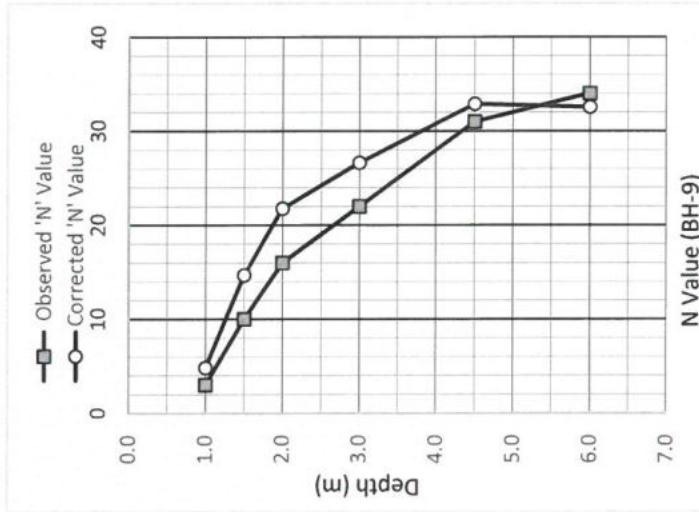


Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Depth from NSL (m)	Observed 'N' Value		Corrected 'N' Value	
	BH-9	BH-10	BH-9	BH-10
1.00	3	5	4.83	8.03
1.50	10	8	14.67	11.73
2.00	16	15	21.77	20.42
3.00	22	22	26.63	26.63
4.50	31	25	32.89	26.59
6.00	34	32	32.57	30.73



Page 32 of 36

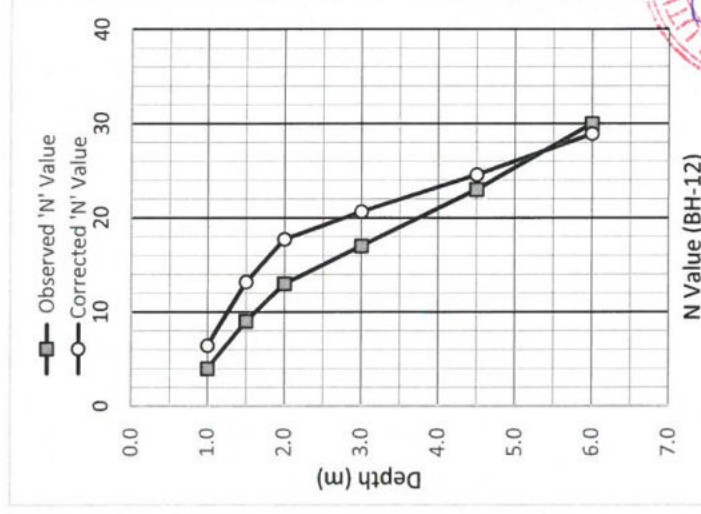
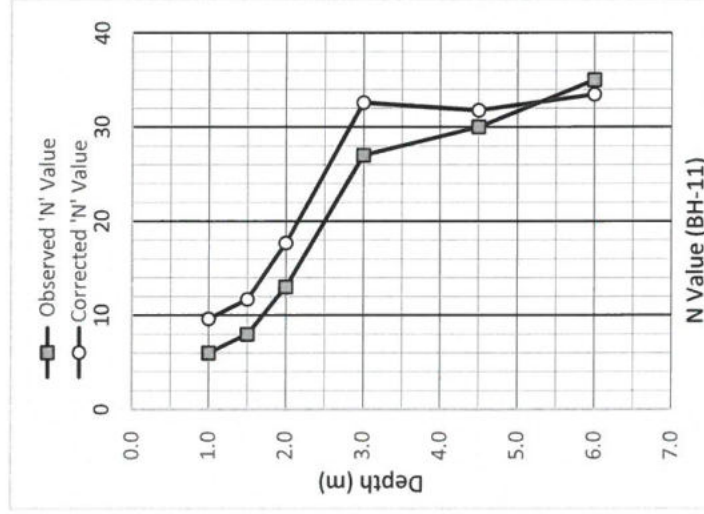


Report No.: GM/22/198B

Date: 25/08/2022

Project: Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Depth from NSL (m)	Observed 'N' Value		Corrected 'N' Value	
	BH-11	BH-12	BH-11	BH-12
1.00	6	4	9.61	6.43
1.50	8	9	11.71	13.20
2.00	13	13	17.69	17.72
3.00	27	17	32.60	20.67
4.50	30	23	31.78	24.57
6.00	35	30	33.46	28.90



Page 33 of 36



Report No.: GM/22/198B

Date: 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Appendix I

N'_c, N'_q, N'_γ	=	Bearing capacity factors for local shear failure.
N_c, N_q, N_γ	=	Bearing capacity factors for general shear failure.
S_c, S_q, S_γ	=	Shape factors.
d_c, d_q, d_γ	=	Depth factors.
W'	=	Water table correction factor.
N	=	Observed SPT value.
N_N	=	Normalised SPT value.
C_N	=	Correction factor.
N_c	=	Corrected N value
γ	=	Bulk unit weight.
γ'	=	Submerged unit weight
γ_d	=	Dry unit weight.
γ_{sat}	=	Saturated unit weight.
G	=	Specific gravity of soil.
LL	=	Liquid Limit.
PL	=	Plastic Limit.
PI	=	Plasticity Index.
GSF	=	General shear failure.
LSF	=	Local shear failure.
q_u	=	Unconfined compressive strength.
c_u	=	Un-drained shear strength
c_c	=	Compression index
B	=	Width of foundation
L	=	Length of foundation
D_f	=	Depth of foundation
H	=	Thickness of clayey layer
B_t	=	Top width of sandy layer
H	=	Thickness of sandy layer
q	=	Effective surcharge
Φ'	=	Angle of shearing resistance
Φ'_m	=	Mobilised angle of shearing resistance
c'	=	Cohesion intercept
$SSWL$	=	Sub soil water level
q_u	=	Ultimate bearing capacity
q_{nu}	=	Net ultimate bearing capacity
q_{ns}	=	Net safe bearing capacity against shear failure
q_{np}	=	Net safe bearing pressure against settlement failure
q_a	=	Allowable bearing capacity
WT	=	Water Table
GW	=	Well graded gravels
GP	=	poorly graded gravels



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

GM	=	Silty gravels
GC	=	Clayey gravels
SW	=	Well graded Sand
SP	=	poorly graded Sand
SM	=	Silty Sand
SC	=	Clayey Sand
CL	=	Clay of low compressibility
ML	=	Silt of low compressibility
CI	=	Clay of medium compressibility
MI	=	Silt of medium compressibility
CH	=	Clay of high compressibility
MH	=	Silt of high compressibility
S _t	=	Total settlement
S _a	=	Allowable settlement
S _o	=	Settlement due to net unit foundation loading intensity
BH	=	Bore hole
OBP	=	overburden pressure
NSL	=	Natural surface level
C ₁	=	Correction factor for depth of foundation embedment
C ₂	=	Correction factor for creep in soils
I _z	=	Influence factor
E _s	=	Modulus of elasticity
ESL	=	Existing Surface Level



**Report No.:** GM/22/198B**Date:** 25/08/2022

Project:	Geotechnical investigation report for setup of 2000MW Solar Park & Installation of 810MW Solar project in tehsil- Pugal, Distt - Bikaner, Rajasthan.

Appendix-II

I. S. Codes

Following IS Codes are used for the testing and calculations in this report.

1. IS:1904-1986,	"Design & Construction of Foundation in Soils, General Requirements."
2. IS:2131-1981,	"Method for Standard Penetration Test for Soil."
3. IS:2720-Part-2 1973,	"Determination of Water Content."
4. IS:2720-Part-3 1980,	"Determination of Specific gravity-Fine-grained soils."
5. IS:2720-Part-4 1975,	"Grain size analysis."
6. IS:2720-Part-5 1970,	"Determination of Liquid and Plastic Limits."
7. IS:2720-Part-13 1982,	"Direct Shear Test"
8. IS:2720-Part-15 1986,	"Determination of Consolidation Properties."
9. IS:6403-1981,	"Code of Practice for Determination of Bearing Capacity of Shallow Foundation"
10. IS:8009-Part 2-1980,	"Code of Practice for calculations of settlement of Foundation-Deep Foundation subjected To Symmetrical Static Vertical Loading."
11. IS:8763-1978,	"Guide for Undisturbed Sampling of Sand."
12. IS:9259-1979,	"Specifications for Liquid Limit Apparatus for Soils."
13. IS:9640-1981,	"Specifications for Split-spoon Sampler."



**REPORT ON GEOELECTRIC RESISTIVITY SURVEY
FOR
UNDER GROUND WATER INVESTIGATION
AT VILLAGE - CHHOTA RAMSARA, BIKANER**

**PROPONENT
TUV SUD SOUTH ASIA PRIVATE LIMITED**

**PREPARED BY
GEOMIN SOLUTION PVT LTD
C-28, RIICO RESIDENTIAL COLONY,
STATE WOOLEN MILL, INDUSTRIAL AREA,
BICHHWAL BIKANER(RAJ)
MOB. 09314185551, TEL.01512940100
Email id- geominsolution@gmail.com**

To,

TUV SUD SOUTH ASIA PVT LTD.

Village-Chhota Ramsara , Bikaner.

Scope of work

The geophysical survey includes following guidelines:-

- A. Geo electric resistivity survey with resistivity meter using wenner's 4 pin method.
- B. Preparation of Litho-logical sections on the basis of variation in resistance of litho-units below ground level.
- C. Result after interpretation of data.

Methodology

Soil resistivity measurements were carried out using wenner's 4 pin method as per I S-7808(1975) specification. In this investigation computerized resistivity monitor was deployed to obtain information about resistance values at different depths.

In this system electric current are injected into ground and resistance offered by different litho units (soil/weathered zone/ Rock horizon/Rock type) are obtained in to apparent resistivity and total resistance.

Resistivity response of soil depends primarily on the constituents of that soil clayey soil tends to have low resistivity owing to the presence of conductive minerals sandy soil show comparatively higher resistivity owing to dominance of conductive minerals on the basis of calibration it was found that the resistivity varies with change in litho logy. The thickness of alluvium over rock surface also affects the resistivity of deeper formation. Each spot measurement made recorded and work carried out by competent trained and qualified personal.

Hydrogeology

The study area situated near village Chhota Ramsara, Bikaner is represents plain Topography and area covered by thick alluvial formation and intercalation of shale and clay material making poor quality of ground water.

Soil cover in the study area varies from 0-20 mt then underlain by clay and sand.

First aquifer is formed of Sand and Gravel after it there may be possibility of intercalation of clay. The presence of such clayey material making this aquifer highly saline in nature so in this area ground water is saline.

RESULTS

(Spot-1)

Depth (Meter)	Litho logy	Discharge	Quality
0-20	Sand	---	---
20-60	Gravel, Sand and Kankar	--	--
60-120	Clay Gravel, Sand with saturation	Low	Saline
120-150	Clay Sand with saturation	Low	Saline

(Spot-2)

Depth (Meter)	Litho logy	Discharge	Quality
0-15	Sand	---	---
15-70	Gravel, Sand and Kankar	--	--
70-130	Clay Gravel, Sand with saturation	Low	Saline
130-150	Clay Sand with saturation	Low	Saline

(Spot-3)

Depth (Meter)	Litho logy	Discharge	Quality
0-20	Sand	---	---
20-80	Gravel, Sand and Kankar	--	--
80-130	Clay Gravel, Sand with saturation	Low	Saline
130-150	Clay Sand with saturation	Low	Saline

(Spot-4)

Depth (Meter)	Litho logy	Discharge	Quality
0-20	Sand	---	---
20-80	Gravel, Sand and Kankar	--	--
80-130	Clay Gravel, Sand with saturation	Low	Saline
130-150	Clay Sand with saturation	Low	Saline

INFERENCE

Spot 01

According to geophysical data it is inferred that at this spot the water table encountered at the depth of 60mt with Low saturation with Clay, Gravel & Sand is dominant upto depth of 120mt. after the depth of 120mt clay is dominant and making water quality saline and quantity very low.

