GAIL (India) Limited

(A Government of India Undertaking)
A Maharatna Company
GAIL Jubilee Tower, B-35 & 36, Sector-1,
Noida- 201301, State: Uttar Pradesh, India

(BIDDING DOCUMENT NO.: GAIL/NOIDA/CnP/PROJ/SOL/24-75)

TENDER ID- 2025_GAIL_232304_1

BIDDING DOCUMENTS

FOR

DESIGN, ENGINEERING, PROCUREMENT & SUPPLY, CONSTRUCTION, ERECTION, TESTING, COMMISSIONING, OPERATION AND MAINTENANCE OF 17.5 MW (AC) FLOATING SOLAR PHOTOVOLTAIC GRID-CONNECTED POWER PLANT AT GAIL PATA, DIST. AURAIYA, UTTAR PRADESH

OWNER:	CONSULTANT:
M/s GAIL (INDIA) LIMITED B-35 & 36, 17th FLOOR, JUBILEE TOWER, SECTOR-1, NOIDA 201301 (U.P.), INDIA	BHARAT HEAVY ELECTRICAL LIMITED SOLAR BUSINESS DIVISION, MALLESWARAM, BANGALORE- 560012 KARNATAKA, INDIA

SECTION-VII: TECHNICAL VOLUME

(SPECIFICATIONS, SCOPE OF WORK AND DRAWING ETC.)

DISCLAIMER

A. The information contained in this Document or subsequently provided to Bidder(s), in documentary or in any other form, by or on behalf of Company, any of their employees or Consultants, is provided to Bidder(s) on the terms and conditions set out in this TENDER DOCUMENT and such other terms and conditions subject to which such information is provided.

B. This TENDER DOCUMENT is not an agreement and is neither an offer nor invitation by Company to the prospective Bidders or any other person. The purpose of this TENDER DOCUMENT is to provide interested parties with information that may be useful to them in the formulation of their Bid for qualification pursuant to this TENDER DOCUMENT. This TENDER DOCUMENT includes statements, which reflect various assumptions and assessments arrived at by Company or their consultants or employees or agents, in relation to the Project. Such assumptions, assessments and statements do not purport to contain all the information that each Bidder may require. This TENDER DOCUMENT may not be appropriate for all persons, and it is not possible for Company, their employees or advisors to consider the investment objectives, financial situation and particular needs of each party who reads or uses this TENDER DOCUMENT.

C. The assumptions, assessments, statements and information contained in this TENDER DOCUMENT may not be complete, accurate, adequate or correct. Each Bidder should therefore, conduct its own investigations and analysis and should check the accuracy, adequacy, correctness, reliability and completeness of the assumptions, assessments, statements and information contained in this TENDER DOCUMENT and obtain independent advice from appropriate sources.

D. Information provided in this TENDER DOCUMENT to the Bidder(s) is on a wide range of matters, some of which depends upon interpretation of law. The information given is not an exhaustive account of statutory requirements and should not be regarded as a complete or authoritative statement of law. Company would not have any responsibility for the accuracy or otherwise for any interpretation or opinion on law expressed herein.

E. Company, their employees and Consultants make no representation or warranty and shall have no liability to any person, including any Bidder or Bidder(s), under any law, statute, rules or regulations or tort, principles of restitution or unjust enrichment or otherwise for any loss, damages, cost or expense which may arise from or be incurred or suffered on account of anything contained in this Bid or otherwise, including the accuracy, adequacy, correctness, completeness or reliability of the TENDER DOCUMENT and any assessment, assumption, statement or information contained therein or deemed to form part of this TENDER DOCUMENT or arising in any way with prequalification of Bidders for participation in the Bidding process.

F. Company also accepts no liability of any nature whether resulting from negligence or otherwise howsoever caused arising from reliance of any Bidder upon the statements contained in this TENDER DOCUMENT. Company may, in their respective absolute discretion but without being under any obligation to do so, update, amend or supplement the information, assessment or assumptions contained in this TENDER DOCUMENT.

G. The issuance of this TENDER DOCUMENT does not imply that Company is bound to select and short-list prequalified Bids for Bid Stage (the "Bid Stage") or to appoint the selected Bidder, as the case may be, for the Project[s] and Company reserves the right to reject all or any of the Bid or Bids without assigning any reasons whatsoever.

H. The Bidder shall bear all its costs associated with or relating to the preparation and submission of its Bid including but not limited to preparation, copying, postage, delivery fees, expenses associated with any demonstrations or presentations which may be required by the Company or any other costs incurred in connection with or relating to its Bid proposal. All such costs and expenses will remain with the Bidder and the Company shall not be liable in any manner whatsoever for the same or for any other costs or other expenses incurred by a Bidder in preparation or submission of the Bid proposal regardless of the conduct or outcome of the Bidding process.

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SECTION 1: DEFINITION & INTERPRETATION

The following words and expressions shall have the meanings hereby assigned to them:

1. "**FSPV project**" means Floating Solar PV project
2. **"Actual Energy Delivered"** means the net energy in kilo-watt hour (kWh) from 17.5 MW (AC) FS PV plant as measured at the Metering Point at 33kV GAIL's substation end.
3. **"Adjudicator"** means the person, who shall be an engineer or a firm of engineers who is appointed by the Company to act as the adjudicator to decide on or to settle any dispute or difference between the Company and the Contractor referred to it or her by the parties pursuant to RFP (Adjudicator) hereof.
4. **"Applicable Law"** means any statute, law, regulation, ordinance, notification, rule, regulation, judgment, order, decree, bylaw, approval, directive, guideline, policy, requirement or other governmental restriction or any similar form of decision of, or determination by, or any interpretation or administration as per Indian law and the State Government, by any Government Authority or instrumentality thereof, whether in effect as of the date of this Contract or thereafter.
5. **"NEEGG"** is the Net Electrical Energy Generation Guarantee in KWh. The value of NEEGG shall be given as part of the tender and bidder must give its consent to meet the NEEGG with notarized sign and stamp on Letter Head.
6. **"Bid"** shall mean the Techno Commercial and the Financial Proposal submitted by the Bidder along with all documents/credentials/attachments annexure etc., in response to this RFP, in accordance with the terms and conditions hereof.
7. **"Bidder"** shall mean Bidding Company submitting the Bid including its successors, executors and permitted assigns;
8. **"Commissioning"** means the satisfactory, continuous and uninterrupted operation of the electrical equipment/system as specified after all necessary statutory approvals, execution of required contracts for utilization of generated energy, initial tests, checks and adjustments for a period of at least 3 days to the satisfaction of the Company and necessary certificates are issued by the all concerned/ nodal agencies appointed by appropriate authority/Government.
9. **"Completion"** means that the all Facilities/Utilities/infrastructure/Electrical System /Electrical Equipments (or a specific part thereof where specific parts are specified in the Scope of Work) have been completed operationally and structurally and put in a tight and clean condition and that all work

in respect of Commissioning of the Facilities or such specific part thereof has been completed as per the Scope of Work mentioned in the tender.

10. **"Company"** means GAIL (INDIA) LIMITED and includes the legal successors or permitted assigns of the Company.
11. **"Contract"** or "Contract Agreement" means the totality of the Agreement signed between the Company (Company) and the Contractor to execute the entire Scope of Work
12. **"Contractor"** means the person(s) whose bid to perform the Contract has been accepted by the Company as successful bidder and undertaking to perform the works, which shall include the legal representative, successors or permitted assigns of the Contractor.
13. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
14. **"Capacity Utilization Factor (CUF)"** shall have the same meaning as provided in CERC (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009 as amended from time to time.
15. **"Chartered Accountant"** shall mean a person practicing in India or a firm whereof all the partners practicing in India as a Chartered Accountant(s) within the meaning of the Chartered Accountants Act, 1949.
16. **"Completion Certificate"** shall mean the certificate to be issued by the Company or his representative when the all works have been completed as per tender to his satisfaction.
17. **"Commercial Operation Date" (COD)**: with respect to the Project/Unit shall mean the date on which the project / unit is commissioned (certified by UPPCL/UPPTCL/GAIL/State Transcom/State Discom/State Nodal Agency for Solar) and available for commercial operation and such date as specified in a written notice given at least 10 days in advance by the EPC Contractor to Company.
18. **"Day"** means calendar day of the Gregorian calendar.
19. **"Delivery Point"** shall be the interconnection point at 33kV voltage level of GAIL's Substation
20. **"Defect Liability Period"** means the period of validity of the warranties given by the Contractor, during which the Contractor is responsible for defects with respect to the Facilities (or the relevant part thereof) as provided in relevant Clause.

21. **"Effective Date"** shall mean the date of issuance of Letter of Intent (LoI)/LOA/FOA/NTP/Date mentioned in contract agreement from which the time for completion shall be determined by the Company.
22. **"Facilities"** means the Plant and Equipment to be supplied and installed, as well as all the Installation Services to be carried out by the Contractor under the Contract for enabling the installation/Construction/Erection, erection, construction, testing and commissioning of the Solar Power System(s).
23. **"GCC"** means the General Conditions of Contract hereof.
24. **"Government Authority"** means Government of India, any state government or any governmental department, commission, board, body, bureau, agency, authority, undertaking, court or other judicial or administrative body or any sub-division or instrumentality thereof, central, state, or local, having jurisdiction over the Contractor, the Facility, or the performance of all or any of the services, obligations or covenants of Contractor under or pursuant to this Contract or any portion thereof.
25. **"Guarantee Test(s)"** means the Performance & Guarantee test(s) specified in the (Guarantee Test) to be carried out to ascertain whether the Facilities or a specified part thereof is able to attain the Functional Guarantees.
26. **"Installation Services"** means all those services ancillary to the supply of the Plant and Equipment for the Facilities, to be provided by the Contractor under the Contract; e.g., transportation and provision of marine or other similar insurance, inspection, expediting, Site preparation works (including the provision and use of Contractor's Equipment and the supply of all civil, structural and construction materials required), installation, Commissioning, carrying out guarantee tests, operations, maintenance, the provision of operations and maintenance manuals, training of Company's personnel etc.
27. **"Month"** means calendar month of the Gregorian calendar.
28. **"MNRE"** means Ministry of New and Renewable Energy, Government of India.
29. **"O&M"** means Operations and Maintenance.
30. **"OWNER or EMPLOYER"** means GAIL (INDIA) LIMITED
31. **"Party"** means the **"Company or the Bidder"** as the case may be, and **"Parties"** means both of them.
32. **"Plant Capacity"** is defined as 17.5 MW (AC) Grid-Connected Floating Solar Photovoltaic Power Plant proposed at GAIL PATA, Dist. Auraiya, Uttar Pradesh as per the provisions in this Tender including but not limited to its Design, Engineering, Supply & Procurement, Construction, Erection,

Testing, Commissioning (Date of Commissioning (COD) with UPNEDA/UPPCL/UPPTCL/GAIL/State Transcom/State Discom/State Nodal Agency for solar),

33. **"Project"** means Design, Engineering, Procurement & Supply, Construction, Erection, Testing, Commissioning and Comprehensive Operation & Maintenance of 17.5 MW(AC) Floating Solar Photovoltaic Grid-Connected Power Plant using Photovoltaic Technology of with associated Three (3) years operation & maintenance of the same on turnkey basis at GAIL PATA, Dist. Auraiya, Uttar Pradesh.
34. **"Project Manager"** means the person appointed by the Company in the manner provided in the RFP (Project Manager) hereof and named to perform the duties delegated by the Company.
35. **"Prudent Utility Practices"** means those practices, methods, techniques and standards, that are generally accepted for use in civil, mechanical & electric utility industries taking into account conditions in India, and commonly used in prudent electric utility engineering and operations to design, engineer, construct, test, operate and maintain equipment lawfully, safely, efficiently and economically as applicable to power stations of the size, service and type of the Project, and that generally conform to the manufacturer's operation and maintenance guidelines.
36. **"RFP document"** shall mean the bidding document issued by the Company including all attachments vide RFP No.
37. **"Site"** means the land and other places upon which the Facilities are to be installed, and such other land or places as may be specified in the Contract as forming part of the Site.
38. **"Solar Power System(s)"** means the solar photovoltaic grid interactive power system(s) to be established at the site specified in the RFP.
39. **"Subcontractor"**, including vendors, means any person to whom execution of any part of the Facilities, including preparation of any design or supply of any Plant and Equipment, is sub-contracted directly or indirectly by the Contractor, and includes its legal successors or permitted assigns.
40. **"Successful Bidder"** means the eligible bidder who has been awarded the Contract and described as Contractor for the "Project".
41. **"Time for Completion"** shall be the date on or before which Completion of all Facility/Utilities/Infrastructure/Electrical System/Electrical Equipment has to be achieved to the satisfaction of the Company and such date is specified in Notice Inviting Tender (NIT).
42. **"Inter Connection Point/ Delivery/Metering Point"** 33kV GAIL's substation end.

43. **"Consultant"** means the agency designated by company to inspect/monitor/instruct to EPC contractor on behalf of company during entire project execution tenure.
44. **"BHEL"** means Bharat Heavy Electricals Limited consultant to Company Interpretations
45. **Language:** The parties shall use the English language and the Contract and the other Bid documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with that language.
46. **Singular and Plural:** The singular shall include the plural and the plural the singular, except where the context otherwise requires.
47. **Headings:** The headings and marginal notes in the General Conditions of Contract are included for ease of reference, and shall neither constitute a part of the Contract nor affect its interpretation.
48. **Persons:** Words importing persons or parties shall include firms, corporations and government entities.
49. **Men:** The word 'Men' in this RFP shall mean all genders i.e. male, female and others.
50. **Entire Agreement:** The Contract constitutes the entire agreement between the Company and Contractor with respect to the subject matter of Contract and supersedes all communications, negotiations and agreements (whether written or oral) of parties with respect thereto made prior to the date of Contract. The various documents forming the Contract are to be taken as mutually explanatory. Should there be any discrepancy, inconsistency, error or omission in the Contract documents, the matter may be referred to the Adjudicator and the Contractor shall carry out work in accordance with the decision of the Adjudicator.
51. **Amendment:** No amendment or other variation of the Contract shall be effective unless it is in writing, is dated, expressly refers to the Contract, and is signed by a duly authorized representative of each party hereto.
52. In case if any clause for any item/work is repeated in the Bid document/RFP/Tender Document at any place which is contradictory to each other then, most stringent/rigid/strict clause will final and applicable to EPC contractor without any further clarification.

SECTION-2. PROJECT INFORMATION

1.1 INTRODUCTION

GAIL (India) limited, is operating successfully an integrated gas based Petrochemical complex at Pata (U.P) since March 1999. The petrochemical complex is the only petrochemical plant located in north-central India. This complex recovers ethane-propane (C2/C3) from natural gas, after sweetening, (CO_2 removal), coming from Vijaipur through HVJ Pipeline for producing Petrochemicals. GAIL, Pata is the first and only gas based, landlocked petrochemical Complex in India.

GAIL PATA complex has six raw water reservoirs, with a distribution of four reservoirs (R1 to R4) for the PC I complex and two reservoirs (R5&R6) allocated for the PC II complex. In a strategic move towards sustainable energy practices, GAIL intends to utilize the available area in PC II reservoirs to generate power by setting up a Floating Solar Photovoltaic (FSPV) plant of aggregate capacity of 17.5 MW AC in first phase of the project. GAIL has appointed Bharat Heavy Electrical Limited (BHEL) as Project Management Consultant (PMC) for this project. In future, floating solar PV plant of ~ 20 MW AC capacity shall be planned in PC I reservoirs in second phase through a separate tender.

The solar power project shall be developed through Single EPC tender based on Open Category PV Cell and Modules. This EPC package will be awarded to a Single successful bidder with suitable Bid Evaluation criteria, as defined separately in the bidding documents.

1.2 PROJECT CAPAPCITY

TABLE 1: PROJECT CAPACITY DETAILS

Name of the Package	"Development of 17.5 MW (AC) Floating Solar PV Project at GAIL PATA"
Cumulative Project AC Capacity	Minimum 17.5 MW
DC Capacity	Minimum 24.30 MWp
Bid Capacity	Bidder has to quote for full capacity.
Metering Point and Terminal Point	As per indicative tender SLD.

1.3 LOCATION AND APPROACH

The project site is situated within GAIL Pata complex. The detailed location of the site is as follows:

TABLE 2 : LOCATION AND APPROACH DETAILS

PARTICULARS	DESCRIPTION
Place	Pata
District	Auraiya
State	Uttar Pradesh
Nearest Airport	Kanpur (130 KM), Lucknow (180 KM)
Nearest Railway Station	Phaphund (10 KM)
Nearest Road	NH-19
Nearest Municipal Town	Dibiyapur

The location Latitude and longitude of center of reservoirs are as follows:

TABLE 3: COORDINATES OF RESERVOIRS

RESERVOIR No.	LATITUDE (N)	LONGITUDE (E)
Reservoir-5	26°39'06"	79°29'37"
Reservoir -6	26°39'14"	79°29'44"

The project site is well connected to Kanpur through Road as well as rail network. The site is equally accessible through road from Lucknow also. However, the nearest connectivity is from Kanpur only.

1.4 AREA AVAIALBILITY

The Water Body Area Availability of raw water reservoirs in GAIL Pata are as below:

TABLE 4: AREA AVAILABILITY

RESERVOIRS	Approx. total Available Area in Sq. M	Max. Water Depth at full Capacity (M)	Approx. Capacity of Reservoirs in Cubic Meter	Minimum Draw Down Level in M	Approx. Area at MDDL in Sq. M
Reservoir 5	104000	2.75	286000	0.4	85970
Reservoir 6	108000	2.75	297000	0.4	88935

GOOGLE IMAGE OF RESERVOIRS IN GAIL PATA COMPLEX

Land & Water body will be provided by GAIL PATA on "as is where is basis" to the successful EPC Bidder.

SECTION-3. INTENT OF SPECIFICATION

1.1 SCOPE OF WORK

The scope of the project shall be Design, Engineering, Supply, Construction, Erection, Testing, and Commissioning of grid connected 17.5 MW-AC Floating Solar PV plant along with power evacuation system at final evacuation point (as per Tender Drawing).

The scope also includes three (3) years Comprehensive Operation and Maintenance (O&M) of the solar PV plant from the successful completion date of Operational Acceptance Test (OAT) or 90 days from commissioning, whichever is the earlier. 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 in the technical specification.

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 substation / Switchyard 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:

1. Basic Engineering of the plant and systems.
2. Detailed design of all the equipment and equipment system(s) including civil works.
3. Providing of engineering drawings for review and approval, data, process, calculations, test procedures, Structural Design Calculations, Equipment Layout, Drawings / Data sheets of bought out items, Civil Structural / Architectural Drawings, OAT and PG test procedure (as mentioned in Technical Specification) etc.
4. Providing Operation & Maintenance/ instruction manuals, as built drawings and other information.
5. Providing training of Employer's personnel.
6. Finalization of sub-vendors, manufacturing quality plans and Field quality plans.
7. 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.