Spot 02

According to geophysical data it is inferred that at this spot the water table encountered at the depth of 70mt with Low saturation with Clay Gravel & Sand is dominant upto depth of 130mt. after the depth of 130mt clay is dominant and making water quality saline and quantity very low. `

Spot 03

According to geophysical data it is inferred that at this spot the water table encountered at the depth of 80mt with Low saturation with Clay Gravel and sand is dominant upto depth of 80mt. after the depth of 130mt clay is dominant and making water quality saline and quantity very low.

Spot 04

According to geophysical data it is inferred that at this spot the water table encountered at the depth of 80mt with Low saturation with Clay Gravel and sand is dominant upto depth of 80mt. after the depth of 130mt clay is dominant and making water quality saline and quantity very low.

Recommendations

In this area water quality is saline due to presence of clay material in it. The aquifer of the area is sand and Gravel but contaminated with clay. The nature of clay is showing saline quality of ground water.

(Geologist)
For Geomin Solution Pvt. Ltd.

Note:- the result showing ground water condition of the day survey was carried out and result should consider under limitation of geophysical technique and there may be deviation in results.

Table 3: Balance Sheet

No of Months of Operation FY Ending		31-Mar-22	31-Mar-24	6 31-Mar-25	12 31-Mar-26	12 31-Mar-27	12 31-Mar-28	12 31-Mar-29	12 31-Mar-30	12 31-Mar-31	12 31-Mar-32	12 31-Mar-33	12 31-Mar-34	12 31-Mar-35	12 31-Mar-36	12 31-Mar-37	12 31-Mar-38	12 31-Mar-39	12 31-Mar-40	12 31-Mar-41	12 31-Mar-42	12 31-Mar-43	12 31-Mar-44	12 31-Mar-45	12 31-Mar-46	12 31-Mar-47	12 31-Mar-48	12 31-Mar-49	12 31-Mar-50	
ASSETS																														
1	Fixed Assets (Gross Block)			84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91	84,753.91
2	Less: Depreciation			1,435.28	4,305.83	7,176.39	10,046.95	12,917.50	15,788.06	18,658.62	21,529.17	24,399.73	27,270.28	30,140.84	33,011.40	35,881.95	38,752.51	41,623.07	44,493.62	47,364.18	50,234.74	53,105.29	55,975.85	58,846.40	61,716.96	64,587.52	67,458.07	70,328.63	73,199.18	76,069.74
3	Fixed Assets (Net Block)			83,318.63	80,448.07	77,577.51	74,706.96	71,836.40	68,965.85	66,095.29	63,224.73	60,354.18	57,483.62	54,613.06	51,742.51	48,871.95	46,001.40	43,130.84	40,260.28	37,389.73	34,519.17	31,648.61	28,778.06	25,907.50	23,036.94	20,166.39	17,295.83	14,425.28	11,554.72	8,684.16
4	Investment and Cash			(6,966.82)	(6,352.52)	(5,616.23)	(4,748.51)	(3,739.27)	(2,577.74)	(1,252.41)	249.00	1,939.59	3,833.35	5,945.16	8,291.00	10,887.75	13,753.52	16,907.56	20,370.40	24,009.96	26,527.61	29,302.95	32,362.32	35,732.63	39,441.59	43,517.87	47,991.24	52,892.78	57,804.32	62,615.86
5	Current Assets																													
6	Total Assets			76,351.81	74,095.55	71,961.29	69,958.45	68,097.13	66,388.11	64,842.88	63,473.73	62,293.77	61,316.97	60,558.24	60,033.50	59,759.70	59,754.91	60,038.40	60,630.88	61,399.88	61,046.76	60,951.57	61,140.37	61,640.13	62,476.54	63,684.26	65,287.88	67,318.96	69,350.08	71,381.20
LIABILITIES																														
1	RVUNL Equity																													
2	Reserves			1,656.91	2,512.94	3,490.96	4,600.42	5,851.39	7,254.65	8,821.71	10,564.85	12,497.17	14,632.66	16,986.22	19,575.77	22,412.25	25,519.75	28,915.52	32,620.09	36,501.39	39,260.77	42,277.84	45,578.94	49,190.98	53,141.87	57,459.68	62,174.79	67,318.06	72,461.33	77,604.60
3	One Time Upfront Charges - Amortized			74,694.90	71,582.61	68,470.32	65,358.03	62,245.75	59,133.46	56,021.17	52,908.89	49,796.60	46,684.31	43,572.02	40,459.74	37,347.45	34,235.16	31,122.87	28,010.59	24,898.30	21,786.01	18,673.72	15,561.44	12,449.15	9,336.86	6,224.57	3,112.29	(0.00)	(0.00)	(0.00)
4	Installments due within one year																													
5	Term Loan																													
6	Working Capital Loan																													
7	Total Liabilities			76,351.81	74,095.55	71,961.29	69,958.45	68,097.13	66,388.11	64,842.88	63,473.73	62,293.77	61,316.97	60,558.24	60,033.50	59,759.70	59,754.91	60,038.40	60,630.88	61,399.88	61,046.76	60,951.57	61,140.37	61,640.13	62,476.54	63,684.26	65,287.88	67,318.96	69,350.08	71,381.20

Table 4: Profit and Loss Statement

			No. of Months of Operation FY Ending																													
			31-Mar-23	31-Mar-24	6 31-Mar-25	12 31-Mar-26	12 31-Mar-27	12 31-Mar-28	12 31-Mar-29	12 31-Mar-30	12 31-Mar-31	12 31-Mar-32	12 31-Mar-33	12 31-Mar-34	12 31-Mar-35	12 31-Mar-36	12 31-Mar-37	12 31-Mar-38	12 31-Mar-39	12 31-Mar-40	12 31-Mar-41	12 31-Mar-42	12 31-Mar-43	12 31-Mar-44	12 31-Mar-45	12 31-Mar-46	12 31-Mar-47	12 31-Mar-48	12 31-Mar-49	12 31-Mar-50		
1	INCOME																															
1.1	Proposed Capacity of the Project (MW)				2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00		
1.2	One Time Upfront Charges (Per MW)				38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90	38.90		
1.3	Revenue from One Time Upfront Charges-Deferred				13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29	13,112.29		
1.4	Annual Fees (per MW)				2,635.49	5,572.47	5,891.22	6,228.19	6,564.45	6,901.08	7,359.25	7,780.20	8,225.23	8,695.71	9,195.10	9,719.95	10,274.87	10,862.00	11,483.94	12,140.82	12,835.27	13,569.45	14,345.82	15,166.19	16,033.07	16,950.83	17,920.41	18,945.46	20,029.14			
1.5	Total Income				5,747.77	6,884.76	9,005.50	9,346.48	9,696.73	10,072.36	10,471.54	10,892.49	11,337.51	11,800.28	12,305.39	12,831.24	13,387.16	13,974.88	14,592.22	15,253.11	15,947.56	16,681.74	17,457.91	18,276.48	19,143.99	20,063.11	21,032.70	22,057.75	23,141.43			
2	EXPENSES																															
2.1	O & M Expenses				2,217.50	4,605.30	4,782.15	4,965.78	5,156.47	5,354.48	5,560.09	5,773.60	5,995.30	6,225.52	6,464.58	6,712.82	6,970.59	7,238.26	7,516.21	7,804.84	8,104.54	8,415.76	8,738.92	9,074.50	9,422.96	9,784.80	10,160.53	10,550.70	10,955.85			
2.2	Insurance Charges				87.30	171.64	165.72	159.81	153.90	147.98	142.07	136.16	130.24	124.33	118.42	112.50	106.59	100.68	94.76	88.85	82.94	77.02	71.11	65.20	59.28	53.37	47.46	41.54	35.63			
2.3	Land Lease Charges				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
2.4	Total Expenses				2,304.80	4,776.94	4,947.87	5,125.59	5,310.36	5,502.46	5,702.16	5,905.76	6,125.54	6,349.85	6,583.00	6,825.32	7,077.18	7,338.94	7,610.98	7,893.69	8,187.48	8,492.78	8,810.03	9,138.99	9,482.24	9,838.17	10,207.59	10,592.24	10,991.43			
3	PBDIT				3,442.98	3,907.82	4,055.63	4,214.89	4,386.37	4,570.90	4,769.38	4,982.73	5,211.97	5,458.15	5,722.39	6,005.91	6,309.98	6,635.94	6,985.25	7,359.42	7,760.08	8,188.96	8,647.88	9,138.79	9,663.75	10,224.95	10,824.71	11,465.51	12,149.95			
4	Depreciation				1,435.28	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56			
5	PBIT				2,007.70	1,937.26	1,185.08	1,344.33	1,515.81	1,700.35	1,898.82	2,112.18	2,341.41	2,587.59	2,851.84	3,135.36	3,439.42	3,765.39	4,114.89	4,488.96	4,899.53	5,316.18	5,777.32	6,268.23	6,793.19	7,354.29	7,954.15	8,594.95	9,279.40			
6	Interest				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
6.1	Interest on Term Loan				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
6.2	Interest on Working Capital				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
6.3	Total Interest				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
7	Profit Before Tax (PBT)				2,007.70	1,937.26	1,185.08	1,344.33	1,515.81	1,700.35	1,898.82	2,112.18	2,341.41	2,587.59	2,851.84	3,135.36	3,439.42	3,765.39	4,114.89	4,488.96	4,899.53	5,316.18	5,777.32	6,268.23	6,793.19	7,354.29	7,954.15	8,594.95	9,279.40			
8	Income Tax				350.79	181.23	207.06	234.88	264.84	297.08	331.76	369.04	409.09	452.10	498.27	547.81	600.94	657.89	718.92	784.29	1,008.23	2,559.02	2,760.25	2,967.14	3,181.15	3,403.69	3,636.15	3,879.85	4,136.13			
9	Profit After Tax (PAT)				1,656.91	856.03	978.02	1,094.45	1,250.97	1,403.26	1,567.06	1,743.14	1,932.32	2,135.49	2,353.56	2,587.59	2,838.48	3,107.50	3,395.77	3,704.97	3,881.29	2,759.38	3,017.07	3,291.16	3,612.04	3,950.70	4,318.01	4,716.10	5,143.27			

Table 5: Calculations of Depreciation

6: No. of Months of Operation																															
FY Ending		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		31-Mar-23	31-Mar-24	31-Mar-25	31-Mar-26	31-Mar-27	31-Mar-28	31-Mar-29	31-Mar-30	31-Mar-31	31-Mar-32	31-Mar-33	31-Mar-34	31-Mar-35	31-Mar-36	31-Mar-37	31-Mar-38	31-Mar-39	31-Mar-40	31-Mar-41	31-Mar-42	31-Mar-43	31-Mar-44	31-Mar-45	31-Mar-46	31-Mar-47	31-Mar-48	31-Mar-49	31-Mar-50	31-Mar-51	31-Mar-52
A Depreciation as per books																															
1	Fixed Assets		75,540.96																												
2	Depreciation		1,435.28	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56
3	Closing WDV		74,105.68	71,235.12	68,364.56	65,494.01	62,623.45	59,752.90	56,882.34	54,011.78	51,141.23	48,270.67	45,400.11	42,529.56	39,659.00	36,788.45	33,917.89	31,047.33	28,176.78	25,306.22	22,435.66	19,565.11	16,694.55	13,823.99	10,953.44	8,082.88	5,212.33				
B Depreciation as per income tax																															
1	Opening WDV		-	65,337.32	56,511.94	48,876.64	42,276.40	36,565.95	31,626.83	27,354.86	23,659.93	20,464.08	17,699.91	15,309.11	13,241.25	11,452.70	9,905.73	8,567.73	7,410.45	6,405.49	5,543.75	4,794.92	4,147.25	3,587.06	3,102.54	2,683.47	2,321.00				
2	Addition during the year		75,540.96																												
3	Depreciation		10,203.63	8,825.38	7,853.30	6,902.24	5,710.45	4,938.11	4,271.97	3,694.94	3,195.85	2,764.17	2,390.80	2,067.87	1,788.55	1,548.96	1,338.01	1,157.28	1,000.96	885.76	748.81	647.67	560.19	484.52	419.07	362.47	313.51				
4	Closing WDV		65,337.32	56,511.94	48,876.64	42,276.40	36,565.95	31,626.83	27,354.86	23,659.93	20,464.08	17,699.91	15,309.11	13,241.25	11,452.70	9,905.73	8,567.73	7,410.45	6,405.49	5,543.75	4,794.92	4,147.25	3,587.06	3,102.54	2,683.47	2,321.00	2,007.49				

Table 7 : Key Ratio Analysis

No of Months of Operation		31-Mar-23	31-Mar-24	6 31-Mar-25	12 31-Mar-26	12 31-Mar-27	12 31-Mar-28	12 31-Mar-29	12 31-Mar-30	12 31-Mar-31	12 31-Mar-32	12 31-Mar-33	12 31-Mar-34	12 31-Mar-35	12 31-Mar-36	12 31-Mar-37	12 31-Mar-38	12 31-Mar-39	12 31-Mar-40	12 31-Mar-41	12 31-Mar-42	12 31-Mar-43	12 31-Mar-44	12 31-Mar-45	12 31-Mar-46	12 31-Mar-47	12 31-Mar-48	12 31-Mar-49	12 31-Mar-50	
1	Project RR																													
1.1	Project Cost	(1,21,077.01)	(60,538.50)	(60,538.50)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2	Net Profit After Tax				1,656.91	856.03	978.02	1,109.45	1,250.97	1,405.26	1,567.06	1,743.14	1,932.32	2,135.49	2,353.56	2,587.55	2,838.49	3,107.50	3,395.77	3,704.57	3,881.29	2,759.38	3,017.07	3,301.10	3,612.04	3,950.70	4,318.01	4,715.10	5,143.27	
1.3	MNRE CFA/Subsidy				36,323.10																									
1.4	Depreciation				1,435.28	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	
1.5	Preliminary Exp. W Off				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.6	Land lease premium written off				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.7	Interest on Term Loan				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.8	Interest on Working Capital				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.9	Change in Working Capital				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10	One time Uplift Charges - Amortized	77,807.18	0.00	77,807.18	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29	-3112.29
1.11	Residual Value	(60,538.50)	53,591.78	(26,100)	614.30	736.29	887.72	1,008.24	1,161.53	1,325.33	1,501.41	1,690.59	1,893.75	2,111.83	2,345.82	2,596.75	2,865.77	3,154.04	3,462.84	3,639.56	2,517.05	2,775.34	3,059.36	3,370.31	3,708.96	4,076.28	4,473.37	4,916.31	5,402.35	
1.12	Operating Cash Inflow	(60,538.50)	53,591.78	(26,100)	614.30	736.29	887.72	1,008.24	1,161.53	1,325.33	1,501.41	1,690.59	1,893.75	2,111.83	2,345.82	2,596.75	2,865.77	3,154.04	3,462.84	3,639.56	2,517.05	2,775.34	3,059.36	3,370.31	3,708.96	4,076.28	4,473.37	4,916.31	5,402.35	
1.13	Project RR	11.21%																												

No of Months of Operation																													
3.1 NPV		31-Mar-23	31-Mar-24	6 31-Mar-25	12 31-Mar-26	12 31-Mar-27	12 31-Mar-28	12 31-Mar-29	12 31-Mar-30	12 31-Mar-31	12 31-Mar-32	12 31-Mar-33	12 31-Mar-34	12 31-Mar-35	12 31-Mar-36	12 31-Mar-37	12 31-Mar-38	12 31-Mar-39	12 31-Mar-40	12 31-Mar-41	12 31-Mar-42	12 31-Mar-43	12 31-Mar-44	12 31-Mar-45	12 31-Mar-46	12 31-Mar-47	12 31-Mar-48	12 31-Mar-49	12 31-Mar-50
3.1.1	Project Cost	(1,21,077.01)	(60,538.50)	-	-	856.03	978.02	1,109.45	1,250.97	1,403.26	1,567.06	1,743.14	1,932.32	2,135.49	2,353.56	2,587.55	2,838.49	3,107.50	3,395.77	3,704.57	3,881.29	2,759.38	3,017.07	3,301.10	3,612.04	3,950.70	4,318.01	4,715.10	5,143.27
3.2	Net Profit After Tax	(60,538.50)	(60,538.50)	1,656.91	856.03	978.02	1,109.45	1,250.97	1,403.26	1,567.06	1,743.14	1,932.32	2,135.49	2,353.56	2,587.55	2,838.49	3,107.50	3,395.77	3,704.57	3,881.29	2,759.38	3,017.07	3,301.10	3,612.04	3,950.70	4,318.01	4,715.10	5,143.27	
3.3	MNRE CFA/Subsidy		36,323.10																										
3.4	Depreciation		1,435.28	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56
3.5	Less time uplift charges - Amortized		77,807.18	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)	(5,112.29)
3.6	Preliminary Exp. Whorl		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.7	Land lease premium written off		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.8	Interest on Term Loan		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.9	Interest on Working Capital		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.10	Change in Working Capital		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.11	Residual Value		(60,538.50)	53,591.78	(26,100)	614.30	736.29	887.72	1,008.24	1,161.53	1,325.33	1,501.41	1,690.59	1,893.75	2,111.83	2,345.82	2,596.75	2,865.77	3,154.04	3,462.84	3,639.56	2,517.05	2,775.34	3,059.36	3,370.31	3,708.96	4,076.28	4,473.37	4,916.31
3.12	Operating Cash Inflow	(60,538.50)	53,591.78	(26,100)	614.30	736.29	887.72	1,008.24	1,161.53	1,325.33	1,501.41	1,690.59	1,893.75	2,111.83	2,345.82	2,596.75	2,865.77	3,154.04	3,462.84	3,639.56	2,517.05	2,775.34	3,059.36	3,370.31	3,708.96	4,076.28	4,473.37	4,916.31	5,402.35
3.13	NPV	9,856.98																											
		\$0.00																											

Table 8 : Other Ratios

Age of Months of Operation		31-Mar-23	31-Mar-24	12 31-Mar-25	12 31-Mar-26	12 31-Mar-27	12 31-Mar-28	12 31-Mar-29	12 31-Mar-30	12 31-Mar-31	12 31-Mar-32	12 31-Mar-33	12 31-Mar-34	12 31-Mar-35	12 31-Mar-36	12 31-Mar-37	12 31-Mar-38	12 31-Mar-39	12 31-Mar-40	12 31-Mar-41	12 31-Mar-42	12 31-Mar-43	12 31-Mar-44	12 31-Mar-45	12 31-Mar-46	12 31-Mar-47	12 31-Mar-48	12 31-Mar-49	12 31-Mar-50	
1	Net Profit Ratio			28.83%	9.86%	10.86%	11.88%	12.90%	13.93%	14.96%	16.00%	17.04%	18.09%	19.13%	20.17%	21.20%	22.24%	23.28%	24.29%	25.34%	26.34%	27.35%	28.36%	29.37%	30.38%	31.39%	32.40%	33.41%	34.42%	35.43%
2	Cash Profit Ratio			53.80%	42.91%	42.75%	42.61%	42.55%	42.43%	42.36%	42.36%	42.30%	42.40%	42.45%	42.54%	42.65%	42.76%	42.93%	43.11%	42.34%	35.75%	33.75%	33.78%	33.76%	33.86%	34.00%	34.18%	34.39%	34.63%	34.87%
3	Return on investment (after tax)			2.17%	1.16%	1.36%	1.59%	1.84%	2.11%	2.42%	2.75%	3.10%	3.48%	3.89%	4.31%	4.75%	5.20%	5.68%	6.11%	6.62%	7.14%	7.69%	8.26%	8.85%	9.46%	10.09%	10.74%	11.40%	12.07%	12.75%
4	Cash Return on Investment (after tax)			4.05%	5.03%	5.53%	6.05%	6.50%	6.94%	7.38%	7.79%	8.16%	8.53%	8.90%	9.25%	9.58%	10.00%	10.44%	10.84%	11.00%	9.22%	9.66%	10.09%	10.52%	10.92%	11.29%	11.62%	11.90%	12.18%	12.46%
5	Return on Equity			100.00%	34.06%	28.02%	24.12%	21.38%	19.34%	17.76%	16.30%	15.46%	14.99%	13.86%	13.22%	12.66%	12.18%	11.74%	11.36%	10.63%	7.69%	7.24%	7.43%	7.58%	7.74%	7.91%	8.08%	8.25%	8.42%	8.59%
6	Cash Return on Equity			186.62%	148.30%	110.24%	86.51%	70.44%	58.91%	50.30%	43.67%	38.43%	34.21%	30.76%	27.66%	24.47%	21.43%	18.50%	15.34%	13.94%	13.34%	13.18%	12.84%	12.51%	12.20%	11.90%	11.60%	11.30%	11.00%	10.70%
7	Current Ratio			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Debt-Equity			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	TOLTYRW			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	FAUCR			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No of Months of Operation	6	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
1.1	Operation and Maintenance Cost	2,304.80	4,776.94	4,947.97	5,125.59	5,310.38	5,502.46	5,702.16	5,909.75	6,125.54	6,349.85	6,583.00	6,825.32	7,077.18	7,338.04	7,610.98	7,893.09	8,187.48	8,492.76	8,810.03	9,139.00	9,482.24	9,838.17	10,207.99	10,592.24	10,991.49				
1.2	Interest on Term Loan & Working Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3	Depreciation	1,435.28	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56	2,870.56
1.4	Total Outflow	3,740.07	7,647.50	7,818.43	7,996.15	8,180.93	8,371.02	8,572.71	8,780.31	8,996.10	9,220.41	9,453.56	9,695.86	9,947.14	10,209.50	10,481.55	10,764.24	11,058.03	11,363.34	11,680.39	12,012.25	12,352.80	12,706.72	13,076.55	13,454.80	13,842.80	14,241.95	14,652.33	15,074.82	15,508.49
1.5	Discounting Factor	1.00	0.91	0.83	0.76	0.69	0.63	0.58	0.53	0.48	0.44	0.40	0.37	0.33	0.30	0.28	0.25	0.23	0.21	0.19	0.18	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07
1.6	Discounted cash outflow	3,740.07	6,978.81	6,570.94	6,076.70	5,673.55	5,289.99	4,942.48	4,629.48	4,336.66	4,064.79	3,820.33	3,594.85	3,379.37	3,170.92	2,971.33	2,782.46	2,597.85	2,398.64	2,250.02	2,101.23	1,961.58	1,840.42	1,747.15	1,641.23	1,542.13	1,448.40	1,359.44	1,275.64	1,196.20
1.7	Peak Capacity	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
1.8	Levelized Cost of Expt Per MW		1.7532																											