8. 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.
9. Packing and transportation from the manufacturer's works to the site including Customs clearance & port clearance, port charges, (if any).
10. Receipt, storage, preservation, security 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. A separate storage shed shall be constructed by bidder, especially for indoor equipment storage.
11. Topographical survey & Geo-Technical investigation of land/waterbody and bathymetry survey of water body, as applicable and as per requirement of design of floating solar PV systems.
12. Supply of all Equipment required for complete FSPV Plant.
13. Supply of floaters, Installation, anchoring, mooring, fixing of floaters for SPV panels, pathways for the floating system, including fixing of PV Modules on Floaters.
14. Launching platforms, O&M platforms/Jetty with suitable road and water access as per requirement.
15. Construction of RCC/Pre-Engineered type Inverter room/Open Equipment platforms which includes Central Inverter/AC combiner box, Inverter Transformers along with associated LT and HT switchgear as per design. UPS and Battery Bank should be kept in separate enclosures.
16. All associated electrical and civil works required for interfacing with grid i.e. Transformers, Isolators, CTs, CBs, panels, protection system, cables, metering at 33KV level, grid compliance study as per regulation etc.
17. All equipment, materials and services that are necessary for implementation of the reactive power compensation system and any other equipment required to make the plant CEA compliant as per the grid study with satisfactory operation of the Solar PV system.
18. Evacuation of power as per tender drawing. Scope shall include supply of new panel and extension to the existing 33KV switchgear board of SS32 (make shall be specified elsewhere in specification). The new panel for the SS32 substation shall be of same make as existing panel. Installation & Commissioning of panel shall be done in presence of OEM Engineer.
19. Construction of Central Monitoring and Control Station (CMCS) for 17.5 MW Capacity with SCADA, PPC panel and associated equipment with provision of future extensions for SCADA system, UPS and

Battery bank at identified location within Solar Plant Premises. UPS and Battery Bank should be kept in separate enclosures inside CMCS.

20. A CMCS building is to be built as indicated in the vicinity map in the tender drawing. The Identified location is tentative and may be changed during detailed engineering as per site conditions.
21. Module cleaning system (Wet Method) including supply and installation of all accessories like monitoring system at CMCS and associated equipment and services at identified location to cover the complete plant.
22. SCADA system for remote monitoring and control of Inverters with all hardware & software and complete set of Weather Monitoring Station including cloud cover and OFC/LAN connectivity up to GAIL control room.
23. CCTV System for remote monitoring of the complete project including supply and installation of all accessories like monitoring system at CMCS and associated equipment and services at identified location.
24. Comprehensive Operation & maintenance of SPV Plant along with electrical equipment, consumables, and spare parts for a period of three years from the successful completion of OAT.
25. Reliability and Functional guarantee tests (OAT and PGT) after successful commissioning of full Capacity.
26. Design and construction of Sedimentation Tanks with required length of diversion channel & de-silting pumps as per Sedimentation Plan of the Project.
27. Supply of Mandatory Spares.
28. Satisfactory completion of the contract.
29. Special tools and tackles if any required for maintenance of the plant.
30. Detailed system wise scope is elaborated in respective part of the technical specification.
31. 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 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.

32. 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 ITB. 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.
33. The Bidder shall be responsible for providing all material, equipment and services, specified or otherwise which are required to fulfill the intent of specification and ensuring operability, maintainability and the reliability of the complete work covered under this specification.
34. 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.
35. 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.
36. Statutory compliances across the timeline of the contract as per extant regulations prevailing on the bid opening date.

3-A DESIGN & ENGINEERING

1. Contractor shall prepare the detailed design basis report (DBR) along with relevant standards (with respective clause description), Program evaluation and review technique (PERT) Chart and Master Document & Drawing List (MDL). Contractor shall submit a copy of the same to GAIL/BHEL for review and approval prior to detail engineering.
2. All documents and drawings (soft copy) shall be submitted to the GAIL/BHEL for review and approval. Every drawing shall also be submitted in '*.dwg' format. In case of design calculations done in spread sheet, editable (working) soft copy of the spread sheet shall also be submitted along with 'pdf' copies during every submission. GAIL/BHEL shall return to the Contractor with category of approval marked thereon.
   - Category-I: Approved
   - Category-II: Approved subject to incorporation of comments. Re-submit for approval after incorporation of comments
   - Category-III: Not approved. Re-submit for approval after incorporation of comments
   - Category-IV: Kept for record/ reference
   - Category-IV (R): Re-submit for record/ reference after incorporation of comments

   (**Note:** Approval of document neither relieves the Vendor/ Contractor of his contractual obligations and responsibilities for correctness of design, drawings, dimensions, quality & specifications of materials, weights, quantities, assembly fits, systems/ performance requirement and conformity of supplies with Technical Specifications, Indian statutory laws as may be applicable, nor does it limit the Employer/ Purchaser's rights under the contract).
3. The Contractor shall submit complete Master Document & Drawing list (MDL) to the EMPLOYER within 2 weeks after issue of LOA. The MDL shall list all the Drawings & Documents envisaged for submission/ approval from the EMPLOYER and shall also have all the required information like drawing no (both vendor and EMPLOYER's drawing no), title, scheduled date of submission, actual date of submission and approval. The category of approval shall be decided mutually between Contractor and the EMPLOYER at the time of finalization of the MDL which shall be the basis for drawing & document approval process during project execution. The construction shall be done only as per drawings approved under Category – I, II & IV. The EMPLOYER shall be kept updated with

all proceedings and technical details during the course of design vetting of Floating unit and anchoring & mooring system.

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

   a) Solar insolation data and basis for generation
   b) Detailed technical specifications (GTP) of all the equipment
   c) General arrangement and assembly drawings of all major equipment
   d) Schematic diagram for entire electrical system (DC, AC and auxiliary systems)
   e) GTP & G.A. drawings for all types of structures/ components, Floats, Anchoring
   f) mechanisms, 33 kV switchgears & other interfacing panels
   g) Test reports (for type, routine and acceptance tests)
   h) Relay setting charts
   i) Design calculations and design templates for Floating System, Anchoring and Mooring mechanism
   j) Shadow analysis
   k) Concrete mix design report for different grades of concrete to be used for construction
   l) Bathymetric survey report including topographical survey data in digital format
   m) (Excel file) and Contour plan of the area.
   n) Geotechnical (on-shore & off-shore) and Geophysical (off-shore) investigation reports
   o) Array/ Plant Layout
   p) GA, & detail drawings for architectural, civil, structural and RCC works for the entire project which shall include various buildings and facilities like CMCS, IR, Foundation and plinth for Open installations for IR (as applicable), Weather protection canopy/ shed over open equipment installations, Sewerage, Water supply & module washing system networks, Security room & watchman cabin(s), Fire protection system, Boundary & transformer yard fencing etc.
   q) Transmission line drawings and erection plans as per DISCOM/ STU guidelines
   r) Quality assurance plans for manufacturing (MQP), Standard Operating procedure
   s) (SOP) and field activities (FQP)
   t) Detailed site EHS plan, fire safety & evacuation plan and disaster management plan.
   u) O&M Instruction's and maintenance manuals for major equipment and complete plant

v) As-built drawings / documents and deviation list from good for construction (GFC) drawings/documents

5. Estimation of the plant generation based on Solar Radiation and other climatic conditions at site.
6. Design of associated civil, structural, electrical & mechanical auxiliary and plumbing systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for civil, structural, RCC and plumbing & sanitary works, roads and drainage etc. including analysis & design input file, Earth- mat, Bus Bar & Spacers indoor and outdoor lighting/ illumination etc., GTP and GA drawings for the major equipment including transmission line. Design basis & calculation sheets, and other relevant drawings and documents not covered above but required for engineering of all facilities within the periphery shall be provided under this contract.
7. All drawings shall be fully corrected to match with the actual "As – Built" site conditions and submitted to Employer after commissioning of the project for record purpose. All as-built drawings must include the Good for Construction deviation list.
8. Indicative Master Drawing & Document list is attached in Tender Drawings.

3-B ELECTRICAL SCOPE OF SUPPLY & SERVICES

1.0 BASIC ENGINEERING DESIGN PARAMETER OF FLOATING SOLAR PV PLAN

a) MINIMUM PLANT AC CAPACITY : 17.5 MW

b) MINIMUM DC CAPACITY : 24.30 MWP

c) DESIGNED SYSTEM VOLTAGE : 1500 V DC

d) POWER CONDITIONING UNIT (PCU) :

i. **CAPACITY:** The continuous combined rating of all PCUs shall not be less than Plant capacity at
   a. Unit power factor at ambient temperature of 50 deg.
   b. 0.95 power factor at ambient temperature of 45 deg.

ii. **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.

e) Same rating of Inverter is recommended for the whole plant and same rating of Inverter Transformer is also preferred considering Mandatory spare management.

f) 33 kV 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: 2.55 times of system fault current.
iv. Spare 33 kV breaker panels with VCB, relay and all other accessories shall be provided. Total quantity of spare panels (if any) are indicated in tender indicative AC SLD. VCB with protection relay shall be used at all switchgear panels including 33 kV Aux Transformer feeder.
v. 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, then suitably rated AC/DC converter/power pack shall be used to meet the DC control supply requirement of switchgear panels.
vi. The 33kV switchgears (both indoor and outdoor type where allowed as per TS) shall have an internal Arc Classification corresponding to system fault current
vii. The Rooms shall have sufficient ventilation facility.

viii. Design of Local Pooling Station, HT cable from Local pooling station to Final evacuation point and new switchgear in SS-32 Substation shall be done considering the combined capacity of 17.5 MW in Phase-I and 20 MW in Phase-II (i.e. for total 37.5MW). Total power to be evacuated in SS-32 switchgear though suitably rated equipment.

ix. As mentioned in indicative AC SLD, the switchgear panels for spare requirement and future connections requirement shall be maintained.

x. Supply and installation of metering panel along with control cable shall be in bidder's scope. ABT/SEM metering arrangement shall be as per CTU/STU requirement/standard.

g) 33 kV Switchgear at SS-32 substation:

i. Bidder shall extend the existing 33KV switchgear board of SS32 and new switchgear panel shall be connected to the existing switchgear.

ii. The new panel for the SS32 substation shall be of same make as existing panel. Installation & Commissioning of panel shall be done in presence of OEM Engineer.

iii. **Power Evacuation System:** Solar power shall be integrated in existing 33KV spare feeder in SS-32. For making use of the existing spare feeder, two-panel extension, one in Bus-A and one in Bus-B of Substation-32 shall be done by bidder. Extension of panel shall be done by bidder in presence of OEM service engineer. Extension of panel may be done during Plant Shutdown.

iv. Supply and installation of metering panel along with control cable shall be in bidder's scope. ABT/SEM metering arrangement shall be as per CTU/STU requirement/standard.

v. In the existing 33KV spare outgoing feeder, **existing 12 no.s CTs have to be changed with suitably rated CT and a Line PT/other suitable arrangement for voltage measurement and protection, shall be provided**. All the necessary equipment (coils, contactors, relays and wiring) for these modifications is in bidder's scope.

vi. Details of the existing system:

a) Make: Siemens

b) Model: 8BK80

c) Busbar Rating: 1600A

d) Busbar details: AL conductor,2*160*10MM

e) SC rating :31.5KA for 1sec

f) Circuit breaker type-Vacuum CB,1250A

g) Make- Siemens, Model-3AH3

h) Earthing conductor: Cu,400*10MM.

h) Metering:

(i) Metering shall be done at both location Solar plant end and 33kV GAIL's substation which is interconnection point at the Switchyard/substation at 33kV GAIL Substation end where the power is injected into the substation i.e. The delivery point / final evacuation point/interconnection point.

(ii) Bidder shall provide MAIN and CHECK Energy meters in the final evacuation point (SS-32) and STANDBY Energy Meter in final OG feeder from solar end. The meters shall have all necessary statutory and regulatory clearances. Supply and integration are in bidder's scope.

(iii)Automated meter reading (AMR) facility to be ensured with ABT meters. Laptop with necessary software & hardware support to be provided by EPC bidder for interfacing with ABT meters.

(iv)Final metering philosophy shall be decided during details Engineering as per the approval of metering philosophies from Local Electricity board and Discoms and Grid Authorities.

i) Earth Pit for DC System:

For floating Solar PV Systems, the number of earth pits shall be reviewed during detailed engineering based on actual site requirement and Bidder's earthing proposal.

j) 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 0.5 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 100msec. For final power evacuation feeder, the time for cable size calculation shall be minimum 1.0 sec.

k) SCADA: Bidder shall provide SCADA system (as per chapter B-6 of section-6) of same make of existing SCADA system of GAIL substations/plants.

Licenses for Remote Monitoring of SCADA - 2 Nos with provision of Concurrent viewing for all users. Provision of data telemetry/remote communication to concerned RLDC to be kept, if required.

l) **Telemetry System**: Bidder shall integrate the solar plant SCADA system with existing CMS at SS-32. All the necessary equipment (Network switches, communication cables etc.) required for this integration shall be in bidder's scope. All the necessary data shall be made available in the system of CMS at SS-32. 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 is in contractor's scope (If applicable).

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.

m) **DC and LT Power cable voltage drop criteria**: From Module to Inverter Transformer shall be limited to 3% of rated voltage. For all other LT cables, Maximum Voltage drop shall be limited to 3% of rated voltage.

n) DC system voltage of 125V/250V shall be considered for design of equipment rating, which has auxiliary voltage fed from 110V/220V battery and same shall be decided during details Engineering.

o) The DC Power and AC Cables shall be laid on floats in a manner that they are not submerged in water. Bidder to use suitable cable trays, cable supports etc. to achieve this. The DC power cables shall be brought to the bund and then up to inverters, using suitable arrangements mentioned in the cable installation methodology chapter (B-5 of section-6). This DC cable arrangement shall be reviewed during detail engineering and finalized as per the GAIL site team's confirmation. For complying the same, if any additional structures/arrangements requirements arise, then same shall form of this specification and shall be done by bidder.

The AC Cables shall be laid in trefoil formation using good quality trefoil clamps and other cable clamps shall also be able to sustain the harsh floating environment. Cable straps used shall be UV resistant.

Bidder can propose suitable laying scheme taking into consideration the floating aspect of the project which shall be reviewed during detailed engineering.

AC HT cable from Local pooling station to Final evacuation point, the sizing shall be done considering the future project requirements (i.e. for total 37.5MW). Accordingly, equipment shall be selected.

p) Closed Circuit Television (CCTV) and control and Monitoring System: CCTV system shall have full coverage for the solar blocks. For detailed specifications of CCTV system, refer relevant chapter of Technical Specifications.

Bidder shall integrate the solar plant CCTV system with GAIL plant's main CCTV server. All the necessary equipment (Network switches, communication cables etc.) required for this integration shall be in bidder's scope.

q) **FIRE ALARM SYSTEM**: For detailed specifications of Fire alarm system, refer relevant chapter of Technical Specifications.

Bidder shall provide necessary technical support for integration of Floating Solar Fire Alarm system with existing Plant Fire Alarm & Annunciation system. All the necessary equipment required for this integration shall be in bidder's scope.

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

2.0 SUPPLIES & ASSOCIATED WORKS

DC SIDE
Solar PV Modules
HDPE Floaters for floating system
Mooring System accessories for Floating System
DC Cables including field connectors and DWC pipes
String Combiner Box (if applicable)
String Inverter/ Central inverter
AC SIDE
LT Switchgear (ACCB, ACDB)
HT Switchgear and other necessary equipment at evacuation point
Inverter Transformer& Auxiliary Transformer
LT Cables
HT Cables
Cable Laying – DC, LT & HT cables
SCADA & Time Synchronization Equipment and integration with existing SCADA system
Instrumentation and Communication cable
Earthing System for Floating based systems
Lightning Protection System
Plant Illumination system
Auxiliary Power Supply System
Battery and Battery Charger
UPS
PPC
Grid compliance study and supply & installation of interfacing equipment so as to meet statutory requirements.
GENERAL SYSTEMS
Weather Monitoring Station
Fire Detection and protection system
Module Cleaning system
Closed Circuit Television (CCTV) and Monitoring System

3.0 Provision of SCADA HMIS/SERVER Operator Work-Station (OWS) at CMCS Room

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

TABLE 5 : SCADA ROOM EQUIPMENT AND FURNITURE

Sl .n o	Description	Quantity
1	Engineering cum Operator work station (EWS+OWS) (Server with Monitor)	01 Set
2	Operator work station (OWS) (Server with Monitor) One at CMCS and Another at GAIL's Control Room	02 Set
3	Portable (laptop based) EWS	01 No
4	Historian (Desktop)	01 No
5	65 Inch LED display	01 No
6	Time Synchronization equipment*	01 No
7	Control Desk	01 Set
8	Chairs for Control Desk	02 No
9	Laser Printer	01 No

*The SCADA/ all other related system shall have facility to synchronize time on Network Time Protocol with Time Synchronization Equipment to be supplied under the package.

3-C CIVIL SCOPE OF SUPPLY & SERVICES

1.0 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.

2.0 DESIGN & CONSTRUCTION OF PERMANENT FACILITIES: (To be read in conjunction with Tender Drawings)

TABLE 6: LIST OF PERMANENT FACILITIES

Sr. No.	Facility / Building	Quantity
1.	Site investigation-Topography survey, Bathymetry & Geotechnical investigation	As per system design requirement and specifications.
2.	Floating System including Anchoring and Mooring for Floating Solar PV System	As required.
3.	Central Monitoring and Control Station (CMCS) building	1 no.
4.	Inverter Room(s) - Pre-Engineered Building (PEB) / Containerized System/Outdoor system	As required.
5.	Cable floats with necessary fittings and accessories including Anchoring and Mooring System.	As required.
6.	Cable Trenches / Trestle including any Cable Tray supporting facility	As required.
7.	Toilet	As required
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.	Approach Roads &Internal Roads	As per bidder's proposal and Tender Drawing (Refer Indicative Layout and Road Section Drawings)
11.	Drainage system (Internal & External along approach road)	As per bidder's proposal, Tender Drawing and requirement

12.	Any internal Fencing and Gates, e.g. for Yards (Transformer, inverter)	As per Tender Drawing / System Requirement
13.	Site Clearing and Grading including dismantling of Building if any.	As per the requirement
14.	Sedimentation Tank – 3 nos with required length of diversion channel & de-silting pump as per sedimentation plan of the project.	As per bidder's proposal, Tender Drawing and requirement
15.	PEB Security Cabin (Min. Size 1.8 M X 1.8 M)	2 Nos.

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

A) Site Preparation (as required for installation of panels / equipment etc. during construction, erection, and commissioning activities).
   1. Cutting, Clearing, transporting and disposal of plants, bushes, other vegetation, roots, stub, old structures etc.
   2. Any temporary drainage including any dewatering, site approach & service roads.
   3. All temporary work in bidder scope i.e. Fencing, Parking Shed, Road, Porta cabin and other infrastructures etc.
   4. Swatch Bharat Yojana policy for cleaning and deposal of sewage.

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

B) O&M Related Facilities to be developed by EPC Contractor
   1) Rainwater Harvesting for RCC Buildings - If RCC Buildings are provided.
   2) Design, Supply & Installation of a Module cleaning system including any requisite Construction works.
   3) Design & Construction of Permanent water Supply / Network system for cleaning/ washing.
   4) During O&M period, Optimum utilization of wet (by water) cleaning system shall be done 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.
   5) Any fencing shall be in bidder scope for protection of their offices, equipment against theft or otherwise.