ROI 10.50%

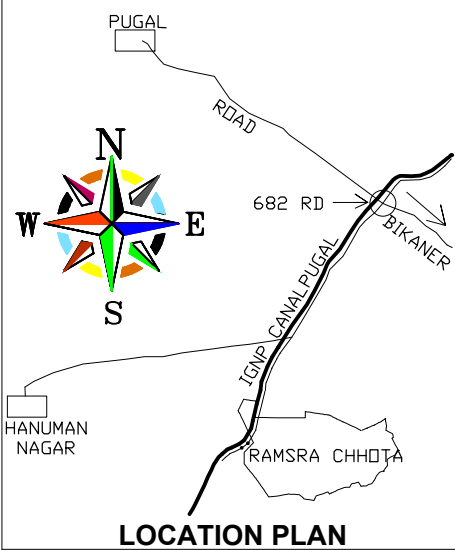
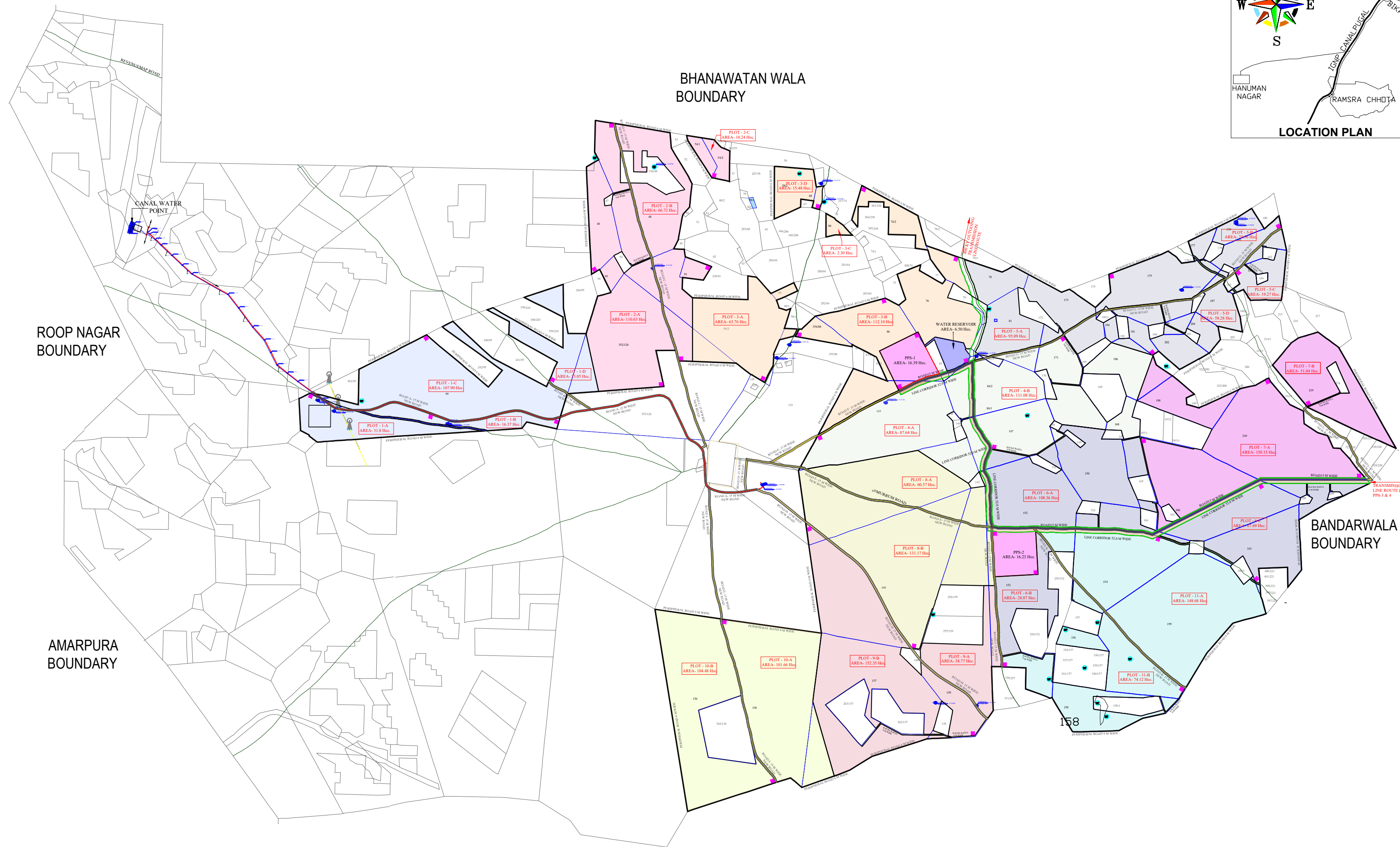
Phasing of Expenditure and Interest During Construction						Actual IDC		Extended IDC	
Sr. No.	Month	%	Total Cost Rs in Lakhs	Loan Rs in Lakhs	Promoter Rs in Lakhs	Loan Period Months	Interest Rs in Lakhs	Loan Period Months	Interest Rs in Lakhs
1	Sep-23	5.00%	6,053.85	4,237.70	1,816.16	21	778.68	27	1,001.16
2	Oct-23	0.00%	-	-	-	20	-	26	-
3	Nov-23	0.00%	-	-	-	19	-	25	-
4	Dec-23	0.00%	-	-	-	18	-	24	-
5	Jan-24	3.00%	3,632.31	2,542.62	1,089.69	17	378.21	23	511.70
6	Feb-24	0.00%	-	-	-	16	-	22	-
7	Mar-24	12.00%	14,529.24	10,170.47	4,358.77	15	1,334.87	21	1,868.82
8	Apr-24	0.00%	-	-	-	14	-	20	-
9	May-24	0.00%	-	-	-	13	-	19	-
10	Jun-24	30.00%	36,323.10	25,426.17	10,896.93	12	2,669.75	18	4,004.62
11	Jul-24	0.00%	-	-	-	11	-	17	-
12	Aug-24	0.00%	-	-	-	10	-	16	-
13	Sep-24	12.00%	14,529.24	10,170.47	4,358.77	9	800.92	15	1,334.87
14	Oct-24	0.00%	-	-	-	8	-	14	-
15	Nov-24	0.00%	-	-	-	7	-	13	-
16	Dec-24	12.43%	15,046.24	10,532.37	4,513.87	6	552.95	12	1,105.90
17	Jan-25	0.00%	-	-	-	5	-	11	-
18	Feb-25	0.00%	-	-	-	4	-	10	-
19	Mar-25	25.57%	30,963.02	21,674.12	9,288.91	3	568.95	9	1,706.84
20	Apr-25	0.00%	-	-	-	2	-	8	-
21	May-25	0.00%	-	-	-	1	-	7	-
22	Jun-25	0.00%	-	-	-		-	6	-
23	Jul-25	0.00%	-	-	-		-	5	-
24	Aug-25	0.00%	-	-	-		-	4	-
25	Sep-25	0.00%	-	-	-		-	3	-
26	Oct-25	0.00%	-	-	-		-	2	-
27	Nov-25	0.00%	-	-	-		-	1	-
Total		100.00%	1,21,077.01	84,753.91	36,323.10		7,084.33		11,533.91

M/s Rajasthan Rajya Vidyut Utpad Nigam Limited - 2000 MW Solar Park at Bikaner Dist.

Sensitivity Analysis

Type of Ratio	If Lease Rental Varied By					
		-10%	-5%	0%	5%	10%
	100%	90%	95%	100%	105%	110%
Lease Rental for Solar Park Maint	2.2900	2.0610	2.1755	2.2900	2.4045	2.5190
Project IRR	11.21%	9.21%	10.24%	11.21%	12.12%	12.99%
NPV @ 9.58 %	9856.96	4923.78	7396.72	9856.96	12300.09	14730.80
Type of Ratio	If Cost of Project Varied By					
		-10%	-5%	0%	5%	10%
	100%	90%	95%	100%	105%	110%
Project Cost	1,21,077.01	1,09,493.50	1,15,285.25	1,21,077.01	1,26,868.76	1,32,660.51
Project IRR	11.21%	11.55%	11.38%	11.21%	11.06%	10.91%
NPV @ 9.58 %	9856.96	9782.26	9819.61	9856.96	9894.01	9928.21
Type of Ratio	If Rate of Interest Become					
		-14%	-6%	0%	5%	8%
	100%	87%	95%	100%	106%	108%
Rate of Interest	10.50%	9.08%	9.92%	10.50%	11.08%	11.34%
Project IRR	11.21%	11.23%	11.22%	11.21%	11.20%	11.20%
NPV @ 9.58 %	9856.96	11307.91	10428.72	9856.96	9310.29	9069.76

RAMSARA CHHOTA



S.NO.	PLOT	AREA	LEGEND
1	PLOT - 1	188.90 Hec	
2	PLOT - 2	187.59 Hec	
3	PLOT - 3	193.64 Hec	
4	PLOT - 4	198.72 Hec	
5	PLOT - 5	197.20 Hec	
6	PLOT - 6	204.92 Hec	
7	PLOT - 7	201.18 Hec	
8	PLOT - 8	191.74 Hec	
9	PLOT - 9	191.12 Hec	
10	PLOT - 10	206.14 Hec	
11	PLOT - 11	222.79 Hec	

Total = 2183.94 Hec	
	PPS
	LINE CORRIDOR
	ROAD - 15 M WIDE NEW ROAD
	ROAD - 9 M WIDE KACHA RASTA
	ROAD - 6 M WIDE PERIPHERAL ROAD
	WATCH TOWERS 43 NO.

PPS-1 = 16.39 Hec.
PPS-2 = 16.23 Hec.
RAW WATER RESERVOIR AND TREATMENT PLANT -6.50 Hec.

LEGEND		
EXISTING ROAD SHOWN THUS		ELECTRIC LINE
ROAD SHOWN THUS		CONTOUR LINE
KHASRA TO RVUNL	00	CONTOUR LEVEL
KHASRA NUMBER		
KHASRA		
BENCH MARK LOCATION / COORDINATE		
WATER TANK OF SHOWN THUS		
HIGH TENSION TOWER		
HIGH TENSION LINE		
ELECTRIC POLE SHOWN THUS		

CLIENT :- M/s. ZUBERI ENGINEERING CONSTRUCTION PVT. LTD. JAIPUR.

DEPARTMENT :- SUPERINTENDING ENGINEER (SOLAR) RVUN JAIPUR

CONSULTANT :- PDCOR Limited
FIRST FLOOR, PRESS TRUST OF INDIA (PTI) BUILDING,
5-B, JHALANA DOONGRI INSTITUTIONAL AREA,
JAIPUR - 302004, RAJ.

PROJECT:-
DESC OF C & M WORKS FOR 2000 MW RVUN SOLAR PARK AT
VILLAGES RAMSAR CHHOTA, BARALA & BANDAREWALA ,
TEHSIL PUGAL DIST. BIKANER

TITLE:- LAYOUT PLAN OF SOLAR PARK AT RAMSARA CHHOTA VILLAGE

DATE .
22-01-2025

DRG No. PDCOR/SP/RC/R0

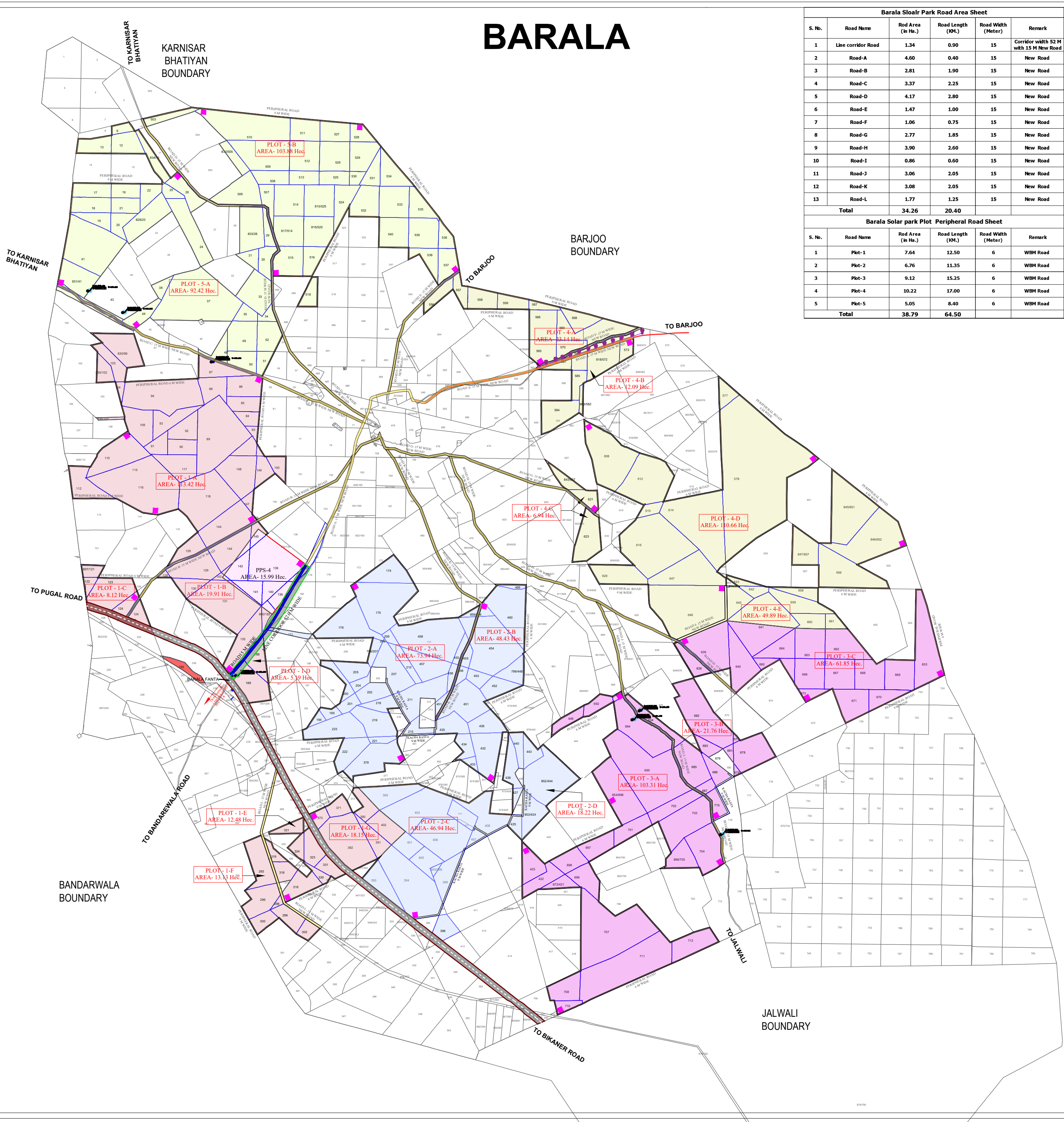
DRAWN BY : RECOM. BY : CHECKED BY : APPROVED BY :