C) Bidder has to carry out following site Investigations before start of work.
   a) Topographical survey
   b) Bathymetry Survey
   c) Geo-Technical investigation
   d) Hydrological studies

NOTE:

A. In case, any study / investigation report / design carried out by GAIL/BHEL, 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 GAIL/BHEL.

3.0 SURVEY, INVESTIGATION REPORT & RECOMMENDATIONS (IF ANY)

a) The bidder must carry out Bathymetry and Topographical survey on his own as per requirement of design.

b) The bidder has to carryout detailed Geotechnical Investigation, as per the requirements of Technical Specifications.

c) Bidder may carry out Hydrological studies for the site for assessment & Design of Drainage system.

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.

3-D MISCELLANEOUS

1.0 CODES AND STANDARDS

All works shall be carried out as per the 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.

2.0 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 this document. 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.

3.0 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.

4.0 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 under this contract at no additional cost to the owner either at third party lab or in presence of client /owner's 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.

5.0 CONSTRUCTION OF TEMPORARY STORAGE YARD

a) Bidder shall, at a suitable location at the site, as decided based on discussions with BHEL/GAIL site engineer, construct temporary yards for safe storage of bidder supplied items.

b) Area of all storage yards/sheds shall be selected based on sizes of items. Bidder shall, at the time of starting their activities at site, submit drawings/ sketches/ dimensions etc to obtain approval from BHEL/GAIL.

c) Safety and security of all the items shall be within bidder scope. Accordingly, bidder shall ensure adequate security watch and ward for these items round the clock.

6.0 CONSTRUCTION OF TEMPORARY FACILITY

The Bidder shall provide a temporary facility/ arrangement at site or otherwise for the office of Employer's employee/ consultant at the time of construction of the Solar Power Plant. One (1) No. of air-conditioned Porta Cabin (20x10 ft) with facilities shall be provided by the bidder for Owner's use. The porta cabins shall be equipped with AC, Furniture, Fan, Tube light, plug sockets and other equipment for comfortable working at construction site. Prior to supply, the Bidder shall submit the Office Porta Cabin layout proposal to GAIL/BHEL Site Engineer in Charge for approval.

Porta Cabins, with the above facilities, shall be the property of the bidder only and the bidder is free to take back from the plant after PGT after taking necessary permissions from the Employer.

7.0 PA (PUBLIC ADDRESS) SYSTEM

Public address (PA) system equipment i.e. Field call stations (FCS), beacon lamps, hooter for CMCS building and reservoir area shall be provided by EPC Bidder. Preparation of PA layout and supply & installation of Plant communication devices in Reservoirs and CMCS building as per approved layout including PA system cabling is in scope of bidder including complete Supply, Installation, testing and commissioning.

8.0 SPARES

The Bidder shall include following spares in his scope of supply.

i. All the necessary recommended spares, commissioning spares and O&M spares.

ii. Mandatory spares as mentioned Section-10 of this specification.

9.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

All the contract personnel entering plant shall wear safety helmet, safety goggle, safety shoes (or the required foot protective equipment like gum boots) and protective clothing such as boiler suit. In addition to the above requirement, any PPE which is required for the safe execution of job shall be provided by the Contractor and the requirement will be provided by the Engineer in charge/ authorized person of the area concerned or Safety section. The PPEs provided by the contractor to his/her personnel shall meet the requirements as per ANSI/EU/IS standards.

10.0 OTHER DETAILS

The following clearances shall be arranged by bidder. However, necessary documentations/applications shall be in the name of GAIL.

TABLE 7: DETAILS OF STATUTORY CLEARANCES

SL.NO	ITEM	DETAILS
1	Water Requirement during construction	Shall be arranged by GAIL at single point, further distribution will be in bidder scope – Bidder to inform their water requirement at least 10 days prior to the actual requirement.
2	Power Requirement during construction	Power Requirement during construction shall be provided by GAIL on Chargeable basis @ Rs. 10/- per Kwh. One feeder of 3-Phase power supply 415VAC shall be arranged by GAIL at single point, further distribution will be in bidder scope. A Commercial Energy Meter to be installed by EPC bidder for billing of Electricity.
3	MOEF Clearance	Shall be arranged by GAIL, wherever applicable
4	SPCB Clearance	Application by GAIL. Inputs for application & processing to be facilitated by bidder
5	MNRE Clearance	To be facilitated by bidder
6	CEA/CEIG Clearance	To be facilitated by bidder
7	Tree Cutting Permission	To be facilitated by bidder

Bidder shall apply for necessary approvals, permits and clearances not more than 90 days from the issuance of LOA, which shall be complete in all respects, incorporating the clarifications/changes as required by the concerned authorities.

All the statutory fees for approvals till the completion of O&M period shall be in the scope of bidder (unless otherwise specifically mentioned in the document).

11.0 TRAINING OF EMPLOYERS PERSONNEL

The bidder shall provide training (free of cost) to 20 personnel of GAIL for 7 days at site for erection, testing, commissioning and O&M of the plant which must include training on Operation of Inverters, SCADA, Module Washing System from respective OEMs etc.

SECTION-4. TENDER DRAWINGS

A) Following list of drawings are annexed to this specification.

1. Indicative AC SLD along with existing substation (SS-32) SLD
2. Civil drawings (Indicative)

2.1. Reservoir GA Drawing

2.2. Cross Section details for Approach road

2.3. Main Control Room-Architecture Plans, Elevations & Finishing (RCC)

2.4. Main Control Room-Architecture Plans, Elevations & Finishing (PEB)

2.5. General Arrangement for Platform for PCU/HT Panel

2.6. Proposed De-Sedimentation Plan of the project

2.7. Typical Details of Sedimentation Tank

2.8. Typical Fencing Details

2.9. Typical Fence Gate Details

2.10. Indicative Field quality plan for Civil works

3. Indicative Master Drawing & Document List
4. PC-II Reservoir Water test Report

B) The above list of drawings shall form part of the specification and shall supplement the requirements specified in these technical specifications. These drawings are preliminary drawings for bidding purpose only and subject to changes that may be necessary during the detailed engineering keeping the basic parameters as specified. Various parameters for building and other equipment specified in the tender drawing are the minimum required & any increase in these parameters if required to meet the system requirement shall be made by the Bidder without any additional cost implication to Employer.

SECTION-5. PROJECT SPECIFIC DATA

1.1 TECHNOLOGY

In Solar Photovoltaic 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.

1.2 SOLAR INSOLATION DATA FOR PROPOSED GAIL PATA SITE

TABLE 8: SITE IRRADIATION DETAILS

Month	GHI (kWh/m²)
January	106
February	132.7
March	179.7
April	199.1
May	211.1
June	172.6
July	156.9
August	158.3
September	150.8
October	146.5
November	118.9
December	110.6
Total	**1843.2**

System unavailability of minimum 1% in terms of energy shall be considered by bidder in PVsyst for estimation of annual generation. This includes the loss due to data inaccuracy/ data variability also.

1.3 MODULE MOUNTING: Fixed Tilt type on Floating Structure

1.4 CORROSIVE CATEGORY (FOR PAINTS)

i. Classification of environments for Corrosive category shall be in accordance with ISO12944-2, the applicable atmospheric corrosivity categories as per requirement as mentioned above.

ii. ISO12944-5 shall be used related to paint systems in combination with guidance for the selection of different types of protective paint system.

iii. 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.

iv. 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 (The derating should not limit the continuous rated operation of the project. Requirement of suitable shed/canopy shall be reviewed based on the offered solution during detailed engineering stage.

v. For metal enclosed outdoor HT switchgear, pooling switchgear on the LT side (if applicable) from string inverter to inverter transformer, suitable shed (for floating) shall be provided considering the O&M space which shall be reviewed based on the offered solution during detailed engineering stage.

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

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

1.5 SEISMIC DATA & DESIGN CRITERIA

i. All structures and equipment shall be designed for seismic forces adopting the information provided in this document and in accordance with the provisions of IS:1893 (Part 1):2002 and IS:1893 (Part 4):2005.

ii. Vertical acceleration spectral values shall be taken as 2/3rd of the corresponding horizontal values.

1.6 WIND DATA & DESIGN CRITERIA

Location	Basic wind speed
GAIL PATA	As per IS-875 part-3 latest

5-A NEEGG: NET ELECTRICAL ENERGY GENERATION GUARANTEE

a) The bidder shall comply with the 'Net Electrical Energy Generation Guarantee" for annual basis as per below.

TABLE 9: NEEGG FOR 17.5MW (AC)

Sr. No.	Year of operation	NEEGG for 17.5 MW (AC) SPV project (In kWh)
1	NEEGG for 1st Year	35,607,000
2	NEEGG for 2nd Year	35,357,751
3	NEEGG for 3rd Year	35,110,247

b) The bidder shall demonstrate "Actual Delivered Energy" at metering point (GAIL substation end) as compared to the 'NEEGG' for every year from the date of starting of O&M Period.

c) The NEEGG for each year O&M is provided after considering the degradation factor. No further degradation is allowed.

d) Bidder shall adopt module mounting arrangement as mentioned in relevant chapters of technical specifications to achieve the quoted generation.

5-B: OPERATIONAL ACCEPTANCE TEST & PERFORMANCE GUARANTEE TEST

PART A: OPERATIONAL ACCEPTANCE TEST

I) TEST PROCEDURE:

1. Performance Ratio as determined through the OAT Procedure specified here shall **not be less than 75%** for successful completion of OAT.

2. The Operational Acceptance Test to prove the guaranteed performance parameters of the power plant shall be conducted at site by the Contractor in presence of the Owner. The Contractor's Engineer shall make the plant ready to conduct such tests. The Operational Acceptance Test shall be commenced, immediately after successful Commissioning and, there will be continuous monitoring of the performance for 30 days. Any extension of time beyond the above one (1) month shall be mutually agreed upon. These tests shall be binding on both the parties to the Contract to determine compliance of the equipment with the guaranteed performance parameters. This monitoring will be performed on the site under the supervision of the Owner/ Owner's engineer.

3. The test will consist of guaranteeing the correct operation of the plant over 30 days, by the way of the efficiency rate (performance ratio) based on the reading of the energy produced and delivered to the grid and the average incident solar radiation. During this period of 30 days, any 5 (five) instances of 15 (fifteen) minutes (preferably between 10:00 AM to 4:00 PM as per mutually agreed time) shall be taken to calculate the instantaneous Performance Ratio of 15 minutes block as per the formula given below in Point No. 5. If the PR of these fives individual instances is equal to or above 75%, then Operational Acceptance Test (OAT) shall be considered successful.

4. PR shall be demonstrated against the installed DC Capacity.

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

$$\textbf{Performance Ratio (PR)} = Y_A / Y_R \, [1 - \alpha * (T_{Cell\ avg.} - T_{Cell})]$$

Where;

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

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

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

Or, $Y_R = I_R$ Site/ I_R STC

E_{ac}	=	AC energy injected into the grid during a clearly specified amount of time (kWh)
P_{Nom}	=	Installed nominal peak power of modules (Flash test rating at STC) (kWp)
I_R Site	=	Irradiation on the module plane of array during a clearly specified amount of time (measured with a Pyranometer installed on the array plane) (kWh/sq. m)
I_R STC	=	Irradiance at STC (kW/ sq. m)
$T_{cell\ avg}$	=	Average cell/ module temperature (°C)
T_{cell}	=	STC cell/ module temperature (°C)
α	=	temperature coefficient of power (negative in sign) corresponds to the installed module (%/°C)

II) MONITORING SYSTEM FOR PR VERIFICATION:

The following instrumentation will be used to determine the Solar Plant Performance:

1. Main Meter at the final evacuation point.
2. One no. calibrated pyranometer to determine irradiance on the plane of array.
3. Two nos. calibrated pyranometer to determine irradiance on horizontal plane.
4. Two nos. thermocouples to measure module temperature.
5. Shielded ventilated thermocouple.
6. An anemometer mounted on a pole mast at an appropriate height to measure wind speed.
7. Data measurement shall be witnessed in the format mutually agreed before the start of OAT by the employer and the contractor jointly for the said period.
8. The Contractor shall show the specified PR for Operational Acceptance.

III) The EPC contractor shall be allowed to conduct the Operational Acceptance Test till the test is successful as specified in this tender specification. For each unsuccessful attempt, no penalty shall be imposed.

IV) The O& M period shall start only after successful completion of OAT or 90 days from commissioning, whichever is the earlier.

PART B: PERFORMANCE GUARANTEE TEST (PGT)

A) TEST PROCEDURE:

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 BHEL/GAIL. This test shall be binding on all the parties of the Contract to determine compliance of the equipment with the functional guarantee. 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.

The procedure for PG demonstration test shall be as follows:

1. During first year of O&M, any consecutive 90 days period for conducting performance guarantee test shall be chosen on the discretion of BHEL/GAIL.
2. Bidder is required to meet the annual target generation as specified in the tender specification.
3. The month wise generation target for the bidder shall be as per the PVsyst report finalized during detailed engineering stage.
4. If the Project is not able to achieve the target generation as per the PG procedure during the test period, then contractor shall compensate GAIL with an amount equivalent to the loss of generation based on tariff mentioned elsewhere in the specification.
5. Actual energy exported from the plant shall be noted for three consecutive month 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.
6. This measured value of energy shall be compared with “Month wise Target Generation” for the PG test.
7. Following factors shall be considered for computing the “target Generation” and shortfall (if any)

   a. Effect of any meteorological parameters shall not be considered except of solar radiation.

   b. Variation of Performance Guarantee on account of Generation loss due to grid outage (or power evacuation system which is not in the scope of the Bidder): The measured global solar radiation of the period of the outage of the power evacuation system shall be excluded 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.
8. If the difference of reading between the two horizontally mounted pyranometers exceeds more than 2%, the test shall be halted and resumed only after rectification of errors which has led to mismatch. The data of that particular day(s) shall be discarded, and test period shall be extended by same numbers of day(s).

9. The test shall be repeated in case of outage of following equipment for more than cumulative 7 days.
    a. Inverter transformer
    b. Power Conditioning Unit
    c. SCADA and data logger combined
    d. Both pyranometers.
    e. HT switchgear
10. If bidder is not able to demonstrate PG test during these 90 days, he shall be given one more chance to demonstrate the PG test. In that case, the steps for PG test shall be repeated again as above after carrying out necessary modification/rectification. However, in any case the demonstration of PG Test shall be within one year from start of O&M.

B) CALCULATION OF ENERGY SHORTFALL:

A sample calculation for shortfall in energy generation for period from 10th January to 09th April and LD calculation for the site is given in below Table 10.

TABLE 10: A SAMPLE CALCULATION FOR THE SOLAR PLANT FOR TOTAL SHORT FALL IN ENERGY FOR DESIGN LIFE

Month	(a) Global Insolation of the month (kWhr/m2)	(b)Target Generation (Mwhr) (Final Target generation)	(c)No of test days of the month	(d)Reference Solar Insolation (a) x (c)/ (Ndm*)	(e)CHANGED Target Generation of the month (Mwhr) (b)x(d)/(a)	(f)Measured Global Horizontal Solar Insolation (kWhr/m2)
January	106	2233.18	22.00	75.23	1584.84	78.99
February	132.7	2446.41	28.00	132.70	2446.41	139.34
March	179.7	3563.49	31.00	179.70	3563.49	188.69
April	199.1	3803.61	9.00	59.73	1141.08	62.72
TOTAL	∑(a) 617.5	∑(b) 12046.69	∑(c) 90	∑(d) 447.36	∑(e) 8735.82	∑(f) 469.72

* Ndm= Nos of days in the month

** Test is assumed to start from 10 January till 9th April

Cumulative Reference Solar Insolation for PG Period, i.e. 90 days – (D)	Σ(d) = 447.36 kWhr/m2
Cumulative Changed Target Generation for PG period, i.e. 90 days- (E)	Σ(e) = 8735.82 MWhr
Cumulative Measured Solar Insolation for PG Period, i.e. 90 days – (F)	Σ(f) = 469.72 kWhr/m2
Corrected Target Generation for PG period- (G)	(E x F)/D = 8735.82x 469.72/447.36 = 9172.61 MWhr
Measured/Achieved Generation at site during PG Period – (H)	**9072.61 MWhr**
Total shortfall in Energy for the test period – (I)	G-H = 9172.61 -9072.61 =100.0 MWhr
Target Yearly Generation (GY)	35607 MWhr
Yearly Shortfall in Generation (ΔGY)	= GY x (I)/ (G) = 35607 x 100/9172.61 = 339.37 MWhr
Applicable LD (INR)	ΔGY x 1000 x Applicable rate for LD as per specification
Applicable LD for complete life of plant in INR	= 339.37 x 1000 x Applicable rate for LD as per specification

C) LD TERMS FOR PERFORMANCE GUARANTEE TEST:

1. The maximum Liquidated Damages for the shortfall of generation during PG test period shall be limited to an amount equivalent to 10 % of the contract value. LD shall be levied on the last offered PG test.
2. Tariff for computing Liquidated damages for PGT- **Rs. 64.44 per kWh.**

5-C: WARRANTY AND COMPREHENSIVE AMC

A) WARRANTY:

Original Equipment Manufacturer (OEM) or EPC contractor shall provide warranty for the following components as follows:

TABLE 11: WARRANTY DETAILS

Sr. No.	Product/Equipment/ System Name	Warranty in Years
1	PV Module	Performance Warranty: 25 Years Product Warranty: 10 Years
2	Floating System (Floater units & platforms) including anchoring & mooring with complete system	Design Life: 25 Years Product Warranty: 10 Years
3	Central/String Inverters	5 Years
4	LT/HT Panels/AC Combiner Box	5 Years
5	Inverter Transformers	5 Years
6	Other Items	As per OEM's Standard Warranty Terms

Warranty period shall start from the date of successful completion of OAT .

B) COMPREHENSIVE AMC

1. 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:

TABLE 12: COMPREHENSIVE AMC DETAILS

Equipment/System	Comprehensive AMC
Floating System (Floater units & platforms) including anchoring & mooring with complete system	10 Years
Central/String Inverter	10 Years
SCADA	10 Years
Power Plant Controller [PPC] system	10 Years
CCTV system	10 Years

2. CAMC period shall start from the date of successful completion of OAT.

3. 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.

4. 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.

5. For Warranty and Comprehensive AMC, the EPC contractor shall arrange the necessary documents from respective OEM on the name of GAIL for entire warranty/Comprehensive AMC duration.

6. Failure from the OEM/EPC to adhere the activity and the time schedule may lead to BG encashment submitted for AMC and Warranty of Critical Equipment.

5-D: STATUTORY AND REGULATORY COMPLIANCES, GRID CONNECTIVITY

1. All construction, operation and maintenance procedures shall be carried out through appropriate relevant standards, regulations laid by UPNEDA/UPPCL/UPPTCL/DISCOMS /UPERC/ GAIL/ GOI / MNRE/CERC/CEA/CEI and / or any other agency as and when applicable. Further, this shall comply with the applicable labor laws. The Bidder shall make himself aware of such requirements and shall not solely depend on the Company to avail full information.

2. All the supplies and site activities shall comply relevant OISD/PNGRB standards and all necessary standards of Oil and Gas producing installations. Few relevant and frequently used regulations/OISD guidelines but not limited to:

OISD-STD-105	Work Permit System
OISD-RP-110	Recommended Practices on Static Electricity
OISD-STD-113	Classification of Area for Electrical Installations at Hydrocarbon Processing & Handling Facilities
OISD-STD-137	Inspection of Electrical Equipment
OISD-RP-146	Preservation of idle electrical equipment
OISD-RP-147	Inspection & safe practices during electrical installations
OISD-RP-148	Inspection & safe practices during overhauling electrical equipment
OISD-RP-149	Design aspects for safety in electrical systems
OISD-STD-155	Personal Protective Equipment
OISD-STD-173	Fire Prevention and Protection System for Electrical Installations
OISD-GDN-180	Lightning Protection
OISD-GDN-192	Safety Practices during Construction
OISD-GDN-206	Guidelines on Safety Management System in Petroleum Industry
OISD-GDN-207	Contractor Safety
IS 5216	Guide for safety procedures and practices in electrical works

IS -5728	Guide for short circuit calculations
IS-5572	Classification of hazardous area
IS-5571	Guide for selection of electrical equipment for hazardous area
IS-8239	Classification of maximum surface temperatures of electrical equipment for use in explosive atmosphere.
IS-3202	Code of practice for climate proofing an electrical equipment

3. In respect of all Labour, directly or indirectly employed in work for the performance of Contractor's part of this Agreement, bidder shall at his own expense arrange for all the safety provisions as per Indian Standards Institution, The Petroleum Act 1934, The Factories Act 1948, The Indian Electricity Act, OISD Guidelines on Safety (Safety practices during construction – OISD GDN192 and Contractor Safety, OISD GDN 207) and such other Acts, Rules and Regulations as applicable.

4. The scope of power evacuation system in the scope of the bidder is up to the terminal point as indicated in the tender SLD.

5. During the entire period of contract Bidder shall also comply all provisions and it's amendment(s)/Clarification(s)thereof of the following:

    a) Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022.
    b) 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".
    c) CERC (Grant of Connectivity, Long Term Access and Medium-term Access in Interstate Transmission and related matters) Regulation 2009 (if applicable as per extant connectivity regulations/procedures).
    d) CERC's revised procedure for "Grant of Connectivity to Projects based on renewable sources to inter-state transmission system" (if applicable as per extant connectivity regulations/procedures).
    e) CEA (Technical Standards for Connectivity to Grid) Regulation,2007.
    f) CEA (Technical Standards for construction of Electrical Plants and Electrical Lines) Regulation,2010.
    g) CEA (Grid Standard) Regulation,2010.

h) CEA (safety requirements for construction, operation and maintenance of Electrical Plants and Electrical Lines) Regulations,2011.
i) CEA (Measures relating to Safety and Electrical Supply) Regulations,2010.
j) CEA (Installation and Operation of Meters) Regulations 2006
k) Indian Electricity Grid Code Regulation,2010
l) CEA (Technical standards for communication system in Power system operations) Regulation 2020
m) CERC (Communication System for Inter State Transmission of Electricity) Regulations 2017
n) MOP Order dated 02.07.2020 stating measures to protect the security, integrity and reliability of the strategically important and critical Power Supply System and Network in the Country.
o) CEA (Cyber Security in Power Sector) Guidelines, 2021.
p) Report of the Working Group in respect of Data Submission Procedure And Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022.
q) MNRE/CEA/MOP guidelines/OM/Advisory/Clarifications
r) And any other applicable standards/regulations /Guidelines /clarifications/ OMs/ Advisories.

6. Bidder shall facilitate GAIL by arranging required documents for submission of connectivity application (connectivity application shall be submitted by GAIL) as per CERC guidelines. Bidder shall bear the statutory charges to be paid for connectivity application.

7. Contractor has to liason and take necessary approval, required for setting up of a solar power plant including but not limited to registration & approval of project from State and Central statutory/competent government authorities, approval from CEA/CEI, approval for connectivity, approval for construction power, approval for power evacuation from state & central statutory/ government competent authorities like UPNEDA/UPPCL/UPPTCL/DISCOMS /UPERC/ GAIL/ GOI / MNRE/CERC,CEA,CEI and / or any other agency as and when applicable, as per requirement. Contractor shall co-ordinate with all statutory authorities and facilitate them for smooth executions and approvals.

8. Supply of hot standby redundant PLC/RTU/DCS based power plant controllers (PPC) and associated independent equipment/accessories is in the scope of the Bidder. Detailed control logic and setting of the PPC shall be in line with latest CEA (Technical Standards for Connectivity to Grid) and as per RLDC/SLDC requirement. The solar plant PPC networks shall be suitably designed, so that PPC shall directly and independently be able to control/communicate the individual solar inverter (dual or multi master) including any other reactive compensating equipment, WMS (dual master) and redundant Power Quality Meters (IEC 61000-4-30 class A) at suitable location/final outgoing portion of plant/As per the directions of SRLDC. It shall also able to two way communicate with RLDC/SLDC on IEC

104 protocol for its various mode of control. Bidder shall install the PQM at POI/As per the directions of RLDC and integrate with PPC at solar plant end. PPC healthiness shall be monitored by SCADA.

9. Bidder shall also submit detailed Grid compliance study (steady state/Dynamic/Power Quality) with Power Plant Controller for solar project (in PSS/E and PSCAD platform) as per CEA technical standard to grid connectivity/CTU requirement/ Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid and latest guideline of RLDC for first charging clearance. In this regard, Bidder shall submit the single inverter, aggregated and detailed RMS model of the plant in PSS/E along with PSCAD aggregated model in line with CEA Working Group report and/or applicable standard. In case any site testing is required for grid compliance as per RLDC, it shall also be conducted.

10. Payment to concerned regulatory body for system study, SLDC Charges, Connectivity charges, registration charges, CEA/CEI Inspection charges, any other statutory charges shall be re-imbursed by the GAIL by submission of original payment slip/Receipt from contractor. However, all Co- ordination, liaison work, Paper work etc. shall be in the scope of the EPC Contractor. GAIL shall re-imburse for only those statutory services/charges for which Company will have to sign/had signed agreements with relevant statutory bodies and are claimable from GAIL as per regulatory provisions. This is excluding DSM charges for Forecasting & Scheduling. GAIL will facilitate for documentation work which requires from GAIL for the applying of the statutory approval.

11. All necessary procedures/Statutory approval for cutting of trees should be in the scope of Successful Bidder.

12. All approvals, equipment, item and works which are not specifically mentioned in this document but are required for completion of work including construction, commissioning, operation & maintenance of Solar Photovoltaic Power Plant in every respect and for safe and efficient construction & erection, operation and guaranteed performance are included in the scope of this bid.

13. Bidder shall submit preliminary CEA grid compliance study as per timeline mentioned for CON4 submission to CTU/RLDC in Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators. Based on the comments received on the submitted report, the study and Model shall be updated and resubmitted again within stipulated timeline, with solar plant latest parameters for final acceptance. Availability of required PSSE and PSCAD model of Inverter and PPC shall be ensured by Bidder during selection of respective Manufacturer.

14. Bidder shall provide all data and applicable study/simulation reports as per 'Procedure for Integration of solar plant those are regional entities" for submission to RLDC/SLDC/STU for first time charging clearances (as required by regulatory/statutory body). Some information/documents from the above procedure and Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022/latest amendments are mentioned below. However, bidder shall refer the applicable documents in detailed on their own for compliance.

Dynamic Model:

a) Copy of dynamic model as per the connectivity.

b) Updated dynamic model at least three months ahead of the proposed date of first-time charging.

c) Following Reports also to be included along with the dynamic model:

i. Parameters of Inverter in .dyr file to be validated with the test report results from the LVRT/HVRT certification and the validation report to be submitted.

ii. Simulation Report of plant model confirming CEA compliance for Dynamic reactive support /LVRT/ HVRT/Frequency control.

iii. Simulation Report of Reactive Capability Curve of Plant measured at POI to ISTS system for compliance of CEA technical standard (for Voltage 0.95/1/1.05 pu with pf ranging from 0.95 lag to 0.95 lead) and short circuit study/Load flow study/harmonics analysis results.

d) Inclusion of EMTP model of plant (in PSCAD platform), benchmarking report of model along with the dynamic model.

e) Harmonic study (Voltage and current harmonics) flicker study at Inverter level, Pooling Switchgear Level and POI. Impedance vs Frequency plot of the plant.

f) Bidder shall provide the PSSE and PSCAD model and related study report at least 12 months before the schedule commissioning date of the project and Final Updated dynamic model after commissioning of the entire station (within one month of commissioning declaration) after site verification and site testing.

g) Bidder has to ascertain that all the queries of GAIL/BHEL/CTU/RLDC with respect to submitted reports and models are answered to their satisfaction.

h) Bidder shall update themselves with latest requirement for technical data requirement/PSSE/PSCAD Model as per RLDC/CTU. The minimum data required is attached in Appendix-4 for IBR (Inverter Based Resources) to be submitted to GAIL/BHEL for Grid study. Bidder shall submit above documents within 3 months from LoA. However, the final requirement

or any other requirement shall be as per RLDC. The simulation study has to be carried out as per POI data (like SCR, X/R etc.) shared by GAIL/BHEL/RLDC/CTU.

i) Bidder shall install suitable reactive compensation equipment for compliance of dynamic reactive power compensation at rated capacity at POI under CEA technical standard of connectivity to Grid and Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022 and it's amendments/clarifications thereof.

j) Bidder shall measure harmonic content, DC injection and flicker at least once in a year in line with the provisions mentioned as per CEA Technical Standards for Connectivity to the Grid, 2007. Bidder shall ensure that the power quality values at POI are within the limit specified as per CEA Technical Standards for Connectivity to the Grid, 2007. This measurement shall be done every year till the completion of O&M and report shall be submitted to RLDC/GAIL/BHEL for verification to ensure compliance.

All equipment, materials and services whether explicitly stated or not in Technical Specifications or anywhere in the tender documents but that are necessary for the successful commissioning of Solar Plant as per latest statutory regulations/procedures/clarifications/Advisories/OMs/Guidelines/standard 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 and bidder shall comply the same.

15. **Requirement of Single IBR unit Simulation model & Benchmarking report:**

Requirement of Single IBR unit Simulation model & Benchmarking report-

a) Single SoC (Statement of Conformity) and Evaluation Report for Type test report as per CEA Connectivity standard mentioning all Hardware/software/Firmware version
b) Fault current characteristics (voltage -current) of Inverter during fault condition.
c) Current and voltage Waveform capture facility during LVRT/HVRT at Inverter output terminal during event and accessible to GAIL.
d) Inverter controller Setting facility from local as per CEA Regulation.
e) Time synchronization facility of Inverter with PPC/SCADA
f) Single IBR Controller Setting in compliance with CEA grid connectivity regulation.
g) 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. (Bidder to refer Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE

Generators July 2022 and it's amendments/clarifications for detailed requirement of Benchmarking Report of single IBR.

h) Provision to change setting in inverter according to various operating condition at site is to be provided.

16. Following shall be part of submission-

a) Comparison of field test measurement with simulation results numerical values & as well as graphical values for following points.

i. Power Quality (only in EMT).
ii. Active power set change (RMS & EMT)
iii. Reactive power control- V control, pf & Q control (RMS & EMT)
iv. IBR capability demonstration (RMS & EMT)
v. LVRT (RMS & EMT)
vi. HVRT (RMS & EMT)
vii. Frequency response (RMS & EMT)

b) Final simulation model parameters like Generator model, Electrical control model, drive train model etc. shall be included in benchmarking report. (RMS & EMT).

c) Firmware version of IBR unit controller for which IBR unit got certified shall also be included in this report.

d) Field test report documents shall be referenced in the benchmarking report.

e) 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.

f) 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).

g) 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 initialized within 3 seconds & shall have snapshot capability.

h) 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.

i) Include a table having IBR controller setting, RMS & EMT model parameter for different control parameters as specified. (RMS & EMT)

j) IBR unit model for PSS/E shall include .sav, .dyr, .py, .idv, .sld, .out files and PSCAD.pscx and other supporting files.

k) 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, preferably not be more than 5%.

Please note that Bidder must follow latest relevant guidelines/standards to comply as per the above requirement.

SECTION-6 : TECHNICAL SPECIFICATIONS

A – DC SYSTEMS

A-1 : SOLAR PHOTOVOLTAIC (SPV) MODULES

1.0 GENERAL

The Solar PV module comprises of PV cell(s) connected in any combination to achieve the required module power output. PV cells directly produces DC power on receipt of solar irradiation.

2.0 CRYSTALLINE SILICON MODULES (C-Si)

The PV cells in a crystalline silicon module shall be protected by encapsulation between front glass and back glass. Dual glass PV modules offer enhanced protection from moisture, making them ideal for floating PV project environments. The glass shall be made of high transmissivity and front surface shall give high encapsulation gain.

The technical details of Solar PV Modules shall be as given below.

Sl no.	Description	Details
1	Type of SPV Module	N Type TOPCon Mono crystalline Silicon
2	Peak Power rating of Module	580 Wp or above
3	Module Efficiency	Minimum 21% at Standard Test Conditions
4	Fill Factor	0.75(Minimum)
5	Encapsulation	Dual Glass/ Glass to Glass

3.0 CODES AND STANDARDS

The applicable codes and standards are as mentioned below

Codes	Description
IS 14286 (Part 1)-2019/ IEC 61215 (Part 1)- 2016	Terrestrial Photovoltaic (PV) Modules- Design qualification and type approval Part1- Test Requirements

IS 14286 (Part1/Sec-1)-2019/ IEC 61215 (Part1/Sec-1)-2016	Terrestrial Photovoltaic (PV) modules – Design qualification and type approval Part1- Test Requirements Section 1- Special requirements for testing of crystalline silicon photovoltaic (PV) modules
IS 14286 (Part 2)-2019/ IEC 61215 (Part 2)-2016	Terrestrial P Photovoltaic (PV) modules – Design qualification and type approval Part2- Test procedures
IS/IEC 61730-1-2016	Photovoltaic (PV) module safety qualification-Part 1: Requirements for construction
IS/IEC 61730-2-2016	Photovoltaic (PV) module safety qualification-Part 2: Requirements for Testing
IEC 61701-Edition 2.0 2011-12	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 62804-1 :2015	Photovoltaic (PV) modules – Test methods for the detection of potential-induced degradation-Part1: Crystalline silicon

4.0 TECHNICAL REQUIREMENTS

1. The temperature co-efficient of Power for the module should be better than - 0.35% per deg C. Each and every SPV module shall conform to standards mentioned in 2.2 above and no negative power tolerance shall be accepted. Additionally, the Module wattage band/bin offered shall not be less than 5Wp. Each inverter shall use only one type (Make and Nominal rating) of module.
2. Module shall be made up of N Type TOPCon Mono crystalline Silicon cells. The module should be PID resistant. The front glass used to make the crystalline silicon modules shall be heat strengthened low iron glass. Grid printed back glass shall be preferred. The glass used shall have transmittance of above 90% and with bending less than 0.3% to meet the specifications. In case of glass-to-glass frameless module, the back glass shall have a minimum thickness of 2.5mm and for glass to glass framed modules, the back glass minimum thickness shall be 2.0mm.
3. The module shall not be subjected to any point load during transportation, handling and erection and complete care has to be taken to avoid any undue loading on either side of the module.
4. The interconnected cells shall be laminated in vacuum to withstand adverse environmental conditions. The encapsulant (EPE/POE) used for the modules should be of UV resistant and PID resistant in nature with gel content of minimum 75%.

5. The module frame shall be made of corrosion resistant materials, preferably having aluminium anodized finish. The anodizing thickness shall be 15 microns or better. In case the offered module is frameless, suitable retaining clips/clamps used for installing the modules shall not damage the glass surface in contact with the retaining clamp
6. Module(s) shall be provided with minimum three (03) bypass diode.
7. Junction box at the back glass of the module should be weather proof, dust proof and designed to be used with standard wiring or conduit connection. Additionally, cables coming out of the junction box shall be suitably sealed providing complete electric isolation. In case the junction box houses diode, the junction box shall be of IP 68.
8. SPV module shall perform satisfactorily with ambient temperatures between - 10°C & +60°C and shall be able to withstand mechanical load as per IEC requirement.
9. Solar PV modules used in solar power plants/ systems must be warranted for the product Workmanship for a period of minimum 10 years. Further, they shall also be warranted for their output peak output peak watt capacity, which should not be less than 90% at the end of 10 years and 80% at the end of 25 years from the date of receipt of last batch/lot of equipment at site.
10. The bidder shall provide the sample solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current.
11. Each PV module deployed must use a Radio Frequency identification (RFID) tag for traceability. RFID shall either be placed behind name plate sticker or behind bar code label pasted on the back glass of PV module and must be able to withstand harsh environmental conditions during the module lifetime. One number RFID reader has to be supplied by the bidder which has to be compatible to read the data from the RFID Tag & download the data to Computer. All associated Software & Cables are to be provided along with the RFID reader.

The following information must be mentioned in the RFID used on each module.

i. Name of the manufacturer – PV Module
ii. Name of the Manufacturer of Solar cells
iii. Month & year of the manufacture of the module (separately for solar cells and module)
iv. Country of origin (separately for solar cells and module)
v. I-V curve for the module at STC
vi. Wattage, Im, Vm and FF for the module

vii. Unique Serial No. and Model No. of the module
viii. Date and year of obtaining IEC PV module qualification certificate
ix. Name of the test lab issuing IEC certificate
x. Other relevant information on traceability of solar cells and modules as per ISO 9001

12. All the modules in the PV plant should be arranged in a way so as to minimize the mismatch losses.
13. Each module should have two suitably sized stranded UV resistant cables and terminated with DC plug-in connector directly. The positive (+) terminal has a male connector while the negative (-) terminal has a female connector. Any different design offered shall be reviewed during detailed engineering. 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 shall be of same make for better compatibility (refer Connectors chapter elsewhere for detailed Specification of Field Connectors). In case, 1500 V modules are used, the connecting cable shall be as per the relevant standard.
14. The bidder has to submit, along with the data sheet of the module, a detailed Bill of Material (BoM) elaborating on the properties, such as, thickness, material composition etc of the major components of the module which shall be same as per the type tested and approved Constructional Data Form (CDF).

5.0 NAME PLATE

All individual modules shall be provided with Name Plate label at the back of module which shall provide the information given below for identification. They 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 the life of the panel.

i. Manufacturer's Name
ii. Model Number, Serial Number
iii. Overall Dimensions (W x L x D)
iv. Weight (kg)
v. Maximum Power (P_{MAX}), Voltage (V_{MP}), Current (I_{MP})
vi. Short Circuit Current (I_{SC}), Open Circuit Voltage (V_{OC})
vii. Main System Voltage
viii. Relevant standards, Certification lab. name
ix. Warnings, if any.

6.0 TYPE TEST

SPV modules must be tested and certified by any of the accredited certifying agencies according to above mentioned International Standards at clause 2.0 above and the type test reports shall be submitted for approval.