Ramsar Chhota Solar park Plot Fencing			
S. No.	Road Name	Fencing Length (KM.)	Remark
1	Plot-1	18.80	
2	Plot-2	16.00	
3	Plot-3	18.00	
4	Plot-4	12.40	
5	Plot-5	21.30	
6	Plot-6	18.50	
7	Plot-7	12.70	
8	Plot-8	8.30	
9	Plot-9	13.70	
10	Plot-10	9.30	
11	Plot-11	16.10	
Total		165.10	

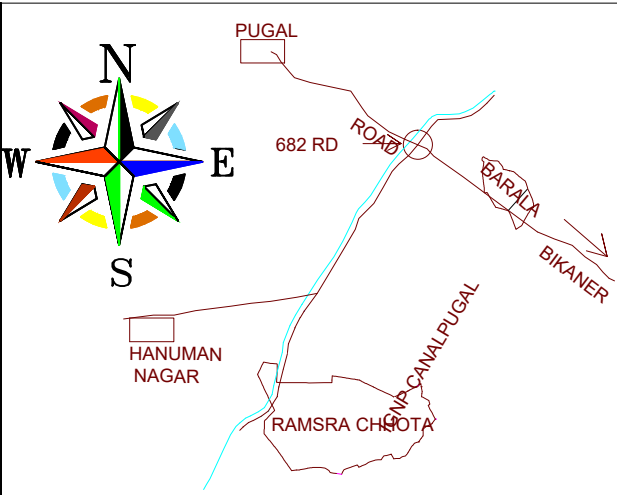
Ramsar Chhota Solar Park Road Area Sheet				
S. No.	Road Name	Road Area (in Ha.)	Road Length (KM.)	Road Width (Meter)
1	Line corridor Road	11.60	7.80	15
2	Road-A	7.30	4.90	15
3	Road-B	0.70	0.50	15
4	Road-C	4.80	3.10	15
5	Road-D	0.45	0.30	15
6	Road-E	4.00	2.30	15
7	Road-F	2.04	1.40	15
8	Road-G	4.90	3.20	15
9	Road-H	4.70	3.10	15
10	Road-I	4.30	3.00	15
11	Road-J	2.00	1.30	15
12	Road-K	3.10	2.10	15
13	Road-L	1.50	1.00	15
Total		51.39	34.00	

Ramsar Chhota Solar park Plot Peripheral Road Sheet				
S. No.	Road Name	Road Area (in Ha.)	Road Length (KM.)	Road Width (Meter)
1	Plot-1	6.80	11.20	6
2	Plot-2	4.70	7.70	6
3	Plot-3	8.08	11.19	6
4	Plot-4	2.00	0.32	6
5	Plot-5	4.30	7.10	6
6	Plot-6	1.20	2.00	6
7	Plot-7	3.70	6.20	6
8	Plot-8	0.30	0.50	6
9	Plot-9	1.70	2.80	6
10	Plot-10	3.00	4.90	6
11	Plot-11	2.00	3.30	6
Total		37.78	57.21	

BARALA



Barala Sloar Park Road Area Sheet				
S. No.	Road Name	Rod Area (in Ha.)	Road Length (KM.)	Road Width (Meter)
1	Line corrior Road	1.34	0.90	15
2	Road-A	4.60	0.40	15
3	Road-B	2.81	1.90	15
4	Road-C	3.37	2.25	15
5	Road-D	4.17	2.80	15
6	Road-E	1.47	1.00	15
7	Road-F	1.06	0.75	15
8	Road-G	2.77	1.85	15
9	Road-H	3.90	2.60	15
10	Road-I	0.86	0.60	15
11	Road-J	3.06	2.05	15
12	Road-K	3.08	2.05	15
13	Road-L	1.77	1.25	15
Total		34.26	20.40	



Barala Solar park Plot Peripheral Road Sheet				
S. No.	Road Name	Rod Area (in Ha.)	Road Length (KM.)	Road Width (Meter)
1	Pbt-1	7.64	12.50	6
2	Pbt-2	6.76	11.35	6
3	Pbt-3	9.12	15.25	6
4	Pbt-4	10.22	17.00	6
5	Pbt-5	5.05	8.40	6
Total		38.79	64.50	

Ramasar Chhota Solar park Plot Fencing			
S. No.	Road Name	Fencing Length (KM.)	Remark
1	Plot-1	20.25	Consideration For Fencing
2	Plot-2	17.46	(a) Both side of Revenue Road passing through the Solar Plot
3	Plot-3	19.75	(b) Surrounding all sides of individual private plots and both sides of connecting roads to the private plots
4	Plot-4	21.15	
5	Plot-5	18.15	
Total		96.76	

S.NO.	PLOT	AREA	LEGEND
1	PLOT - 1	190.40 Hec	
2	PLOT - 2	187.53 Hec	
3	PLOT - 3	186.92 Hec	
4	PLOT - 4	202.72 Hec	
5	PLOT - 5	196.30 Hec	

Total = 963.87 Hec

	PPS
	LINE CORRIDOR
	ROAD - 15 M WIDE NEW ROAD
	ROAD - 9 M WIDE KACHA RASTA
	ROAD - 6 M WIDE PERIPHERAL ROAD
	WATCH TOWERS 37 - NO.

PPS-4 = 15.99 Hec.

LEGEND			
	EXISTING ROAD SHOWN THUS		ELECTRIC LINE
	ROAD SHOWN THUS		CONTOUR LINE
	KHASRA TO RRVUNL		CONTOUR LEVEL
00	KHASRA NUMBER		
	KHASRA		
	BENCH MARK LOCATION / COORDINATE		
	WATER TANK OF SHOWN THUS		
	HIGH TENSION TOWER		
	HIGH TENSION LINE		
	ELECTRIC POLE SHOWN THUS		

CLIENT :-
M/s. ZUBERI ENGINEERING CONSTRUCTION PVT. LTD.
JAIPUR.

DEPARTMENT :-
SUPERINTENDING ENGINEER (SOLAR) RVUN JAIPUR

CONSULTANT :-
 PDCOR Limited
FIRST FLOOR, PRESS TRUST OF INDIA (PTI) BUILDING,
5-B, JHALANA DOONGRI INSTITUTIONAL AREA,
JAIPUR - 302004, RAJ.

PROJECT:-
DESC OF C & M WORKS FOR 2000 MW RVUN SOLAR PARK AT
VILLAGES RAMSAR CHHOTI, BARALA & BANDAREWALA ,
TEHSIL PUGAL DIST. BIKANER

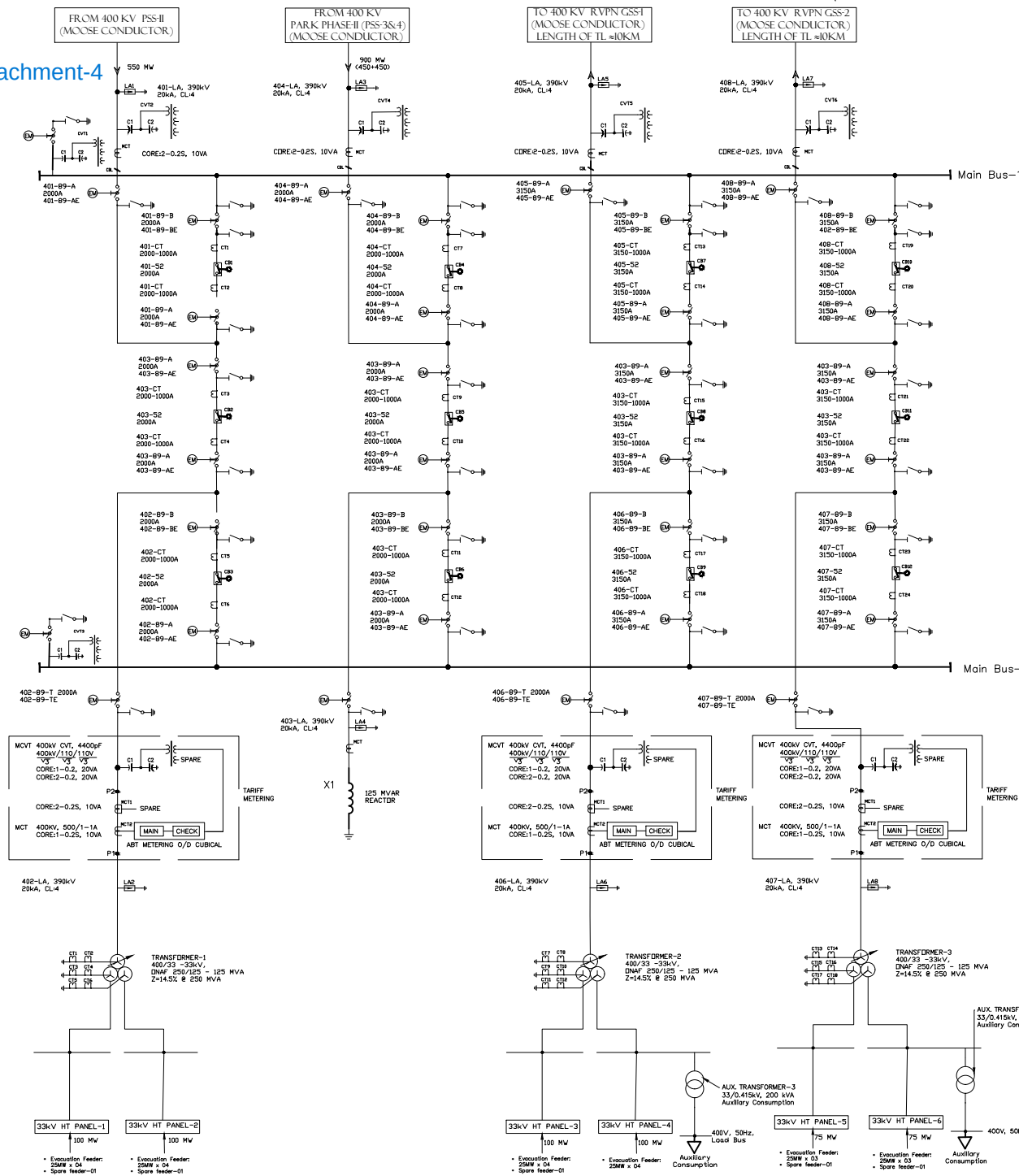
TITLE:-
LAYOUT PLAN OF SOLAR PARK AT BARALA VILLAGE

DATE .
16-01-2025

DRG No. PDCOR/SP/BL/R0

DRAWN BY :
RECOM. BY :
CHECKED BY :
APPROVED BY :

Attachment-4



NOTE:-

- 1) METERING CT & CVT APPROVAL SHALL BE PROVIDED BY RESPECTIVE AUTHORITY.
- 2) 400KV LINE & TRANSFORMER TARIFF METERING PANEL SHALL BE OUTDOOR TYPE AND LOCATED NEAR TARIFF METERING CT & CVT.
- 3) FOR 33KV HT SINGLE LINE DIAGRAM, PLEASE REFER DRG NO.-PEPL-RRUVNL-SLD-03-1, 2 & 3
- 4) AUX. / POWER SUPPLY
 - i.) POWER / AUX. AC SUPPLY - 415V / 230V AC
 - ii.) AUX. DC SUPPLY - 220V DC
 - iii.) CONTROL SUPPLY - 220V DC