Note:

1. The Module Manufacturer, along with the Module datasheet, shall also provide the Details about the PV Cells used for the offered PV Modules. The information shall contain Cell Source, Type, and Electrical Parameters including efficiency, Size, Number of Bus bars and any other relevant information.
2. In case the successful bidder supplies PV Modules of different make and/or model or from different agencies, the fixing holes in the frame/ location of retaining clips, their location, diameter, centre-to-centre distance between them and all other attributes related to mounting should be same, if applicable.
3. Bidder shall submit the following:
   i. **Third-party verified PAN files for any one module, if bidder is offering three wattage bins or less. In case the bidder is offering more than three wattage bins, additional PAN files for each additional wattage bin need to be submitted.**
   ii. Self-certified Electro- Luminescence (EL) Test reports of all the **Crystalline Silicon based** PV Modules being offered to GAIL/BHEL.

4. In line with Office Memorandum No. 283/54/2018-Grid Solar: "Approved Models and Manufactures of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019", dated 2nd January 2019, MNRE's subsequent OM dated 10.03.2021 regarding implementation of said order, including latest OM/amendments/Clarifications etc with respect to the said order, the bidder shall source cells/modules complying with the relevant clause(s) mentioned in the order. For detailed information, bidder to refer Office Memorandum/clarifications issued by MNRE. The applicability of ALMM shall be as per latest amendments as and when issued by MNRE.

   Bidders are also required to consider the provisions of ALMM for Solar PV cells as outlined in the MNRE Office Memorandum No. 283/59/2024, dated 09-12-2024 with it's latest updates, amendments, clarifications, and other relevant directives, when submitting their bids.

7.0 INSPECTION OF PV MODULES

FACTORY TESTS:

PV modules must be type tested and proven as per the applicable IEC/ IS standards mentioned in the technical specification. All the PV modules shall be tested for it's electrical parameters and the test report shall be shared with BHEL/ GAIL along with call for pre dispatch inspection. Pre-dispatch inspection will be carried out at manufacturer works by BHEL/ GAIL/ Third party testing agency.

1. SPV modules to be checked visually for following defects: (Sampling as per Special inspection level IV and AQL 2.5% as per IS 2500 (Part 1): 2000)
    i. Scratches on the frame and/or glass etc.
    ii. Excessive or uneven glue marks on glass or frame
    iii. Inconsistent cell colors, cell crack, ribbon misalignment etc.
2. Performance of SPV module at STC (Standard Test Conditions): (Sampling as per Special inspection level IV and AQL 2.5% as per IS 2500 (Part 1): 2000)
3. Hipot test: (Sampling as per Special inspection level II and AQL 1.5% as per IS 2500 (Part 1): 2000)
4. Electroluminescence Test: (Sampling as per Special inspection level II and AQL 1.5% as per IS 2500 (Part 1): 2000)
5. RFID Check: 2 Nos per lot offered
6. Wet Leakage current test: 1 No per lot offered
7. Robustness of Termination test: 1 No per lot offered
8. Mechanical Load Test: 1 No per lot offered

Note:

This is an indicative list of tests / plans. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents. Visual and EL acceptance criterion to be submitted along with MQP.

A2: FLOATING SYSTEM

1.0 GENERAL

The Floating system comprises of the Floating unit, Module support structure (if applicable), platform for invertor/ transformer/ other electrical equipment and anchoring/ mooring mechanism for the Floating Solar PV system (FSPV).

Any material/ fitting/ equipment or procedure not described or left out of the specifications but considered as normal and necessary for intended services of the floating system, shall be supplied, and fitted by the vendor without any extra charge.

2.0 CODES AND STANDARDS

The floatation system must conform to the latest edition of any of the following IEC/ equivalent standards for floating system design qualification and type approval. The reports verified by third party NABL national or international accredited agency shall be submitted for approval.

CODE	DESCRIPTION	PROPERTY VALUE
ASTM D 792 / ASTM D 1505	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement / Density by the Density-Gradient Technique	Density > 0.9
ASTM D1693	Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics	Environmental Stress-Cracking Resistance: Zero Cracking for 48 Hours
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials	Secant Flexural Modulus at 2% Strain > 750 MPa
ASTM D 638	Standard Test Method for Tensile Properties of Plastics	Tensile Strength at Yield > 22 MPa
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics	Compressive Stress at Yield > 6 MPa
ASTM D2565	Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications	>50% of original break elongation after 3,000 hours exposure (Cycle 4 of ASTM D2565)
UL 94 or IEC/ISO Equivalent	Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances Testing	Classification HB or better

The test reports of HDPE Floaters conforming to above list of code and standards shall be submitted for review and approval to GAIL/BHEL.

3.0 TECHNICAL REQUIREMENTS OF FLOATING UNIT

3.1 The floatation units of module shall be modular and easily connected to each other. Once completely connected, the floating platform must be able to support the weight of PV module, module support structure, cables, SCBs, LA, support railing (if applicable) etc. The floater system shall also be able to support the load of O&M personnel, electrical equipment as mentioned earlier in this document, Module washing system etc.

3.2 The floating units shall be standardized and designed for simple onsite installation.

3.3 The floating unit for PV Module mounting shall be prefabricated and modular in design with appropriate buoyancy to support the weight of at least one solar panel/equipment (as applicable) and additional minimum weight of 60 kg per unit. For other miscellaneous floats minimum buoyancy per sq. meter shall be 80 kg.

3.4 The floating unit design shall facilitate ease of assembly /disassembling, replacement of any module and enable future expansion or scaling.

3.5 The floatation unit should be manufactured from appropriate thermoplastic (virgin material) with UV stabilizer such that the life of floatation device shall be able to sustain for a period of 25 years.

3.6 The material used in manufacturing shall withstand Environmental Stress Crack Resistance (ESCR) and have a combination of hardness and impact strength (ASTM D1693).

3.7 The material used for floatation device shall be chemically resistant to acid, lye, petrol and mineral oil and also partially resistant to benzene and non-detrimental to marine life.

3.8 To protect floating waterbody against deterioration of its water quality a material test certificate of floaters showing no appreciable change in water quality of the reservoir/water body for entire life of the project has to be submitted by the bidders during detailed engineering.

3.9 In order to increase longevity and prevent unexpected loss of buoyancy, the floating unit shall have an average material thickness of 3 mm with moisture retention of less than 5%. High load area shall have superior thickness to take the impact (Detailed design calculation to prove the adequacy of thickness at various points has to be submitted along with drawings at the time of drawing approval).

3.10 The floating unit material shall be designed to balance the thermal expansion so that PV Panel are not stretched due to effect of thermal expansion.

3.11 The complete floating system shall have at least 400 mm floating corridor along the periphery comprising of module floaters and/ or walkway floater to prevent water splash. No Equipment will be installed on periphery floaters.

3.12 The design of the floating system shall incorporate appropriately sized walking platforms for regular maintenance and inspection. The walking platform shall be continuous with minimum width of 400 mm, excluding cable-laying arrangement. Dedicated walkway to be provided to avoid movement on cables.

3.13 Between walking platforms maximum of four continuous rows of modules is allowed. Additional infrastructure required for accessing modules cables etc. during O&M shall be provided by the bidder or any other mechanized approach can be proposed by the technology solution provider to easy access to panels irrespective of rows / configuration.

3.13.1 Min 01 No. dedicated floating approach walkway for each Floating Island/Array to be provided from the end of the Arrays to Embankment to access floating blocks of solar Plant. Width of the walkway from embankment to be Floating plant shall be not less than 1500 mm with 1 M hand railing arrangement on both the sides of the walkway. The design live load of dedicated walkway floater shall be minimum 120 kg/m2.

3.14 Bidder to take into consideration load of all electrical equipment and accessories during the design of floatation platform.

3.15 For, String Inverter/String Combiner Box (SI/SCB), as applicable to be mounted on floaters, bidder to take into consideration the load of Equipment during design of floaters and suitable supporting arrangement for mounting on Equipment floaters. In vertical rows wherever SI/SCBs are to be placed, dedicated additional walkway to be provided. The mounting of SI/SCBs should be designed in such a way that the load should be shared with multiple nos. of floats and buoyancy calculation should include minimum 2 nos. of maintenance persons also.

3.16 Floaters, connection points/ears, connectors, supports etc. should be designed considering the load of the equipment to be mounted. Physical testing of floaters, connection points/ears, supports etc. has to be carried out on equipment floats.

3.17 Floaters carrying cables should be designed to carry load of 1.5 times load of cable and other accessories with proper anchoring and mooring so as to withstand maximum load caused by wind, wave action, water level variation etc.

3.18 The bidder to populate the Array layout in the designated reservoir surface area. Also, this Array population to cast minimum shadow (Shadow loss of the PV-Array limited to maximum 1%). This proposed Array layout has to be submitted to GAIL along with the technical documents for verification. The Array layout to include mandatory clearances for Inverter Rooms and other utilities. The shadow analysis of the array layout to be submitted to GAIL for approval.

3.19 Floating system should be designed to withstand the maximum wind speed of the location.

3.20 The floating units once assembled together should form an integrated structure. The relative alignment of the floating unit subsequent to complete installation shall not misalign the solar panels. The tilt of PV Panels should not get disoriented during lateral shift of the array.

3.21 The design life of the floating units should be 25 years. The floating units shall be re-process able and recyclable at the end of its useful life.

3.22 Vendor to supply the Mandatory spares of each component of floating unit 0.1 % of detailed BOQ quantity of floating system including mooring accessories finalized after detailed engineering.

3.23 The screw and nuts used for floater connection to have a sound locking arrangement to take care of the water flow. The positive locking arrangement to prevent any loosening of screw and nuts. This shall further prevent any loosening in the floater assembly.

3.24 Appropriate vapor escape vents should be provided for each floatation device.

3.25 The Caps of the floaters after interconnecting in assembly should be easily accessible for opening and removing of water in the event of breakage of cap due to thermal expansion or thread loss. There shall be no need to take out the floater from the assembly to remove water and replace the cap due to non-accessibility.

3.26 The PV modules shall be mounted in such a way that the clamping fixtures are easily accessible from top side in the assembled condition. There shall be no need to access from below the water for any removal/repair.

3.27 The Major screws of all HDPE bolts shall incorporate effective and durable additional fastener to prevent loosening over a period of time. This shall be way of Lock nuts, Split pins (only with solid Bolts)

3.28 Floats shall incorporate solid dummy ears at mid points on either side with thickness equal to regular connecting ears so as to enable drilling through them to fix Metallic strip, clamps or hardware for cable and tray supports, SCBs and for Water washing pipes.

3.29 Wherever Multi-tier floater arrangement is called for to support Cables or increase/decrease heights of mounted items, OEM shall design and provide Extra length solid HDPE/LDPE bolts with nuts and lock nuts for assembling 2 or three stacks of floaters.

3.30 Since all the mooring loads will be transferred from mooring line to floater ears through spreader bar, a mechanical destructive test will be done for ear load capacity for its tensile and shear strength. The report of the same to be submitted for review to GAIL before start of assembly of floaters at site.

3.31 All batches of floats to clearly carry Mould stamping showing Batch No. Month, Week of year of manufacture.

3.32 Strength adequacy of the floater (body, ears etc.) and connections to anchoring locations (Spreader bars) has to be established theoretically (CFD analysis or otherwise) with verification from reputed third party NABL accredited agency/ internationally accredited agency/ reputed institutions like IITs and submitted for review and approval.

3.33 The strength adequacy of the floaters and connections to anchoring locations (Spreader bars) has to be established by Physical tests also at NABL accredited laboratory. The test shall be witnessed by BHEL/GAIL.

4.0 MODULE MOUNTING STRUCTURE (MMS) (IF APPLICABLE)

4.1. The MMS shall be so as to allow easy replacement of any module by authorized personnel.

4.2. The MMS and associated hardware / fasteners, if used are metallic in nature, shall be non-corrosive and suitable for site weather and marine conditions. The structures shall be made of anodized aluminum or SS. Any other suitable alloy material shall also be proposed subject to approval of BHEL.

4.3. All fasteners, nuts, bolts and other hardware shall be of Stainless steel – 304 or higher grade to suit the site conditions and to ensure a life of 25 years. However, for saline water SS316 to be used.

4.4. MMS shall be designed to withstand the extreme weather conditions in the area.

4.5. The modules shall be mounted at fixed tilt.

4.6. PV fixation system shall be of proven design and subjected to Mechanical test to withstand unit failure conditions under static and fatigue conditions for base wind speed. The results conforming to above test shall be submitted to BHEL.

4.7. The design calculations and strength verification reports for the MMS components shall be submitted for BHEL/GAIL's approval.

4.8.

5.0 ANCHORING AND MOORING SYSTEM

5.1. STANDARDS AND CODES

The Anchoring and Mooring system shall conform to the latest edition of any of the following standards guidelines as stipulated in table below for Anchoring and Mooring design qualification and type approval. The design reports verified by third party i.e. NABL, national or international accredited agency shall also be required for validation purpose.

Standard/ Code	Description
DNVGL-RP-C205	Environmental conditions and environmental loads.
DNVGL-OS-E301	Position Mooring
DNVGL-OS-E302	Offshore Mooring Chain
DNVGL-OS-E303	Offshore Fibre Ropes
DNVGL-OS-E304	Offshore Mooring Steel Wire Ropes
ISO 19901-7	Station keeping systems for floating offshore structures and mobile offshore units
BV NR493 DT R03 E	Classification of Mooring Systems for Permanent Offshore Units
BV NI 605 DT R00 E	Geotechnical and Foundation Design, August 2014.
BV NR 578 DT R00 E	Rules for the Classification of Tension Leg Platforms (TLP), July 2012.
DNV-RP-E303	Geotechnical Design and Installation of Suction Anchors in Clay.
ISO 14713	Protection against corrosion of iron and steel structures

5.2. TECHNICAL REQUIREMENTS OF ANCHORING & MOORING SYSTEM:

5.2.1. The anchoring and mooring system holds the floating platform in place and provides the mechanical stability it requires throughout its lifetime.

5.2.2. Water level variation and prevailing wind speed are the primary safety considerations for designing the floating solar plant. The mooring system thus needs to be designed such that it not

only restricts lateral movement beyond the permissible limits of the platforms but also accommodates the water level variability.

5.2.3. The design life of the Anchoring and Mooring system shall be 25 years.

5.2.4. The floating solar PV (FSPV) power plant should be at a minimum safe distance from the edge of the land surface/Embankment. In case edge of land surface has a sloped edge then this distance of array from land edge to be calculated w.r.t to the position of floating island at minimum water level condition. However, the exact positioning can be finalized at the time of detailed engineering.

5.2.5. The floating system comprising of floating unit, PV fixation system and associated anchoring system shall be designed as per base wind speed and able to withstand dynamic conditions as per IS 875-3.

5.2.6. The design of the mooring system shall permit minimal lateral movement of the plant in case of maximum wind loads (as per IS 875-3). The lateral excursion of the floating platform **not to exceed 2.5 meters** even at minimum water level. Anchoring design report for the project showing that the system could support the maximum wind load on site shall be submitted to GAIL.

5.2.7. Water variability: The mooring system should accommodate given fluctuations in water level defined elsewhere in the specification. Further, the orientation of the plant needs to be maintained; hence, any fluctuations in water level shall allow minimal movement of the FSPV plant as per mooring system design.

5.2.8. The materials used in the anchoring and mooring system shall not contaminate the water and affect the aquatic ecosystem.

5.2.9. The materials used in the anchoring and mooring system shall have a design life of 25 years.

5.2.10. The block size of the floating system depends on the array layout optimization. The same shall be finalized during detailed engineering.

5.2.11. The design of complete system, including CFD modelling, comprising of Floating unit, MMS and anchoring system, shall be verified by suitable third party NABL accredited agency/ reputed institutions like IITs and submitted for GAIL approval.

5.2.12. The design calculations and strength verification reports for the mooring components shall be submitted for GAIL's approval.

5.3. ANCHORING SYSTEM:

Anchoring of the floating Island can be through Screw Piles/ Anchor Plates/dead weights/RCC piles/ any advance anchoring system supported by design validation which will be most suited for site conditions. In case of anchoring through dead weights /RCC piles relevant chapters in civil works to be referred.

The following conditions shall be adhered to:

i. Puncturing or damage of reservoir bottom is not allowed.

ii. Anchoring & mooring system shall be such that it doesn't damage the embankment and its associated structures.

iii. Special care to be taken while installing and laying of anchors so as not to damage or disturb the reservoir floor/liner/PCC.

iv. Anchoring system shall be placed sufficiently away from the intake structures & top of embankment.

v. At some locations, cutting of road over the embankment may be required for crossing of mooring ropes, the work of cutting, filling and making the passage again in good condition is also in the scope of the bidder.

vi. In case the contractor wishes to adopt concrete pile foundation for anchoring system, Geo-tech. report shall also include the calculations, based on soil properties, for safe pile capacity under direct compression, lateral load and pull out as per IS:2911.

vii. For single pile, Lateral load capacity shall be min. of the values obtained as per IS:2911 & Brom's method corresponding to free pile head. The report shall also include recommendations about type of pile, its depth and dia. to be used.

viii. In case contractor wishes to use helical piles/ anchor plate the design, fabrication and installation shall conform to IBC (International building code). The contractor shall carry out field trials for initial load test on pile to verify the pile design to confirm the safe load carrying capacity under direct compression, Lateral load and Pull out. The min. of the two values (design value as per soil characteristics & field test results) shall be adopted.

ix. The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area and as per the provisions of IS 2911 Part 4. However, minimum 5 nos. of piles shall be tested under each category of load.

x. The contractor shall submit detailed methodology for conducting the tests in line with IS: 2911 (Part 4)/ IBC for Engineer's approval before commencement of any test. For reference, the standard pile test procedures for compression & pull out and lateral load test to be submitted for approval. After completion of these tests the contractor shall compile the test results and submit the report in a proper format as specified in the BIS standard with recommendations/ conclusions for Engineer's approval. The pile work shall start only after approval of the final pile design duly verified/ confirmed with initial load test results.

xi. If Bidder choose to provide helical pile/ anchor plate after due consideration to the above criteria, then following shall be adhered to by the bidder w.r.t Corrosion Protection.

xii. To avoid the corrosion in the steel section, due to continuous impact of water and air, or due to aggressive chemical environments, suitable anti-corrosive measures need to be considered. If Steel Section is proposed for anchoring, it shall be designed considering minimum 90-micron thick galvanization in HDG.

5.4. QUALITY ASSURANCE PLAN (QAP) & INSPECTION:

5.4.1. Detailed Quality Assurance Plan (QAP) for floater and its accessories shall be submitted for approval. A typical MQP for Floaters to be followed is attached for reference.

5.4.2. The floaters and all its accessories should be inspected before dispatch as per approved QAP. The items shall only be dispatched after issue of Material Dispatch Clearance Certificate (MDCC).

5.4.3. For Assembly and anchoring & mooring works, a detailed Field Quality Plan (FQP) shall be submitted for approval. The FQP 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.

5.5. WARRANTY FOR FLOATING SYSTEM AND ANCHORING & MOORING:

A warranty period of 10 years from the date of successful completion of trial run of the project shall be provided for Floater units/ Floating platforms and associated accessories. Even though the warranty period envisaged for floater units and associated accessories is only 10 years, they shall be designed for a service life of minimum of 25 years from the date of successful completion of Operational Acceptance Test (OAT) of the project, considering ambient site conditions. As such, the design shall inherently ensure that there shall be no failure owing to crack, puncture, breakage etc. in the floaters and all associated accessories which affect the integrity of the whole system, for a minimum of 25 years from the date of successful completion of OAT.

The warranty of floating system as well as Anchoring & mooring system shall be provided by OEM only.

5.6. COMPREHENSIVE O & M OF FLOATING SYSTEM AND ITS ASSOCIATED ANCHORING & MOORING:

The EPC Contractor has to do Operation & maintenance of installed system for period specified in Project Information. EPC Contractor has to depute sufficient no. of persons at site during O & M period as per project size requirement. Bidder to submit O & M manual for complete system which must include following (but not limited to):

I. Periodic maintenance schedule for checking the floater condition, sign of crack/ damage, tightening of mooring ropes and any other maintenance needed to maintain healthiness of floating island. This includes replacement of faulty floaters used in the system.

II. Bidder shall maintain a minimum stock of each component of floating system and its associated anchoring & mooring as O & M spare at site during complete O & M Period for maintenance of the system, as per OEM recommendation. Bidder to replenish the spares if consumed and maintain minimum stock at any time during O&M period. The minimum requirement is only indicative and any additional quantity as deemed required shall be maintained at site by the bidder.

III. Schedule and methodology of checking of Anchoring and mooring components periodically for its wear and tear.

IV. Schedule of preventive maintenance and checks.

O & M of floating and A & M works shall be done as per O & M manual approved by GAIL.

6.0 COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT (AMC)

Bidder has to furnish AMC on yearly basis from the date of completion of O & M of the floating system for period specified in Project Information. 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 is required to respond within one working day through telecom or any electronic means. This AMC to include the following:

I. Attending to and resolving any breakdown/fault of the floatation platform.

II. Mandatory 1 half yearly visit (once in six months) to assess the floating platform for any failure or any sign which may lead to subsequent failure. Vendor to send the assessment report to GAIL customer through email.

In case of severe breakdown of the system, OEM has to send their representative within 72 hours. For the minor faults not hampering the generation, 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.

7.0 PROVENESS CRITERIA

I. Bidder shall take necessary approval from BHEL/GAIL before finalisation of the floater supplier.
II. The bidder/his sub-vendor(s) is required to meet the Proveness criteria and/or qualification requirement for Floating, Anchoring and Mooring systems as per the criteria stipulated below:

7.1 SOLAR PV FLOATING SYSTEM

Supplier of Solar PV Floating system shall have manufactured and supplied Solar PV floaters of minimum capacity of 5MW at single location. The supplied floating system should have been successfully commissioned and working satisfactorily for minimum 6 months as on LOA date.

7.2 ANCHORING AND MOORING SYSTEM FOR FLOATING SPV BLOCKS

The Installer of Anchoring and Mooring System shall have designed and installed anchoring and mooring system for a minimum of 2.5MW floating Solar PV blocks at single location. The supplied anchoring and mooring system should have been successfully installed and working satisfactorily for minimum 6 months as on LOA date.

A3: DC CABLES

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

a) Interconnecting SPV modules

b) From SPV Modules upto SCB/String Inverter

c) From SCB upto the Inverter.

2.0 DC CABLES (Interconnecting SPV MODULES and from SPV Modules to SI/SCB)

1. Each module, shall have two 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.

2. Cables used for inter-connecting SPV modules as well as Modules to SCB's shall conform to the requirements of **EN 50618:2014/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).

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

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

5. In addition to manufacturer's identification on cables as per **EN50618/IS 17293**, following marking shall also be provided over outer sheath.
   i. Cable size, voltage grade and code designation “PV”
   ii. Word 'HALOGAN FREE LOW SMOKE’
   iii. Sequential marking of length of the cable

6. 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.

7. 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.

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

9. 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.

10. 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.

11. 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.

3.0 DC CABLES (STRING COMBINER BOX TO INVERTER)

1. Cables used between SCBs and Inverters shall be of 3.3kV (E) grade. These Power cables shall have compacted Aluminum/copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), Armored/ Unarmored, 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.

2. For other details refer chapter –LT Cables

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

4. Cable laying arrangement shall be done as mentioned in the other chapters (3-B: Electrical Scope and Supply &Services) and other relevant chapters of this specification.

4.0 DC CABLES SIZING CRITERIA

As per relevant clause in Chapter AC Cables

5.0 CABLE DRUM

For details refer clause 9.0 of Chapter -AC Cables

A-4 STRING COMBINER BOX (IN CASE OF CENTRAL INVERTER)

1.0 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. SCBs are not applicable in case of string inverters configuration.

2.0 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 61643-12	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.

3.0 GENERAL REQUIREMENT

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

a) DC Disconnector /Breaker to disconnect the PV strings from the Inverter for maintenance purpose as per specification mentioned in this chapter.
b) All component in the SCB shall be suitable for operation within temperature range of 0-65 Deg C.
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 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.

g) String monitoring cards, for measuring Currents, temperatures and Voltages.

4.0 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 micro second 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 disconnector 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 disconnector, the SPD shall be able to extinguish the arc. SPD shall have local visual indication and potential free contact for remote indication.

5.0 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 as per relevant standards and not less than 1.5 times of the input current which shall be suitable for 1500 Volt for crystalline module. 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).

6.0 SCB ENCLOSURE AND ASSEMBLY

SCB shall satisfy the following requirement.

i. The enclosure shall be made of UV Protected, Halogen Free, and Fire- retardant GRP/FRP/Polycarbonate material with self-extinguishing property.

ii. 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.

iii. The mechanical impact resistance of enclosure shall be IK 07 or better.

iv. 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.

v. 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 x (Imp of PV Modules) x (no. of string inputs + 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.

vi. 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.

vii. All terminals blocks shall be rated for min 1500V and rated continuously to carry maximum expected current.

viii. 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. Engraved core identification plastic ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal blocks.

ix. If metallic hinge is being used with enclosure cover, it shall be made of SS304 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.

x. Mounting plate inside the SCB for mounting/fixing of devices shall be made of FRP/GRP or equivalent non-conducting material.

7.0 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-ration, 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.

8.0 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.
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

9.0 DC PLUG-IN CONNECTORS FOR FIELD CABLING

9.1 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 suitably sized fuse in positive side of Y-connector.

9.2 TECHNICAL REQUIREMENTS

Rated Current, IEC (85°C)	Min 1.5 times of String current (Isc)
Rated Voltage	Min 1500 Volts
Connector Design	Snap-In locking Type
Protection Degree	IP68 (Mated)
Ambient Temperature	(-) 40 deg C to (+) 85 deg C
Protection/Safety Class	Class II
Contact material	Cu
Contact surface material	Silver/Tin
Contact resistance for plug connecter	< 0.5 milli-ohms
Stripping length	10 MM
Inflammability class	UL 94-V0
Insulating Material	PPE / PPO/Polyamide
Pollution degree	3
Certification	UL/TUV/CSA/EAC or Equivalent
Rated Current, IEC (85°C)	Min 1.5 times of String current (Isc)
Rated Voltage	Min 1500 Volts

9.3 TYPE TEST FOR DC plug-in connectors

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

A-5 POWER CONDITIONING UNIT

1.0 GENERAL

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 3-B: Electrical Scope and Supply &Services.

2.0 CODES AND STANDARDS

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

3.0 GENERAL REQUIREMENTS (Applicable both for Central and String Inverter)

3.01 PCU shall meet the following technical parameter

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, and power factor control features.	Required. Possible both from PPC and SCADA.
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.	(i) AC & DC overcurrent protection. (ii) Synchronization loss protection. (iii) Over temperature protection. (iv) DC & AC under and over voltage protection. (v) Under & over frequency protection. (vi) Cooling system failure protection (vii) PV array ground fault monitoring & detection (viii) PV array insulation monitoring (ix) LVRT protection (x) Anti-islanding protection (xi) Grid monitoring	Required.

3.02 The PCU shall comply with the Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments.

3.03 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.

3.04 The PCU shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.

3.05 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.

3.06 The PCU must be self-managing and stable in operation

3.07 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.

3.08 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.

3.09 PCU shall have necessary limiters in build in the controller so as to ensure the safe operation of the PCU within the designed operational parameters.

3.10 PCU shall have thermal overloading protection to prevent failure of switching devices (ie, 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 detailed 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.

3.11 PCU shall be provided with the mobile user interface facility for monitoring of inverter by plant O&M personnel 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.

3.12 PCU shall have AC and DC side monitoring capability 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

3.13 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.

3.14 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.

3.15 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.

3.16 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 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.

3.17 In case auxiliary supply of PCU is met internally, then it should have sufficient power backup to meet the LVRT requirement.

3.18 Bidder to submit third-party verified OND files of the inverter during detail engineering.

3.19 Bidder may consider sufficient modularization of Inverter to ensure that potential solar generation is minimally impacted due to breakdown/shutdown of a particular Inverter.

4.0 CENTRAL INVERTER

a) PCU 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 PCU/its Modules or separately based on standard design and configuration of PCU 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.

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 Contactor 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 BHEL/GAIL 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.

4.1 INDOOR CENTRAL INVERTER

a) The PCU enclosure protection class shall be IP 20 or better protection.

b) COOLING AND VENTILATION: -

c) To prevent the maximum permissible temperature 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.

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

4.2 OUTDOOR CENTRAL 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 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.

5.0 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.

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-1 (LT Switchgear).

6.0 TYPE TESTING (Applicable both for Central and String Inverter)

a) 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 LOA. 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.

b) However, if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of LOA, 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/owner's representative and submit the reports for approval.

SECTION-6 : TECHNICAL SPECIFICATIONS

B – AC SYSTEMS

B-1 LT SWITCHGEAR

1.0 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

2.0 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)
(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 50ºC ambient:	As Per Requirement
(vii)	Temperature Rise allowed above ambient	40°C for plain joints 55°C 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 or better
(ii)	MFM shall be provided at LT 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	1:00 AM
(iv)	Class of insulation	E or better
(v)	Accuracy class & burden	
	a) For Protection	5P20, 5VA
	b) For Metering	Class 0.5, 5VA (min)
(vi)	Instrument Security Factor for metering CT	5
E. VOLTAGE TRANSFORMERS		
(i)	Type	Cast Resin
(ii)	Voltage Ratio	415 / 110V for line PT 415/√3 / 110/√3V 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 and frequency	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) As per Manufacturer standard. 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.

3.0 DETAILS OF DISTRIBUTION BOARDS

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

1. Switchboards in CMCS shall be of metal enclosed, indoor, floor-mounted, free-standing type. Distribution boards of small size can be of wall/channel mounted type. For inverter stations, if outdoor distribution boards/LT pooling switchgear is proposed, the same shall be of suitable IP class and shall be kept under shed.
2. 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 2.0 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.
3. 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.
4. 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.
5. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. All cutouts shall be provided with EPDM / Neoprene gaskets.
6. All switchboards shall be of uniform height not exceeding 2450 mm.
7. 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.
8. 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/components.

9. 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.
10. 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 aluminum alloy / copper of adequate size.
11. 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.
12. 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.
13. 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.
14. 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 aluminum joints shall be provided with suitable bimetallic washers.

15. All busbars shall be color coded as per IS: 375.
16. Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.
17. The Bidder shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.
18. 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.
19. A galvanized steel / Copper / Aluminum 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.
20. 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.
21. 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.
22. 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. 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.
23. 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.
24. 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 acceptable. The Contractor shall establish earth continuity at site also.

25. All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.
26. 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.
27. 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.
28. All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.
29. 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.
30. 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.
31. Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC/ XLPE insulated, armoured / 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.
32. All power cable terminals shall be of stud type and the power cable lugs shall be solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.
33. All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local push-button stations etc. shall be provided with prominent, engraved identification plates.
34. 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.
35. 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.

36. The gaskets, wherever specified, shall be of good quality EPDM / neoprene with good ageing, compression, and oil resistance characteristics suitable for panel applications.
37. 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.
38. ON/OFF status and protection trip status of incomers and bus coupler (if applicable as per SLD) be provided for SCADA system.
39. Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler (if applicable as per SLD).
40. 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.
41. 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 as per manufacturer's standard, unless required otherwise by the employer. The paint thickness shall not be less than 50 microns.

4.0 MCCB

1. 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.
2. 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).

3. 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 can not 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.

5.0 FUSES

1. 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.

   Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.

2. 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.
3. The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

6.0 LT SWITCHGEAR FOR STRING INVERTER

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

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

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

   SWITCHGEAR / FEEDER COMPARTMENT: - All equipment associated with an 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.

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.

CONTROL COMPARTMENT: - A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.

2. 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 cutouts shall be provided with EPDM / Neoprene gaskets. However, the control / relay compartments shall have degree of protection not less than IP 5X. If outdoor LT switchgear is proposed at inverter stations, the same shall be of suitable IP class and shall be kept under shed.

   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.
3. 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.
4. 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 25mm. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.
5. 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.

6. 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.
7. 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.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.

13. Electrically controlled circuit breaker boards shall be provided with DC control supply.

7.0 CIRCUIT BREAKERS

1. 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.
2. 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.
3. 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 energising 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.
4. 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.
5. Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.
6. 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.
7. 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.

8. Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.
9. 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.
10. Breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.
11. Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.
12. Circuit breaker shall be provided with anti-pumping feature and trip free feature, even if mechanical anti-pumping feature is provided.
13. 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.
14. 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.
15. 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.
16. 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.
17. The motor shall be such that it requires not more than 30 Seconds for fully charging the closing spring at minimum available control voltage.
18. Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.
19. 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.

20. 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.
21. 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.
22. 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.
23. 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.
24. 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.
25. 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

8.0 AC JUNCTION BOXES (FOR USE WITH STRING INVERTERS)

1. 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.
2. Each input of AC junction box shall have protection with suitably rated MCCBs.
3. 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 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.
4. 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.
5. EPDM / Neoprene gasket shall be used to prevent ingress of dust into panels.
6. All non-current carrying metal work of the junction box shall be effectively connected to the system earth bus.
7. 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.

9.0 TEMPERATURE-RISE (FOR LT SWITCHGEAR OF 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.

10.0 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.

B-2 HT SWITCHGEAR

1.0 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
1	IS: 722	AC electricity meters.
2	IS: 996	Single phase small AC and universal electrical motors.
3	IS: 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories.
4	IS/IEC: 60947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
5	IS: 2544	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
6	IS: 2705	Current transformers.
7	IS: 3156	Voltage Transformers
8	IS: 6005	Code of practice for phosphating of iron and steel.
9	IS: 5082	Specification for wrought aluminium and aluminium alloy bars, rods, tubes and selections for electrical purposes.
10	IEC: 61850	Communication Standard for Numerical relays
11	IEC: 61131-3	Automation Standard for Numerical relays
12	IS: 9046	AC contactors for voltages above 1000 volts and upto and including 11000 Volts.
13	IS: 13703	Low voltage fuses
14	IS: 9385	HV fuses
15	IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV

16	IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V
17	IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
18	IS: 13118	Specification for high voltage AC circuit breakers.
19	IEC: 60099-4	Metal oxide surge arrestor without gap for AC system
20	IS/IEC: 62271-100	High voltage alternating current circuit breakers.
21	IS/IEC: 62271-200	High voltage metal enclosed switchgear and control gear.
22	IEC: 60947-7-1	Terminal blocks for copper conductors
23	IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

2.0 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	As per System Fault current
i)	Short time rating for bus bars, circuit breakers, current transformers and switchgear assembly.	

j)	Dynamic withstand rating	2.55 times of system fault current
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 50 C 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	During Engineering stage
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 50ºC.	
b	Short circuit breaker Current	
	a) A.C. component	As per relevant Clause in this specification
	b) D.C. component	As per IS: 13118 or IEC-62271
c	Short Circuit making current	2.55 times of system fault current (peak)
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	0.2s 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		
	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 8 Hours for star connected VTs.
	Class of insulation	Class E or better
c)	Other parameters	0.2S Class or better as per requirement. VA requirement shall be based on application/ requirement. Additional open delta core with damping resistor shall be provided in all VT's to prevent damage on account of Ferro-Resonance conditions
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	0.2S or better

3.0 SWITCHGEAR PANEL

1. 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 LSC 2B-PM (as per IS/ IEC 622771-200). However, manufacturer's standard switchgear designs without inter panel barriers in busbar compartment may also be considered.

2. The circuit breakers and bus VTs shall be mounted on withdrawable trucks which shall roll out 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.
3. 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.
4. 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 covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.
5. The control / relay compartments shall have degree of protection not less then 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 gourmet / 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.

6. 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.
7. 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.
8. The height of switches, pushbuttons and other hand operated devices shall not exceed 1800mm and shall not be less than 700mm.
9. 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.
10. 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" shall be provided on the shutters of incoming and tie connections which could be energized from other end.

11. 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.
12. 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 back doors. 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
13. 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.
14. 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.
15. 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.

4.0 CIRCUIT BREAKERS

1. The circuit breakers shall be of Vacuum type.
2. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.

3. Circuit breaker shall be restrike 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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 upto 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.
10. 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.

11. 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. 4.12 Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.

5.0 CONTROLS AND INTERLOCKS

1. 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.
2. 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.
3. 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.
4. Each panel shall have two separate limit switches, one for the Service position and the other for isolated position.
5. 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.

6. 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/contactor original Auxiliary contacts made available for the of the Employer's use.
7. 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.
8. 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.
9. 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 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.
10. 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.
11. 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.
12. Reverse blocking and Inter tripping shall be implemented in switchgear boards level. Detailed scheme for the same shall be finalized during detailed engineering stage.
13. 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.

6.0 NUMERICAL RELAYS AND NETWORKING

1. 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 shall have necessary protections.

2. 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.
3. 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.
4. One-minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
5. Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.
6. 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.
7. 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.
8. 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.

9. 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.
10. Numerical relays shall have feature of current measurement. Relay shall be able to provide the same in soft to solar SCADA system.
11. Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
12. Master trip (86) and non-86 trips shall be software configurable to output contacts.
13. 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.
14. 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 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.
15. 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.

16. 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.
17. 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.
18. 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.
19. Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI programmable characteristics.
20. 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.
21. All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
22. 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.
23. All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.
24. Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.
25. 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.
26. Ethernet switches shall be suitable to accept both AC & DC supplies with range of 70 % to 120 % of rated voltage.
27. 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.
28. 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.

7.0 OTHER PROTECTIONS AND CONTROL FUNCTIONS IN THE RELAYS

1. Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre-trip and post trip conditions.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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 shall be available on the user interface.
7. The alarm/status of each individual protection function and trip operation shall be communicated to solar SCADA.
8. Sequence of events shall have 1 ms resolution at device level.
9. Measurement accuracy shall be 1 % for RMS Current and voltage.

8.0 BUSBARS AND INSULATORS

1. 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.

2. 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.
3. Contact surfaces at all joints shall be silver plated or properly cleaned and nonoxide 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.
4. Busbar insulators shall be of arc and track resistant, high strength, nonhygroscopic, 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 x 1.1 / 3 . Use of insulators and barriers of in-flammable material such as Hylam shall not be accepted.
5. Successful Bidder shall furnish calculation establishing adequacy of busbar sizes for the specified continuous and short time current ratings.
6. All busbars shall be color coded.
7. 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).