BILL OF EQUIPMENTS - 400kV (63kA/1SEC)

SR.NO	DESCRIPTION	ACTUAL QTY.	SYMBOL
1.0	420KV, 2000A, SF6 CIRCUIT BREAKERS (3-PHASE), 63KA FOR 1 SEC., WITHOUT PIR, WITH CSD	06	
2.0	400KV, 2000A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH ONE EARTH SWITCH	18	
3.0	400KV, 2000A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH TWO EARTH SWITCH	02	
4.0	400KV, 63KA/1sec. 1-PH. 6 CORE, PROTECTION CURRENT TRANSFORMER CT RATIO : 2000-1000/1-1-1-1-1-1A	12	
5.0	420KV, 3150A, SF6 CIRCUIT BREAKERS (3-PHASE), 63KA FOR 1 SEC., WITHOUT PIR, WITH CSD	06	
6.0	400KV, 3150A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH ONE EARTH SWITCH	12	
7.0	400KV, 3150A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH TWO EARTH SWITCH	02	
8.0	400KV, 63KA/1sec. 1-PH. 6 CORE, PROTECTION CURRENT TRANSFORMER CT RATIO : 3150-1000/1-1-1-1-1-1A	12	
9.0	400KV, 63KA/1sec. 1-PH. 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 2000/1-1A (FOR LINE BAY)	11	
10.0	400KV, 63KA/1sec. 1-PH. 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 500/1-1A (FOR TRANSFORMER BAY)	06	
11.0	400KV, 1-PH, BUS CAPACITIVE VOLTAGE TRANSFORMER (CVT) 4400 PF, 3 CORE, CORE DETAILS : 3P/3P/0.2	06	
12.0	400KV, 1-PH, METERING CAPACITIVE VOLTAGE TRANSFORMER (MCVT) 4400 PF, 2 CORE, CORE DETAILS: 0.2/0.2	03	
13.0	380 KV, 1-PHASE, SURGE ARRESTOR, 20kA, CLASS IV	08	
14.0	250 MVA, 3-PH POWER TRANSFORMER (400/33-33kV), ONAF, Z=14.5%,	03	
15.0	AUXILIARY TRANSFORMER	02	

SYSTEM PARAMETER DETAILS:-

SL. NO.	DESCRIPTION OF PARAMETERS	400V SYSTEM
1.0	SYSTEM OPERATING VOLTAGE	400V
2.0	MAX. OPERATING VOLTAGE (RMS)	420kV
3.0	RATED FREQUENCY	50Hz
4.0	IMPULSE WITHSTAND VOLTAGE a) FOR TRANSFORMER & REACTOR b) FOR OTHER EQUIPMENTS c) FOR INSULATOR STRING	1300kVp 1425kVp 1550kVp
5.0	SWITCHING IMPULSE WITHSTAND VOLTAGE (FOR 250/250microsec DRY & WET)	1050kVp
6.0	ONE MIN. POWER FREQUENCY WITHSTAND VOLTAGE DRY (RMS)	630kV
7.0	CORONA EXTINCTION VOLTAGE	320kV
8.0	MIN. CREEPAGE DISTANCE a) FOR INSULATOR STRING ONLY (31mm/kV) b) FOR EQUIPMENT INSULATORS (25mm/kV)	13020mm 10500mm
9.0	MAX. FAULT CURRENT WITH DURATION	63 kA FOR 1 SEC.

400kV, 4400pF CVT DETAILS

APPLICATION	WDG No	PRIMARY KV	SECONDARY KV	OUTPUT VA	ACCURACY CLASS
PROTECTION	1	400/SQRT 3	0.11/SQRT 3	50	3P
PROTECTION	2	400/SQRT 3	0.11/SQRT 3	50	3P
METERING	3	400/SQRT 3	0.11/SQRT 3	50	0.2

400kV, 4400pF METERING CVT DETAILS

APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
METERING	1	400/SQRT 3	0.11/SQRT 3	20	0.2
METERING	2	400/SQRT 3	0.11/SQRT 3	20	0.2

400kV, 2000A CT CORE DETAILS

APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	VOL-VOLTS	MAX TOR Orms	le max at V _{in}	HSF
BUS. DIFF. MAIN-I	1	2000-1000/1A	—	PX	2000/1000	10/5	\$ —	—
BUS. DIFF. MAIN-II	2	2000-1000/1A	—	PX	2000/1000	10/5	\$ —	—
METERING	3	2000-1000/1A	20VA	Q2S	—	—	—	≤ 5
METERING	4	2000-1000/1A	20VA	Q2S	—	—	—	≤ 5
TRANSFORMER BACKUP / LINE PROT.	5	2000-1000/1A	—	PX	2000/1000	10/5	\$ —	—
TRANSFORMER DIFF. / LINE PROT.	6	2000-1000/1A	—	PX	2000/1000	10/5	\$ —	—

NOTE : '\$' - TO BE CONFIRMED LATER

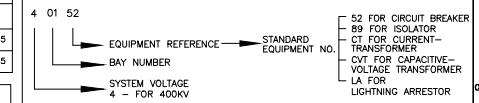
400kV, 2000A METERING CT CORE DETAILS

APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	2000/1A	10VA	0.2S	≤ 5
METERING	2	2000/1A	10VA	0.2S	≤ 5

400kV, 500A METERING CT CORE DETAILS

APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	500/1A	10VA	0.2S	≤ 5
METERING	2	500/1A	10VA	0.2S	≤ 5

NOMENCLATURE:-



DEPT.	BY	DATE	PROJECT NAME	PROJECT NAME
CIVIL				
ELEC.				

DWG. TITLE:	2000 MW Solar Power Evacuation at PSS-1

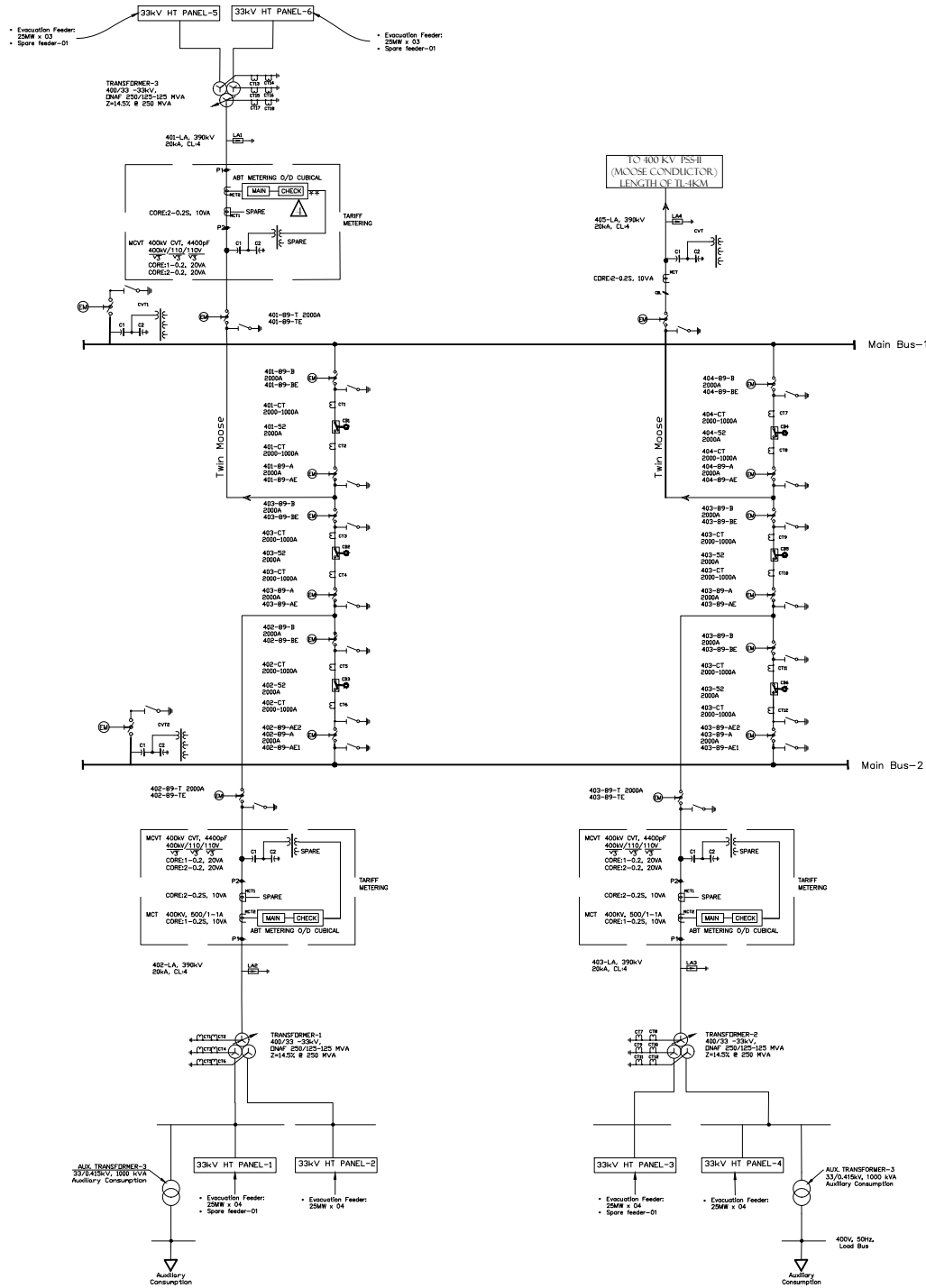
SCALE: NTS	DRAWN: PEPL	CHECKED:	APPROVED:

PEPL DWG NO:- PEPL-RRUVNL-SLD-01		SHEET	

BY		SHEET 01 OF 01

[illegible]

33/400KV POOLING SUBSTATION-I FOR 550MW



NOTE:-

- METERING CT & CVT APPROVAL SHALL BE PROVIDED BY RESPECTIVE AUTHORITY.
- 400kV HT & TRANSFORMER TARIFF METERING PANEL SHALL BE OUTDOOR TYPE AND LOCATED NEAR TARIFF METERING CT & CVT.
- FOR 33kV HT SINGLE LINE DIAGRAM, PLEASE REFER DRG NO.-PEPL-RRUVNL-SLD-03-1, 2 & 3
- AUX. / POWER SUPPLY
 - POWER / AUX. AC SUPPLY - 415V / 230V AC
 - AUX. DC SUPPLY - 220V DC
 - CONTROL SUPPLY - 220V DC

BILL OF EQUIPMENTS - 400kV (63KA/1SEC)

SL. NO.	DESCRIPTION	ACTUAL QTY.	SYMBOL
1.0	420kV, 2000A, SF6 CIRCUIT BREAKERS (3-PHASE), 63KA FOR 1 SEC., WITHOUT PIR, WITH CSD	06	
2.0	400kV, 2000A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH ONE EARTH SWITCH	15	
3.0	400kV, 2000A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH TWO EARTH SWITCH	02	
4.0	400kV, 63kA/1sec, 1-PH, 6 CORE, PROTECTION CURRENT TRANSFORMER (CT) RATIO : 2000-1000/1-1-1-1-1-1A	18	
5.0	400kV, 63kA/1sec, 1-PH, 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 2000/1-1A (FOR LINE BAY)	12	
6.0	400kV, 63kA/1sec, 1-PH, 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 500/1-1A (FOR TRANSFORMER BAY)	06	
7.0	400kV, 1-PH, BUS CAPACITIVE VOLTAGE TRANSFORMER (CVT) 4400 PF, 3 CORE, CORE DETAILS : 3P/3P/0.2	03	
8.0	400kV, 1-PH, METERING CAPACITIVE VOLTAGE TRANSFORMER (MCVT) 4400 PF, 2 CORE, CORE DETAILS: 0.2/0.2	03	
9.0	390kV, 1-PHASE, SURGE ARRESTOR, 20KA, CLASS IV	04	
10.0	250MVA, 3-PH POWER TRANSFORMER (400/33-33kV), ONAF Z=14.5%	03	
11.0	AUXILIARY TRANSFORMER	02	

- FREE ISSUED BY OWNER

SYSTEM PARAMETER DETAILS:-

SL. NO.	DESCRIPTION OF PARAMETERS	400kV SYSTEM
1.0	SYSTEM OPERATING VOLTAGE	400kV
2.0	MAX. OPERATING VOLTAGE (RMS)	420kV
3.0	RATED FREQUENCY	50Hz
4.0	IMPULSE WITHSTAND VOLTAGE a) FOR TRANSFORMER & REACTOR b) FOR OTHER EQUIPMENTS c) FOR INSULATOR STRING	1300kVp 1425kVp 1550kVp
5.0	SWITCHING IMPULSE WITHSTAND VOLTAGE (FOR 250/250microsec) DRY & WET	1050kVp
6.0	ONE MIN. POWER FREQUENCY WITHSTAND VOLTAGE DRY (RMS)	630kV
7.0	CORONA EXTINCTION VOLTAGE	320kV
8.0	MIN. CREEPAGE DISTANCE a) FOR INSULATOR STRING ONLY (31mm/kV) b) FOR EQUIPMENT INSULATORS (25mm/kV)	13020mm 10500mm
9.0	MAX. FAULT CURRENT WITH DURATION	50KA FOR 1 SEC.