9.0 EARTHING AND EARTHING DEVICES

1. 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.
2. 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.
3. 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.

4. 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.
5. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.
6. 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.
7. 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. 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.
8. 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.
9. 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.
10. 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.
11. Interlocks shall be provided to prevent:
    i. Closing of the earthing switch if the associated circuit breaker truck is in Service position.
    ii. Insertion of the breaker truck to Service position if earthing switch is in closed position.

iii. Closing of the earth switch on a live connection.

iv. Energizing an earthed Section: Complete details of arrangement offered shall be provided during detailed engineering, describing the safety features and interlocks.

12. 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

10.0 PAINTING (INDOOR SWITCHGEAR)

All sheet steel work shall be pretreated, 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 phosphated surfaces shall 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 as per bidder standard 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.

11.0 INSTRUMENT TRANSFORMERS

1. 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.
2. 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.
3. 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 offer instrument transformer of adequate ratings and shall bring out this fact clearly in his Techno commercial bid.

4. All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.
5. 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.
6. 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.
7. 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.

12.0 SURGE ARRESTOR

The surge arrestors shall be provided as per tender indicative AC 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.

13.0 CONTROL SUPPLY AND SPACE HEATER SUPPLY

1. Each switchboard shall be provided at least two (02) Nos of DC feeders for the control supply.
2. In case two DC sources are provided, then suitable rated blocking diodes in both circuit has to be provided. Alternately Bidder can provide source selection switch.
3. 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.

4. 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.
5. 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.
6. All DC circuits shall be fused on both poles. Single phase AC circuits shall have fuses on line and link on neutral.
7. DC and AC supply monitoring relay shall be provided, and alarm shall be generated in SCADA system in case of failure of supply.

14.0 SPACE HEATER

1. 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.
2. 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.

15.0 TERMINAL BLOCKS

1. 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.
2. 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.

3. 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.
4. 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.
5. All panel wring 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.

16.0 SWITCHGEAR WIRING

1. All Switchgear panels shall be supplied completely wired internally upto 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.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.

8. Contractor shall be fully responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.
9. 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.

17.0 POWER CABLE TERMINATION

1. Cable termination compartment shall receive the stranded Aluminium conductor, XLPE insulated, shielded, armored / unarmored, PVC jacketed, single core / three core, unearthed / earthed grade power cable(s).
2. 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.
3. 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

18.0 NAME PLATES AND LABELS

1. 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.
2. 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.
3. Suitable stencilled 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. Labels shall have device number as mentioned in wiring drawings. Type of labels and fixing of labels shall be such that they are not likely to peel off / fall off during prolonged use.

19.0 MODULE DESCRIPTION (Typical)

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

20.0 TESTS

20.1 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 LOA date. 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 center.
	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.
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.

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: – Steady-state simulation	Relevant

	– Dynamic simulation	IEC 60255-100
iii)	Product safety requirements (including the dielectric tests and thermal short time rating)	IEC 60255-27
iv)	EMC requirements:	IEC 60255-26
	– 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, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
	– Cold	
	– Dry heat	
	– Change of temperature	
	– Damp heat	
ix)	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
	– Vibration	
	– Bump	
	– 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.

20.2 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.

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

A. 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

B. 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.

C. Current Transformers

(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) Magnetisation characteristics & secondary winding resistance.

(e) Spare CT cores, if any to be shorted and earthed.

D. Voltage Transformers

(a) Insulation resistance test.

(b) Ratio test on all cores.

(c) Polarity test.

(d) Line connections as per connection diagram.

E. 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

B-3(A) INVERTER TRANSFORMER

1.0 TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sl. No.	TRANSFORMER	INVERTER TRANSFORMER
i)	VA Rating & Quantity	As per system requirement
ii)	Voltage Ratio (KV)	As per system requirement
iii)	Duty, Service & Application	Continuous Solar Inverter application and 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/KNAN
ix)	Tap Changer	As per system requirement OCTC +/- 5% (min.)
x)	Impedance at 75 degC a. Principal Tap b. Other taps	As per system requirement and SLD* & as per Inverter manufacturer recommendation.
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.
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.
xxi)	**Nitrogen Injection Fire Protection System (NIFPS)**	All Inverter transformers with oil quantity more than 2000 litres, shall be equipped with NIFPS.

NOTE (COMMON FOR OIL FILLED AND DRY TYPE TRANSFORMER):

1. 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 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.
2. If Inverter transformer is provided indoor, it shall be necessarily dry type.
3. Harmonic Factor as per Inverter manufacturer recommendation must be considered 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.

4. The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).
5. 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.
6. 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.
7. 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.
8. In case of inverter transformer, it shall be proven and of successfully type tested design
9. 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.
10. Single Line Diagram (SLD) will be finalized during detailed engineering however kVA rating of inverter transformer shall not be less than combined kVA capacity of respective Inverters connected to it.
11. Contractor shall ensure that all the Outdoor Transformers are provided with Sheds, as protection against rain/moisture ingress, after due consideration of Lifting Height of the Transformer. Bus Ducts, as applicable, shall also be covered under the shed.

1.2. CODES AND STANDARDS

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

1.3. 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.

1. 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.
2. A double float type Buchholz relay conforming to IS: 3637 shall be provided.
3. 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.
4. 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
5. 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. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
6. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator with accuracy class of +/-2 deg.
7. 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.
8. 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 IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 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.

1.4. WINDINGS

1. The Bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.
2. The conductors shall be of electrolytic grade copper/electrolytic grade Aluminium free from scales & burrs.
3. All windings of the transformers shall have uniform insulation.
4. Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.

1.5. CORE

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

1.6. TRANSFORMER OIL

1. 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, mm2/s	≤12 at 40°C ≤ 1800.0 at (-)30 °C
2	Flash Point	≥140 °C
3	Pour Point	≤ (-)40 °C
4	Appearance	Clear, free from sediment and suspended matter
5	Density kg/dm3 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 coorsive
9	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10	Anti-oxidants additives	Not detectable
11	Oxidation Stability -Neutralization value, mgKOH/g	≤ 1.2 ≤ 0.8

	-Sludge, % by mass	
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, mm3/min	≤ 5

2. Subsequently oil samples shall be drawn at:

S.no	Parameters	Before filling in main tank & tested for	Prior to energization for 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.)	

3. **For ester filled oil, relevant IS/IEC shall be followed for relevant oil parameters for type/routine test.** The oil supplied with transformers shall be new and previously unused and must conform to IS/IEC while tested at supplier's premises and shall fulfil all oil parameters. Type Test are to be performed by the supplier at NABL accredited Govt approved independent laboratory before supplying the oil and submit for its approval by BHEL.

1.7. BUSHINGS

1. Bushing below 52 kV shall be oil communicating type with porcelain insulator.
2. 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
3. No arcing horns to be provided on the bushings.
4. Inverter Transformer LV bushing palms shall be silver/tin plated.

1.8. BUSHING CTS

1. 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.

2. 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.**

1.9. VALVES

1. 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.
2. Sampling & drain valves should have zero leakage rate.

1.10. GASKETS

1. Gasket shall be fitted with weather proof, hot oil resistant, nitrile rubber-based gasket.
2. If gasket is compressible, metallic stops shall be provided to prevent over compression.
3. 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.

1.11. 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	At least 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (As per manufacturer standard)	One coat each	At least 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (As per manufacturer standard)	Two coats each	At least 100 micron

Internal Radiator surface	Hot oil proof, low viscosity varnish and 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

1.12. 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.

1.13. CABLE BOXES & DISCONNECTING CHAMBER (DISCONNECTING CHAMBER APPLICABLE 3.3 KV AND ABOVE & FOR INVERTER TRANSFORMER BOTH SIDE)

1. 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)
2. 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.
3. A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box
4. The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron
5. The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.
6. 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.
7. 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).
8. 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.

1.14. FITTINGS

Following fittings shall be provided with Transformers covered under this sub section. The fittings listed below are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.

a)	-Conservator for main tank 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.
c)	- It shall be provided with minimum two numbers of spring-operated PRD (with trip contacts) with suitable discharge arrangement for oil shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level). For Inverter Transformers, WTI shall be provided at least for all LV windings.
e)	Top & bottom filter valves with threaded male adapters, bottom sampling valve, drain valve/sludge removal valve at the bottom most point of the tank.
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, 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.

2.0 DRY TYPE INVERTER TRANSFORMER

Sr. No.	PARAMETERS	INVERTER TRANSFORMER
i)	Type	Epoxy cast resin/resin encapsulated
ii)	Duty, Service & Application	Continuous Solar Inverter application and converter duty (Indoor)
iii)	MVA & Voltage ratio	As per system requirement and SLD.
iv)	Vector group	
v)	Termination & Bushing CT	
vi)	Fault Level & Earthing	
vii)	Tap changer type & range	As per system requirement and SLD. OCTC +/-5% (min.)
viii)	Impedance	As per system requirement and SLD & as per Inverter manufacturer recommendation.
ix)	Number of phases	Three (3)
x)	Type of cooling	AN Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance guarantee shall correspond to air natural (AN) cooling.
xi)	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)
xii)	Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method) with Air Natural (AN) cooling.	90 deg.C. (class F) 115 deg.C. (class H)
xiii)	SC withstand time (thermal)	2 sec
xiv)	Noise Level	Not to exceed values specified in NEMA TR-1.
xv)	PD Level (max. Allowable)	10 pc
xvi)	Loading Capability	Continuous operation at rated KVA on any tap with voltage variation of +/-10% corresponding to the voltage of the tap as well as in accordance with IEC60076-12/IS: 6600.

vii)	*Flux Density*	Not to exceed 1.9 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 combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. *c) 140% for at least five seconds.*

2.1 CODES AND STANDARDS

Dry type transformers	IS: 11171, IEC 60076-11
Indian Electricity Act 2003 and Indian Electricity Rules, BEE notification & CEA guidelines	

2.2 DESIGN AND CONSTRUCTIONAL FEATURES

1. The core shall be constructed from high grade non-ageing cold rolled grain oriented silicon steel laminations of M4 grade or better quality. The insulation of core to clamp-plates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.
2. The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23.In case it is placed outdoor, IP for enclosure shall be minimum IP-42 or higher. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.
3. Winding conductor shall be electrolytic grade Copper/ Aluminum. Windings shall be of class F insulation or better. All windings are to be uniformly insulated.
4. Transformer HV bushings and LV bushings can be either solid porcelain or epoxy type. Bushing shall be suitable for satisfactory operation in the high ambient temperature inside Bus Duct enclosure (if applicable). LV flange area shall be of non-magnetic material.
5. Bushing CTs shall be provided in the LV neutral side of adequate rating for REF protection, WTI, etc (as applicable).
6. For Marshalling Box the sheet steel used shall be at least 1.6 mm thick cold rolled. The box shall be tank mounted type. The degree of protection shall be IP-54 in accordance with IS-13947. Wiring

Scheme shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

7. Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance shall correspond to air natural cooling.

2.3 PAINTING

The inside of enclosure and accessories (except M. Box) shall be painted with two coats of fully glossy white colour with total DFT of 25 to 60 microns. The external paint colour of transformer & accessories can be as per manufacturer standard. The external surface of transformer & accessories shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of polyurethane finish paint with total DFT of 80 to 150 microns. The internal surface of M.Box shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of chemical & thermal resistant epoxy enamel white paint with total DFT of 80 to 150 microns.

2.4 FITTING

Winding temperature indicator (WTI)	Shall be Platinum resistance type temperature detector in each limb. Single Indicating meter may be provided for display of temperature of all limbs. Accuracy class of Indicating meter shall be +/- 1% or better and it shall have least count of 0.1 oC or better. 1 no. 4-20 mA signal shall be provided for remote monitoring of winding Temperature.
RTD/Thermistors	1 No. PT-RTD shall be embedded in each limb with alarm and trip contacts for remote annunciation. Additional 1 No. thermistor/RTD shall be embedded in each limb.
Fittings which are generally required for satisfactory operation of the transformers are deemed to be included, in the scope of supply of the Contractor.	

3.0 TESTS AND INSPECTION

In case the bidder/contractor has conducted type test(s) within last ten years, then bidder may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

In case the Bidder is not able to submit report of the type test(s) conducted within last ten years from the date LOA by BHEL, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the Employer and submit the reports for approval.

SHORT CIRCUIT TEST: -

In case short circuit test has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, Bidder /Sub-vendor shall establish" Ability to withstand the dynamic effects of short circuit "for the offered transformer as per latest IEC 60076-5.The ability to withstand the dynamic effects of short circuit can be established either by performing actual short circuit test or by method of calculation with reference to short circuit tested reference transformer as per IEC-60076-5/Annexure-A&B. Bidder shall choose any one the two options mentioned below;

Option-1:- Performing actual short circuit test as Type Test. In order to meet project schedule, Bidder/Sub vendor shall take suitable steps quite in advance to ensure successful conduction of short circuit test within three months' time from date of LOA failing which the offered make of the transformer shall not be considered.

Option-2: By theoretical evaluation of the ability to withstand dynamic effect of short circuit based on 'Calculation and Design and Manufacture Consideration'. In this regard the guidelines given in Annexure-A with applicable tables of the IEC 60076-5 is to be followed. The reference transformer chosen shall be of same application, winding configuration, conductor current density and as per Annexure-B of latest IEC-60076-5. Necessary Design document and reference test reports related to theoretical comparative evaluation must be submitted by Manufacturer/Bidder as required by Employer in this case.

S.N.	**ROUTINE TESTS**	
1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1)	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check (as per IEC 60076-1)	√
5.	Magnetic Balance and Magnetising 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 (as per IEC 60076-1)	√

8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√
9.	IR measurement (As per IEC 60076-1)	√
10.	Measurement of capacitance & tan delta to determine capacitance between winding & earth.	√
11.	Separate Source Voltage Withstand Test /Applied voltage test (as per IEC 60076-3)	√
12.	Induced overvoltage test/Induced voltage withstand (IVW) test as per IEC60076 part 3	√
13.	Repeat no load current/loss & IR after completion of all electrical test	√
14.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause of this sub section)	√
15.	Jacking test followed by D.P. test	√
16.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
17.	IR measurement on wiring of Marshalling Box.	√
S. N.	**TYPE TESTS # (To be carried out on one transformer of each rating)**	
1.	Lightning impulse (Full and chopped wave) test on windings (as per IEC 60076-3) (Not applicable for LV)	√
2.	Short circuit test (special test) as per IEC 60076-5 (if applicable).	√
3.	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample taken before & immediately after temp. rise test. Gas analysis shall be as per IS: 9434 (based on IEC: 60567), results will be interpreted as per IS: 10593 (based on IEC: 60599).	√
4.	Measurement of harmonics of no load current (special test)	√
5.	Measurement of acoustic noise level as per NEMA TR-1 (special test)	√
6.	Tank Vacuum & Pressure Test (as per CBIP norms)	√

(#) NOTE: -

I. All the type and special tests shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.

II. ii) Inverter Transformer LV winding Di-electric tests (except for lightning impulse test for LV winding) shall be carried out corresponding to levels (as per IEC 60076) for 3.6 kV class.

III. iii) All Type tests should be done as per Employer's approved procedure.

3.1 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 subject to BHEL approval. Suitable Fire Fighting arrangements for Oil filled Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/statutory requirements. In case Nitrogen based fire protection system is used, CBIP manual shall be followed for compliance. Firewall & soak pit as applicable (as per statuary 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 BHEL approval. However for all oil filled outdoor a pit shall be provided all around at a distance of 1.0 meter (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.

3.2 ROUTINE / TYPE TESTS (DRY TYPE TRANSFORMERS)

Transformer shall be short circuit tested after conducting the routine tests.
Rest of the type tests shall be conducted after successful short circuit testing.
All routine tests in accordance with IS: 11171 / IEC 60076-11 shall be carried out on each transformer.
And All Type tests should be done as per Employer's approved procedure.

Routine / Type Tests (Dry Type Transformers)		
a)	Measurement of winding Resistance for each tap position.	Routine
b)	Measurement of voltage ratio at each taps position.	Routine
c)	Vector group and polarity check	Routine
d)	Measurement of impedance voltage/short circuit impedance & load loss at principal tap and extreme taps	Routine
e)	Measurement of no load losses and magnetising current at rated frequency and 90%, 100% and 110% rated voltage.	Routine
f)	Measurement of insulation resistance	Routine
g)	Measurement of capacitance and tan delta	Routine

h)	Dielectric Tests		
	1)	PF/Separate source AC withstand voltage test.	Routine
	2)	Chopped wave lightning impulse voltage test on windings (as per IEC 60076-3) (Not applicable for LV)	Type
	3)	Induced over voltage withstand test	Routine
i)	Partial discharge measurement		Routine
j)	Measurement of iron loss & IR (repeat after induced voltage test)		Routine
k)	Short Circuit test as per IEC (if applicable)		Type
l)	Noise Level Measurement		Type
o)	Temperature rise test as per IEC (HV & LV winding)		Type

B-3(B) AUXILIARY TRANSFORMER

1.0 TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sr. No.	DESCRIPTION	AUXILIARY TRANSFORMER (AT)
i)	VA Rating & Quantity	As per system requirement and /or SLD*
ii)	Voltage Ratio (KV)	As per system requirement and / or SLD*
iii)	Duty, Service & Application	Continuous application (Outdoor)
iv)	Winding	TWO
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement and /or SLD*
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement and /or SLD*
x)	Impedance at 75 deg C	
	a) Principal Tap	As per system requirement and /or SLD*.
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	35 deg.C
	b) Winding	40 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault level & Bushing CT	As per system requirement and SLD*
xiv)	Termination	As per system requirement /cable box
xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC 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.
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

NOTE (COMMON FOR OIL FILLED AND DRY TYPE TRANSFORMER):

1. Auxiliary transformers shall be suitable for 3 phase, 4 wire system with additional LVN bushing for equipment earthing.
2. Auxiliary Transformer can be either Oil Natural/Synthetic Ester oil) filled or Dry Type (refer relevant specification).
3. In case Ester Oil filled Transformers are offered, then 50% quantity shall be Natural ester filled and balance 50% quantity shall be of Synthetic Ester oil filled.

2.0 CODES AND STANDARDS

Transformers	IS:2026, IS:6600
Bushings	IS:2099,IS 3347
Insulating oil	IS 16659 / IS 16081
Bushing CTs	IS:2705

2.1 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.

1. 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.
2. A double float type Buchholz relay conforming to IS: 3637 shall be provided.
3. 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.
4. 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
5. 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.
6. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
7. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator (WTI applicable for transformer above 50 KVA) with accuracy class of +/-2 deg.
8. For Transformers above 100KVA, 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.
9. 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 IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 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 (for transformer above 100 KVA). For transformer above 100 KVA, wiring scheme

(TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

10. In case Natural Ester oil (IS 16659) filled transformer, the Transformer should be hermetically sealed and corrugated tank design. It should fit with monitoring equipment like DGPT etc. for accessing the healthiness of Natural ester oil. As transformer becomes hermetically sealed, fitting, valves and accessories shall be decided during detail engineering but all other part of tender specification related to design of transformer active part and testing requirement shall remain same. HV/LV Bushing shall be fitted vertically on tank cover and all necessary measures to be taken to make the transformer leakage proof. Suitable nitrogen capping system shall be provided for preserving Natural ester oil for O&M.