400kV, 4400pF CVT DETAILS					
APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
PROTECTION	1	400/SQRT 3	0.11/SQRT 3	50	3P
PROTECTION	2	400/SQRT 3	0.11/SQRT 3	50	3P
METERING	3	400/SQRT 3	0.11/SQRT 3	50	0.2

400kV, 4400pF METERING CVT DETAILS					
APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
METERING	1	400/SQRT 3	0.11/SQRT 3	20	0.2
METERING	2	400/SQRT 3	0.11/SQRT 3	20	0.2

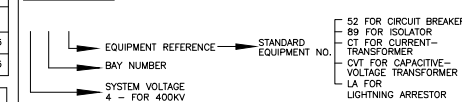
400kV, 2000A CT CORE DETAILS							
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	Vk VOLTS	MAX Ret Ohms	Is mA at Isf
BUS DIFF. MAIN-I	1	2000-1000/1A	-	PX	2000/1000	10/5	\$ -
BUS DIFF. MAIN-II	2	2000-1000/1A	-	PX	2000/1000	10/5	\$ -
METERING	3	2000-1000/1A	20VA	02S	-	-	\$ ≤ 5
METERING	4	2000-1000/1A	20VA	02S	-	-	\$ ≤ 5
TRANSFORMER BACKUP/ LINE PROT.	5	2000-1000/1A	-	PX	2000/1000	10/5	\$ -
TRANSFORMER DIFF. / LINE PROT.	6	2000-1000/1A	-	PX	2000/1000	10/5	\$ -

NOTE : '\$' - TO BE CONFIRMED LATER

400kV, 2000A METERING CT CORE DETAILS					
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	2000/1A	10VA	0.2S	≤ 5
METERING	2	2000/1A	10VA	0.2S	≤ 5

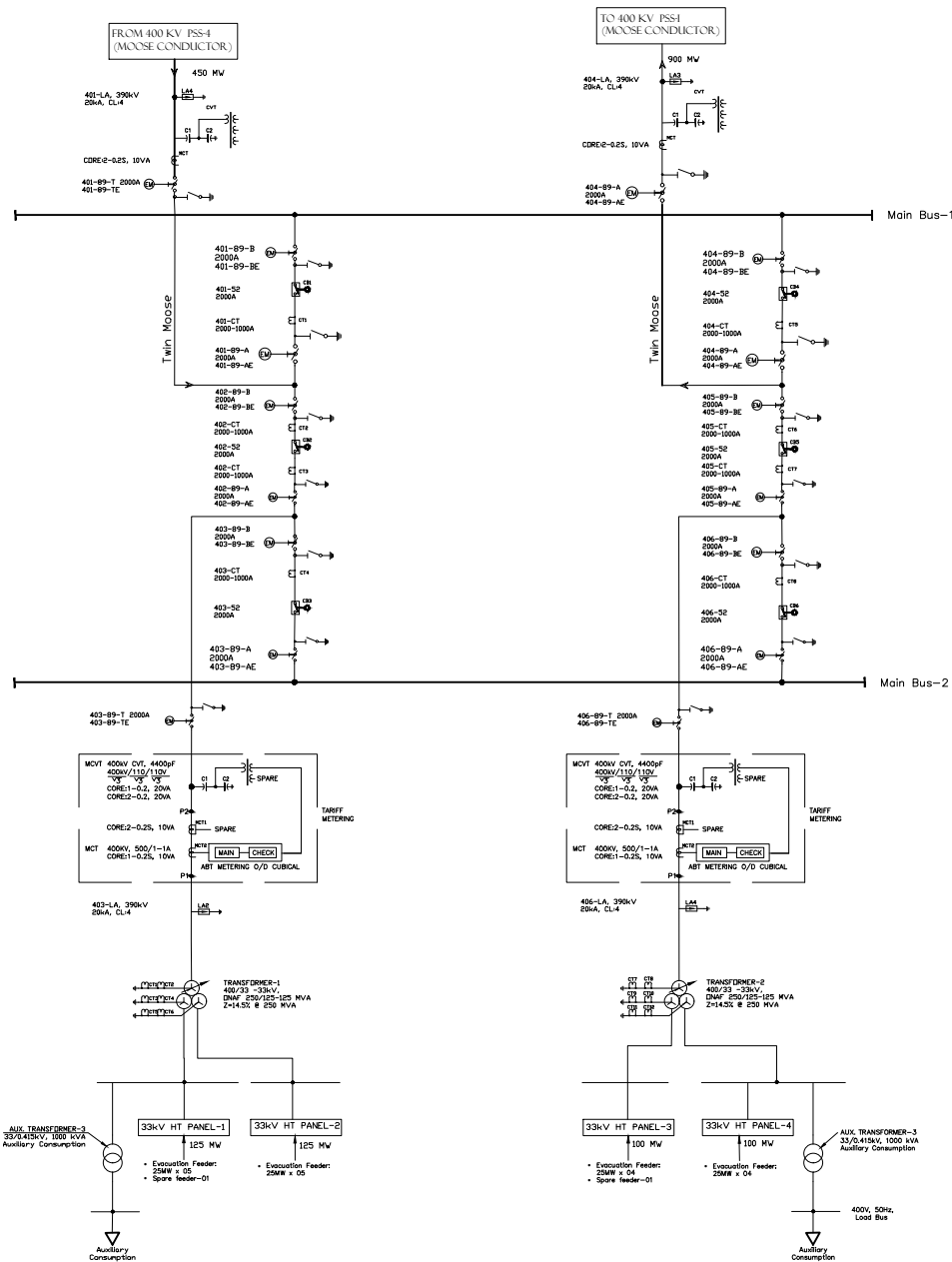
400kV, 500A METERING CT CORE DETAILS					
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	500/1A	10VA	0.2S	≤ 5
METERING	2	500/1A	10VA	0.2S	≤ 5

NOMENCLATURE:-



DEPT.	BY	DATE	PROJECT NAME	PROJECT NAME
CIVIL				
ELEC.				
DWG. TITLE:				
SCALE: NTS			DRAWN: PEPL	CHECKED:
APPROVED:			PEPL DWG NO.: PEPL-RRUVNL-SLD-02	
SHEET 01 OF 01				REV. 3

33/400KV POOLING SUBSTATION-II FOR 550 MW



33/400KV POOLING SUBSTATION-3 FOR 450 MW

NOTE:-

- METERING CT & CVT APPROVAL SHALL BE PROVIDED BY RESPECTIVE AUTHORITY.
- 400KV LINE & TRANSFORMER TARIFF METERING PANEL SHALL BE OUTDOOR TYPE AND LOCATED NEAR TARIFF METERING CT & CVT.
- FOR 33KV HT SINGLE LINE DIAGRAM, PLEASE REFER DRG NO.-PEPL-RRUVNL-SLD-04
- AUX. / POWER SUPPLY
 - POWER / AUX. AC SUPPLY - 415V / 230V AC
 - AUX. DC SUPPLY - 220V DC
 - CONTROL SUPPLY - 220V DC

BILL OF EQUIPMENTS - 400KV (63KA/1SEC).

SER.NO	DESCRIPTION	ACTUAL QTY.	SYMBOL
1.0	420KV, 2000A, SF6 CIRCUIT BREAKERS (3-PHASE), 63KA FOR 1 SEC., WITHOUT PIR, WITH CSD	06	
2.0	400KV, 2000A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH ONE EARTH SWITCH	16	
3.0	400KV, 63kA/1sec, 1-PH, 6 CORE, PROTECTION CURRENT TRANSFORMER CT RATIO : 2000-1000/1-1-1-1-1-1A	12	
4.0	400KV, 63kA/1sec, 1-PH, 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 2000/1-1A (FOR LINE BAY)	08	
5.0	400KV, 63kA/1sec, 1-PH, 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 500/1-1A (FOR TRANSFORMER BAY)	04	
6.0	400KV, 1-PH, BUS CAPACITIVE VOLTAGE TRANSFORMER (CVT) 4400 PF, 3 CORE, CORE DETAILS : 3P/3P/0.2	02	
7.0	400KV, 1-PH, METERING CAPACITIVE VOLTAGE TRANSFORMER (MCVT) 4400 PF, 2 CORE, CORE DETAILS: 0.2/0.2	02	
8.0	390KV, 1-PHASE, SURGE ARRESTOR, 20kA, CLASS IV	04	
9.0	250 MVA, 3-PH POWER TRANSFORMER (400/33-33kV), ONAF Z=14.5X,	02	
10.0	AUXILIARY TRANSFORMER	02	

- FREE ISSUED BY OWNER

SYSTEM PARAMETER DETAILS:-

SER. NO.	DESCRIPTION OF PARAMETERS	400KV SYSTEM
1.0	SYSTEM OPERATING VOLTAGE	400KV
2.0	MAX. OPERATING VOLTAGE (RMS)	420KV
3.0	RATED FREQUENCY	50Hz
4.0	IMPULSE WITHSTAND VOLTAGE	1300kVp
5.0	SWITCHING IMPULSE WITHSTAND VOLTAGE (FOR 250/250microns) DRY & WET	1050kVp
6.0	ONE MIN. POWER FREQUENCY WITHSTAND VOLTAGE DRY (RMS)	630KV
7.0	CORONA EXTINCTION VOLTAGE	320KV
8.0	MIN. CREEPAGE DISTANCE	13020mm
9.0	MAX. FAULT CURRENT WITH DURATION	50KA FOR 1 SEC.

400KV, 4400pF CVT DETAILS					
APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
PROTECTION	1	400/SQRT 3	0.11/SQRT 3	50	3P
PROTECTION	2	400/SQRT 3	0.11/SQRT 3	50	3P
METERING	3	400/SQRT 3	0.11/SQRT 3	50	0.2

400KV, 4400pF METERING CVT DETAILS					
APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
METERING	1	400/SQRT 3	0.11/SQRT 3	20	0.2
METERING	2	400/SQRT 3	0.11/SQRT 3	20	0.2

400KV, 2000A CT CORE DETAILS							
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	Vk VOLTS	MAX Rct Ohms	Is mA at Vx
BUS DIFF. MAIN-I	1	2000-1000/1A	-	PX	2000/1000	10/5	\$
BUS DIFF. MAIN-II	2	2000-1000/1A	-	PX	2000/1000	10/5	\$
METERING	3	2000-1000/1A	20VA	02S	-	-	≤ 5
METERING	4	2000-1000/1A	20VA	02S	-	-	≤ 5
TRANSFORMER BACKUP/ LINE PROT.	5	2000-1000/1A	-	PX	2000/1000	10/5	\$
TRANSFORMER DIFF. / LINE PROT.	6	2000-1000/1A	-	PX	2000/1000	10/5	\$

NOTE : '\$' - TO BE CONFIRMED LATER

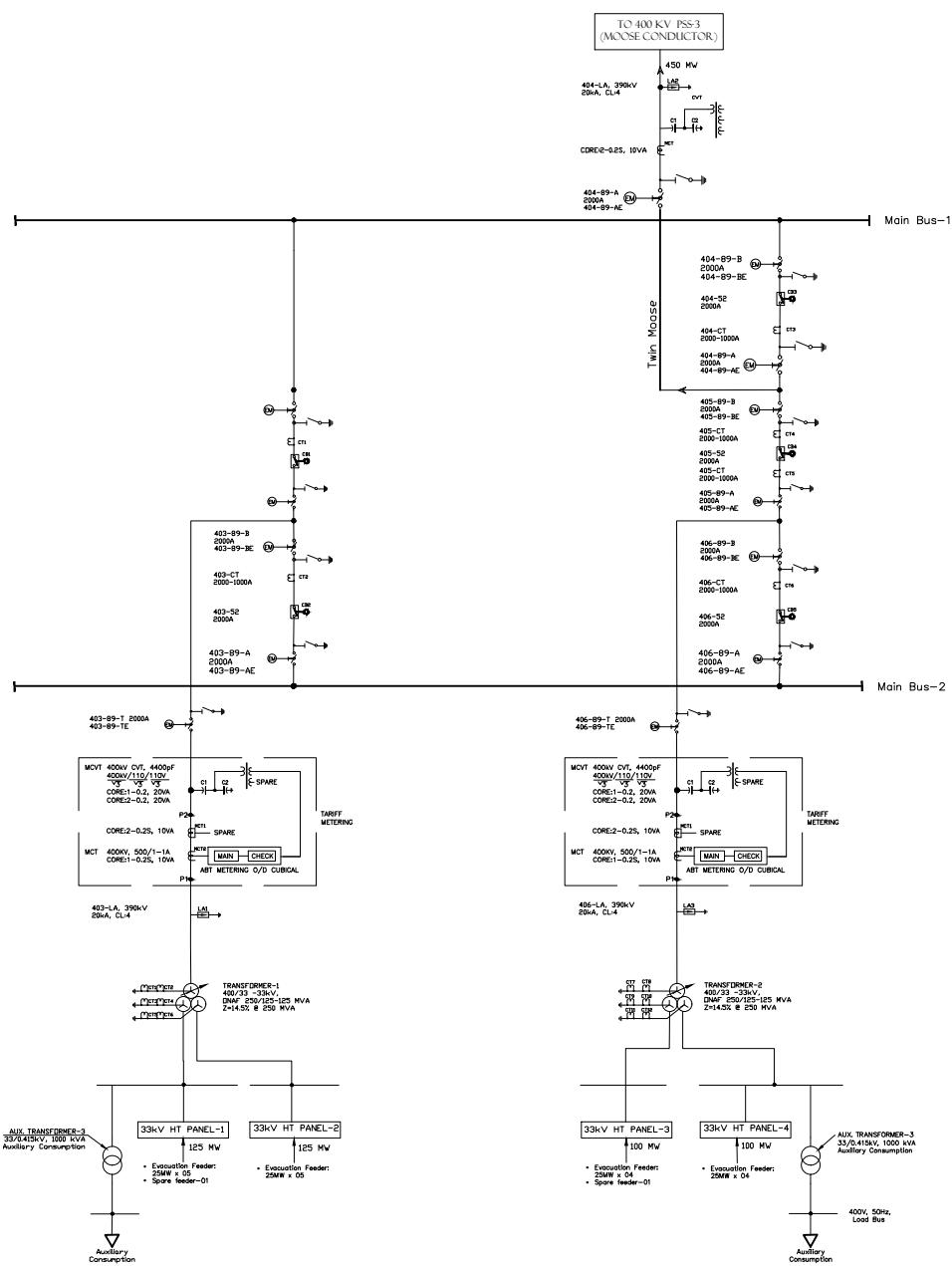
400KV, 2000A METERING CT CORE DETAILS					
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	2000/1A	10VA	0.2S	≤ 5
METERING	2	2000/1A	10VA	0.2S	≤ 5

400KV, 500A METERING CT CORE DETAILS					
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	500/1A	10VA	0.2S	≤ 5
METERING	2	500/1A	10VA	0.2S	≤ 5

NOMENCLATURE:-			
	EQUIPMENT REFERENCE		STANDARD EQUIPMENT NO.
	BAY NUMBER		EQUIPMENT REFERENCE
	SYSTEM VOLTAGE		STANDARD EQUIPMENT NO.
	4 - FOR 400KV		EQUIPMENT REFERENCE

DEPT.	BY	DATE	PROJECT NAME	PROJECT NAME
CIVIL				
ELEC.				

DWG. TITLE:			
SCALE: NTS	DRAWN: PEPL	CHECKED:	APPROVED:
PEPL DWG NO:- PEPL-RRUVNL-SLD-03			
REV.	DATE	DESCRIPTION	DRN. BY
3	14-06-2023	4 th SUBMISSION FOR APPROVAL	PEPL CVD
2	28-03-2023	3 rd SUBMISSION FOR APPROVAL	PEPL CVD
1	17-02-2023	2 nd SUBMISSION FOR APPROVAL	PEPL CVD
0	28-12-2022	FIRST SUBMISSION FOR APPROVAL	PEPL CVD
SHEET	01 OF 01	REV.	2



33/400KV POOLING SUBSTATION-4 FOR 450 MW

- NOTE:-
- METERING CT & CVT APPROVAL SHALL BE PROVIDED BY RESPECTIVE AUTHORITY.
 - 400KV LINE & TRANSFORMER TARIFF METERING PANEL SHALL BE OUTDOOR TYPE AND LOCATED NEAR TARIFF METERING CT & CVT.
 - FOR 33KV HT SINGLE LINE DIAGRAM, PLEASE REFER DRG NO.-PEPL-RRUVNL-SLD-04
 - AUX. / POWER SUPPLY
 - POWER / AUX. AC SUPPLY - 415V / 230V AC
 - AUX. DC SUPPLY - 220V DC
 - CONTROL SUPPLY - 220V DC

BILL OF EQUIPMENTS - 400KV (63KA/1SEC).

SL.NO	DESCRIPTION	ACTUAL QTY.	SYMBOL
1.0	420KV, 2000A, SF6 CIRCUIT BREAKERS (3-PHASE), 63KA FOR 1 SEC., WITHOUT PIR, WITH CSD	05	
2.0	400KV, 2000A, 63KA FOR 1 SEC., 3-PH., MOTORIZED & ELECTRICALLY GANG OPERATED HORIZONTAL DOUBLE BREAK TYPE ISOLATOR WITH ONE EARTH SWITCH	13	
3.0	400KV, 63kA/1sec, 1-PH, 6 CORE, PROTECTION CURRENT TRANSFORMER CT RATIO : 2000-1000/1-1-1-1-1-1A	12	
4.0	400KV, 63kA/1sec, 1-PH, 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 2000/1-1A (FOR LINE BAY)	07	
5.0	400KV, 63kA/1sec, 1-PH, 2 CORE, METERING CURRENT TRANSFORMER(MCT) CT RATIO : 500/1-1A (FOR TRANSFORMER BAY)	04	
6.0	400KV, 1-PH, BUS CAPACITIVE VOLTAGE TRANSFORMER (CVT) 4400 PF, 3 CORE, CORE DETAILS : 3P/3P/0.2	01	
7.0	400KV, 1-PH, METERING CAPACITIVE VOLTAGE TRANSFORMER (MCVT) 4400 PF, 2 CORE, CORE DETAILS: 0.2/0.2	02	
8.0	390KV, 1-PHASE, SURGE ARRESTOR, 20kA, CLASS IV	03	
9.0	250 MVA, 3-PH POWER TRANSFORMER (400/33-33kV), ONAF Z=14.5X,	02	
10.0	AUXILIARY TRANSFORMER	02	

- FREE ISSUED BY OWNER

SYSTEM PARAMETER DETAILS:-

SL. NO.	DESCRIPTION OF PARAMETERS	400KV SYSTEM
1.0	SYSTEM OPERATING VOLTAGE	400KV
2.0	MAX. OPERATING VOLTAGE (RMS)	420KV
3.0	RATED FREQUENCY	50Hz
4.0	IMPULSE WITHSTAND VOLTAGE	
a)	FOR TRANSFORMER & REACTOR	1300kVp
b)	FOR OTHER EQUIPMENTS	1425kVp
c)	FOR INSULATOR STRING	1550kVp
5.0	SWITCHING IMPULSE WITHSTAND VOLTAGE (FOR 250/250microns) DRY & WET	1050kVp
6.0	ONE MIN. POWER FREQUENCY WITHSTAND VOLTAGE DRY (RMS)	630KV
7.0	CORONA EXTINCTION VOLTAGE	320KV
8.0	MIN. CREEPAGE DISTANCE	
a)	FOR INSULATOR STRING ONLY (31mm/kV)	13020mm
b)	FOR EQUIPMENT INSULATORS (25mm/kV)	10500mm
9.0	MAX. FAULT CURRENT WITH DURATION	50KA FOR 1 SEC.

400KV, 4400pF CVT DETAILS					
APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
PROTECTION	1	400/SQRT 3	0.11/SQRT 3	50	3P
PROTECTION	2	400/SQRT 3	0.11/SQRT 3	50	3P
METERING	3	400/SQRT 3	0.11/SQRT 3	50	0.2

400KV, 4400pF METERING CVT DETAILS					
APPLICATION	WDG No.	PRIMARY kV	SECONDARY kV	OUTPUT VA	ACCURACY CLASS
METERING	1	400/SQRT 3	0.11/SQRT 3	20	0.2
METERING	2	400/SQRT 3	0.11/SQRT 3	20	0.2

400KV, 2000A CT CORE DETAILS							
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	Vk VOLTS	MAX Rct Ohms	Is mA at V _k
BUS DIFF. MAIN-I	1	2000-1000/1A	-	PX	2000/1000	10/5	\$ -
BUS DIFF. MAIN-II	2	2000-1000/1A	-	PX	2000/1000	10/5	\$ -
METERING	3	2000-1000/1A	20VA	02S	-	-	≤ 5
METERING	4	2000-1000/1A	20VA	02S	-	-	≤ 5
TRANSFORMER BACKUP/ LINE PROT.	5	2000-1000/1A	-	PX	2000/1000	10/5	\$ -
TRANSFORMER DIFF. / LINE PROT.	6	2000-1000/1A	-	PX	2000/1000	10/5	\$ -

NOTE : '\$' - TO BE CONFIRMED LATER

400KV, 2000A METERING CT CORE DETAILS					
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	2000/1A	10VA	0.2S	≤ 5
METERING	2	2000/1A	10VA	0.2S	≤ 5

400KV, 500A METERING CT CORE DETAILS					
APPLICATION	CORE No.	CURRENT RATIO	OUTPUT VA	ACCURACY CLASS	ISF
METERING	1	500/1A	10VA	0.2S	≤ 5
METERING	2	500/1A	10VA	0.2S	≤ 5

NOMENCLATURE:-

EQUIPMENT REFERENCE

BAY NUMBER

SYSTEM VOLTAGE

4 - FOR 400KV

52 FOR CIRCUIT BREAKER

B9 FOR ISOLATOR

CT FOR CURRENT-TRANSFORMER

CVT FOR CAPACITIVE-VOLTAGE TRANSFORMER

LA FOR LIGHTNING ARRESTOR

DEPT.	BY	DATE	PROJECT NAME	PROJECT NAME
CIVIL				
ELEC.				
DWG. TITLE:				
SCALE: NTS				
DRAWN: PEPL				
CHECKED:				
APPROVED:				
PEPL DWG NO:- PEPL-RRUVNL-SLD-04				
REV.	DATE	DESCRIPTION	DRN. BY	APPD. BY
3	14-06-2023	4 th SUBMISSION FOR APPROVAL	PEPL	CVD
2	28-03-2023	3 rd SUBMISSION FOR APPROVAL	PEPL	CVD
1	17-02-2023	2 nd SUBMISSION FOR APPROVAL	PEPL	CVD
0	28-12-2022	FIRST SUBMISSION FOR APPROVAL	PEPL	CVD
SHEET 01 OF 01				REV. 2