2.2 WINDINGS

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 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.

2.3 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.

2.4 INSULATING MINERAL OIL

1. 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, mm2 /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/dm3 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
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, mm3 /min	≤5

2. Subsequently oil samples shall be drawn at:

Sr. No.	Parameters	Before filling in main tank & tested for	Prior to energization for 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.)	

3. **For ester filled oil, relevant IS/IEC shall be followed for relevant oil parameters for type/routine test.**

2.5 BUSHINGS

a) Bushing below 52 kV shall be oil communicating type with porcelain insulator.

b) No arcing horns to be provided on the bushings.

2.6 BUSHING CTS

Shall be of adequate rating for protection as required, WTI (WTI CT applicable for transformer above 50 KVA) 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

2.7 VALVES

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.

2.8 GASKETS

a) Gasket shall be fitted with weather proof, hot oil resistant, rubberized cork 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.

2.9 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	At least 30 microns
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (As per manufacturer standard)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (As per manufacturer standard)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and 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 microns

2.10 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.

2.11 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).
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.

2.12 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.

2.13 TESTS AND INSPECTION

S.N.	**ROUTINE TESTS**	
1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1)	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check (as per IEC 60076-1)	√
5.	Magnetic Balance and Magnetising 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 (as per IEC 60076-1)	√
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 (as per IEC 60076-3)	√
11.	Induced overvoltage test/Induced voltage withstand (IVW) test as per IEC60076 part 3	√
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.No.	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)	√

2.14 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 subject to BHEL approval.

2.15 FIRE FIGHTING

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 statuary 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 BHEL 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.

3.0 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.

B-4 AC CABLES

1.0 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 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
IS : 4905	Methods for random sampling.
IS : 10418	Specification for drums for electric cables.

2.0 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.

2.1. Cables shall be armored type if laid in switchyard area or directly buried.

2.2. Cable lengths shall be considered in such ways that straight through cable joints are avoided.

2.3. If cables are to be laid underground, laying shall be as per latest relevant IS code.

2.4. If cables are to be laid over ground (eg on RCC/concrete pedestals etc), the cables shall be UV-resistant supported by test reports.

2.5 CONDUCTOR

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

2.6 INSULATION

1. 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.
2. 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.

2.7 ARMOUR

1. 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
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

2. The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264-ohm mm2 per meter at 20 deg C. The sizes of aluminum armoring shall be same as indicated above for galvanized steel.
3. 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.

2.8 OUTERSHEATH

1. 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.
2. 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 ASTMD-2843).
3. 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
4. The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.
5. 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.
6. Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets.
7. Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

3.0 CABLE SELECTION & SIZING

Cables shall be sized based on the following considerations:

1. Rated current of the equipment
2. The Maximum Overall Voltage Drop: As per relevant clause in other chapters.
3. Short circuit withstand capability
4. Fault current- As per system fault current.
5. Time-As per protection time grading requirement subject to the minimum value mentioned at Cable sizing criteria of relevant chapter.

4.0 DERATING FACTORS

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

1. Variation in ambient temperature for cables laid in air
2. Grouping of cables
3. Variation in ground temperature and soil thermal resistivity for buried cables.

5.0 HT POWER CABLES

1. For single-core armored cables, the armouring may constitute the metallic part of insulation screening
2. In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.
3. 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.
4. Cores of the cables of upto 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.
5. The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.
6. The eccentricity shall be calculated as

Eccentricity	Ovality

tmax -tmin ---------- x 100 *t max*	dmax -dmin ---------- x 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	

7. The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%
8. Cables shall conform to IS: 7098 Part - II. These cables shall have mutli-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”.
9. 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.
10. 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 non standard 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.

6.0 LT POWER CABLES

1. 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.
2. 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.

3. 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 fault current level for total breaker tripping time inclusive of relay pickup time.
4. Single core cables shall have no Inner sheath as per IS: 7098 Part-I
5. All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated.
6. 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.
7. 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).

7.0 LT CONTROL CABLES

1. Conductor of control cables shall be made of stranded, plain annealed copper.

2. Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables.

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

- core - Red, Black, Yellow or Blue
- core- Red & Black
- core-Red, Yellow & Blue
- core-Red, Yellow, Blue and Black

4. 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.

5. Cable selection & sizing:

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).

8.0 TESTS

1. 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.
2. 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.
3. 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.
4. However, if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of LOA, 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 reports for following type tests shall be furnished:

Sl	Type Test	Remarks
	Conductor	
1.	Resistance test	
	For Armour 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
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only
Sl	Type Test	Remarks
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	
	b) As a function of temperature	
28. *	Heating cycle test	
29. *	Impulse withstand test	

*Not applicable for 3.3/3.3kV grade cables.

9.0 CABLE DRUMS

1. 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 upto 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.
2. 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 stenciled 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

B-5 CABLE INSTALLATION METHODOLOGY

1.0 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 galvanizing 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.
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.

2.0 DESIGN AND CONSTRUCTIONAL FEATURE

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

2.2 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 40° C and 50° 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.

2.3 TRENCHES

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

2.4 GENERAL

1. The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.
2. 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.
3. Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:
    i. Meet all safety requirements
    ii. Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc

3.0 EQUIPMENT DESCRIPTION

3.1 CABLE TRAYS, FITTINGS & ACCESSORIES

1. 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.
2. 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.
3. 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.
4. 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

3.2 SUPPORT SYSTEM FOR CABLE TRAYS

Cable tray support system shall be pre-fabricated 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:

1. Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.
2. The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fittings and accessories shall be prefabricated factory galvanized.
3. 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
4. All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation.
5. Support system shall be able to withstand
    i. weight of the cable trays
    ii. weight of the cables (75 Kg/Meter run of each cable tray)
    iii. Concentrated load of 75 Kg between every support span.
    iv. Factor of safety of minimum 1.5 shall be considered.

3.3 PIPES, FITTINGS & ACCESSORIES

1. 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
2. GI Pipes shall be of medium duty as per IS:1239

3. 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.
4. Hume pipes shall be NP3 type as per IS 458

3.4 JUNCTION BOXES

1. 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.
2. Terminal blocks shall be 1100V 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. 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.

3.5 TERMINATIONS & STRAIGHT THROUGH JOINTS

1. 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. 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.
2. Straight through joint and termination shall be capable of withstanding the fault level for the system.
3. 1.1 KV grade Straight Through Joint shall be of proven design.

3.6 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 micron. 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.

3.7 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

3.8 TREFOIL CLAMPS

Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current.

3.9 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.

3.10 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 polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

3.11 GALVANIZING

1. 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.
2. 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.

3.12 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.

4.0 INSTALLATION

4.1 CABLE TRAY AND SUPPORT SYSTEM INSTALLATION

1. 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.
2. 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.
3. The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated.

4. 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.
5. All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled 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 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor.
6. In certain cases it may be necessary to site fabricate portions of trays, supports and other non standard 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.

4.2 CONDUITS/PIPES/DUCTS INSTALLATION

1. 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 water proof 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.
2. 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.
3. 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.

4. 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	1M
50 mm	2 M
65-85 mm	2.5M
100mm and above	3M

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

4.3 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.

4.4 CABLE INSTALLATION

1. Cable installation shall be carried out as per IS:1255 and other applicable standards.
2. For Cable unloading, pulling etc following guidelines shall be followed in general :
3. 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 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.

4. 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.
5. Cables shall be laid on cable trays strictly in line with cable schedule
6. 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 center 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 binded to trays/supports by aluminium strips at every five-meter interval and at every bend.
7. Bending radii for cables shall be as per manufacturer's recommendations and IS: 1255.
8. Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe.
9. 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.
10. 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.
11. Wherever few cables are branching out from main trunk route troughs shall be used.
12. Wind loading shall be considered for designing support as well Cable trays wherever required.

13. Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.
14. 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.

4.5 SEPARATION

1. At least 300mm clearance shall be provided between:
   - HT power & LT power cables,
   - LT power & LT control/instrumentation cables,
2. At least 600mm clearance shall be provided between
   - HT power and LT control/ instrumentation cables
3. 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
2C,3C	NIL
5C	1
7C-10C	2
14C and above	3

4.6 DIRECTLY BURIED CABLES

1. 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.
2. 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.

3. 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 centers, 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 aluminum 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
4. While crossing the floors, unarmored cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

4.7 CABLE TERMINATIONS & CONNECTIONS

1. 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.
2. 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.
3. 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.
4. 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.

5. 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.
6. All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

B-6 SCADA

1.0 GENERAL

1. 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.
2. 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.
3. 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 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 authorised 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 GAIL Site for O & M period. Please refer relevant chapter for Nos. of Web Client Licenses for remote monitoring, Nos. of OWS/EWS/Historian with location.

viii. Performing self-monitoring and diagnostic functions

4. 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.
5. 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.
6. 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.
7. 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 BHEL/GAIL Representative.
8. 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-airconditioned area shall be suitable for operating in ambient temperature of 50 Deg C minimum.

9. 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.

2.0 SCADA CONTROLLER SYSTEM:

2.1 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.

2.2 MAIN CONTROL /CMCS ROOM SCADA SHALL HAVE THE FOLLOWING FEATURES:

1. Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.
2. 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.
3. 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 nonvolatile 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.

4. 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.

3.0 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:

1. Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator work station.
2. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.
3. If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility
4. 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.
5. The design and installation of the system bus shall take care of the environmental conditions as applicable.
6. 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
7. Cat 6 UTP or fiber optic cables shall be employed.
8. The Contractor shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.
9. 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 for 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.

4.0 HUMAN MACHINE INTERFACE SYSTEM (HMIS)

1. HMIS configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.
2. 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.
3. For communicating the generation data of plant in GAIL, the SCADA system shall be interfaced/ connected with server of GAIL on OPC Protocol. The details of GAIL SYSTEM shall be furnished during the detailed engineering.
4. Graphical Interface Unit (GIU) / Operator work station (OWS) shall perform control, monitoring and operation (as applicable) for plant equipment's connected with SCADA system.
5. 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.
6. SCADA System shall also be provided with an 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.
7. In addition to a desktop based EWS, vendor shall also provide dedicated portable (laptop) based EWS.
8. 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.
9. The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.
10. 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.

11. 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.
12. 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.
13. 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.
    a. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).
14. 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. GIU shall be ruggedly designed to withstand hard environments like high temperature, shock and vibration.
15. In addition to GUI Display, one 50 Inch LED display shall be provided at SCADA Room.
16. 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.
17. SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.
18. 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.

19. 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.
20. All programming functionalities shall be password protected to avoid unauthorized modification.

5.0 PROGRAMMING FUNCTIONALITIES

1. 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
2. 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.
3. All programming functionalities shall be password protected to avoid unauthorized modification.

6.0 SOFTWARE REQUIREMENT

1. 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 documentation and program listing so that it is possible for the Employer to carry out modification at a later date.
2. The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
3. Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry.
4. 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).
    c. Any other protocol on which the offered equipment (by Contractor) will communicate with SCADA
5. The system shall have user friendly programming language & graphic user interface.
6. 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.

7. 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.
8. 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.
9. 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.
10. All the SCADA Software with license Key shall be handed over to GAIL on the DVD/CD media. All the hardware and software shall be licensed to GAIL.

7.0 PARAMETRIC REQUIREMENTS

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

1. 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).
2. Adjustment Command: - 0.5 to 1 second.
3. On screen Updating and All Control related displays: - 1 second.
4. Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays: - 1 to 2 seconds.
5. 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.

8.0 INPUT/OUTPUT MODULES

1. The SCADA system should be designed according to the location of the input/output cabinets as specified.
2. 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.
3. 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.
4. 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.
5. Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator.
6. The I/O Module shall have the following features:
    i. Power supply monitoring.
    ii. Contact bounce filtering.
    iii. Optical isolation between input and output signals with the internal circuits
    iv. 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.
7. 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.
8. 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.
9. 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.

9.0 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:

1. 10 % spare channels in input/output modules fully wired up to cabinets TB.
2. 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.
3. 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.
4. Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.
5. 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.
6. The Data communication system shall have the capacity to handle the additions mentioned above.
7. 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.
8. The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

10.0 OPERATOR INTERFACE DISPLAYS/LOGS/REPORTS

1. Suitable Operator Interface Displays/Logs/Reports for control operation & monitoring shall be provided. The details shall be finalized during detailed Engineering stage.
2. 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**
a)	Control displays (group/sub-group/ sequence/loop)	(On as reqd. basis subject to 100 minimum)
b)	P&ID/ mimic display	25
c)	X-Y Plot (with superimposed operating curves + using user selectable stored data)	25+25
d)	Group displays	30
e)	Operator guidance message	20
f)	System status & other diagnostic display	on as required basis

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.

11.0 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.

v. 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.

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

Sl.no	**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, SCB/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
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

12.0 SCADA PANEL/CABINET/CONTROL DESK/FURNITURE

1. The SCADA cabinets shall be IP-22 protection class.
2. 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.
3. 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.
4. 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.
5. Cabinet doors shall be hinged and shall have turned back edges and additional braking where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable 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.

6. 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 manufacturer standard
    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
7. 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.
8. 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.
9. The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.
10. 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.
11. One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.
12. All the furniture shall be of reputed make (Godrej or Equivalent).

13.0 HMIPIS HARDWARE

1. 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.

2. 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.
3. 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.
4. 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

4	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.
5	Monitor (color)	Min 22" TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz, Graphic Memory = 16 MB
6	Removable bulk storage drive	1 TB (minimum)
7	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
8	DVD R/W	16x or higher for EWS and OWS
9.	Keyboard	ASCII
10	Pointing Device	Mouse
11	Additional general purpose software (for using over network by servers/workstations/PCU)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.
12	Software	MS. Windows latest, MS Office Editor (EXCEL,WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.

- 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)

14.0 SUPPLY OF OUTDOOR WIRELESS ACCESS POINT

1. 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.
2. Bidder to note that Wireless Access Point is for BHEL/GAIL'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.

15.0 ADDITIONAL CLAUSE

Please refer to the other relevant Chapters for additional clause, if any related to this section of specification.

16.0 FACTORY ACCEPTANCE TEST (FAT)

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

17.0 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.

1. It shall be complete in all respects including antenna, all cables, processing equipment, etc.
2. All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.
3. 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.
4. 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.
5. The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.
6. 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.
7. 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 devises shall be in scope of contractor.
8. The system shall have provisions for combination of any of the following output signals:
    a) NTP (network time protocol) 100Mbits Ethernet port
    b) IRIG-B00x (TTL, pulse width modulated signal)
    c) x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
    d) Any other output port as may be required for the offered system.

e) Alarm status contact indicating healthy status of system

9. 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.
10. 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.

18.0 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**	
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**	
		Minimum **Four or AS REQUIRED** Nos of gigabit 10/100 base T Ethernet ports to be provided.

B1	Firewall Interfaces	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.
C2	NAT & PAT	Dynamic NAT as well as one to one NAT
		Port / IP Address Forwarding 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.
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	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

	features	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.

B-7 INSTRUMENTATION AND COMMUNICATION CABLE

1.0 COMMUNICATION CABLE (OPTIC FIBRE CABLE)

1. Optic Fiber cable shall be 8/12 core, galvanized corrugated steel taped armored, 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.
2. 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.
3. All testing of the optic fiber cable being supplied shall be as per the relevant IEC, EIA and other international standards.
4. Bidder to ensure that minimum 50% (but not less 4) cores are kept as spare in all types of optical fiber cables
5. Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.
6. Spliced/ Repaired cables are not acceptable.
7. Penetration of water resistance and impact resistance shall be as per IEC standard.

1.1 COMMUNICATION CABLE (MODBUS)

a) 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.

2.0 INSTRUMENTATION CABLES

2.1 COMMON REQUIREMENT

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

2.2 Specific Requirement

S No.	Property	Requirement

	Type of Cable	F and G Type cables
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 1014 at 20 deg. C & 1x1011 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 /pair 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
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 mm2,No.ofstrands=7, Dia of strands =0.3 mm
8.	Drain wire provided for overall shield	Yes. Size=0.5 mm2, No.of strands=7,Dia of strands=0.3mm Annealed Tin coated copper
E. FILLERS		
1.	Non-hygroscopic, 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 ASTMD-2863	29%
6.	Minimum Temperature index as per ASTMD-2863	250 deg.C
7.	Maximum acid gas generation by weight as per IEC-60754-1	20%
8.	Maximum Smoke Density Rating as per ASTMD-2843	Maximum 60%
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		
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 above12 pairs

B-8 EARTHING SYSTEM

1.0 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 earthling 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 earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

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

1.1 EARTHING DESIGN REQUIRMENT

1. 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.
2. Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system.

1.2 CODES AND STANDARD

1. 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
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.

2. 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.
3. 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.

2.0 EARTH ELECTRODE

1. 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.

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

2. 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.

2.1 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:-

1. High conductivity, improves earth's absorbing power and humidity retention capability, non-corrosive in nature having low water solubility but highly hygroscopic.
2. 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.
3. Resistivity of less than 0.2 ohms -meter.
4. 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.
5. 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.

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

1. Galvanized 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 form mechanical defects.
2. 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.
3. 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.

2.3 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.

1. 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 armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour 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.

2. 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 shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.
3. 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.
4. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.
5. 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.
6. 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.
7. 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.
8. 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.
9. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

10. 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.
11. 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.
12. Earth pits shall be treated with earth enhancement compound if resistivity is more than 20 ohm meter.
13. 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.
14. Contractor shall obtain all necessary statutory approvals for the earthing system before charging of the plant and electrical equipment.

3.0 TECHNICAL DETAILS FOR AC EARTHING SYSTEM

1. 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.
2. The Contractor shall furnish the detailed design and calculations as per IEEE 80/IS 3043 for Employer's approval for equipment earthing.

a) Conductors above ground level and in built up trenches -Galvanized steel
b) 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)
c) Earth electrodes - Mild steel rod of diameter 40mm or Copper bonded steel rod of dia not less than 17 mm
d) Life Expectancy - 25 years
e) Fault Level - Mentioned Elsewhere
f) Min. Steel corrosion - As per IS 3043
g) Soil Restivity -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
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 Horse power motor	--	8 SWG GS wire
7	Control panel & control desk	--	25 x 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

3. 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.
4. 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.

5. Bidder shall also interconnect the earthing system of Solar PV plant with GAIL existing earthing system wherever available (applicable for Solar Projects being setup inside existing GAIL Projects).
6. 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.
7. 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 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

1. 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), SCB Mounting structure, Module Frames etc.
2. System Requirement for the solar array DC earthing:
    a. Conductors buried in earth -GS Flat or CCS
    b. Conductors above ground level -GS Flat or CCS
    c. Earth Electrode -32 mm or higher dia MS Rod or Copper bonded Steel rod of dia. not less than 14 mm
    d. Life Expectancy -25 Years
    e. System fault level -5 KA for 1 Sec.
    f. Soil resistivity -Actual as per site conditions
    g. Min. Steel corrosion -As per IS 3043
3. Each Module mounting structure (MMS), SPV Module frames, mounting arrangement for String Combiner 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.

4. 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.
5. Earthing conductor for connection to structure and equipment may be kept on the ground below MMS. However, these conductors shall be laid 300 mm below the ground along the pathway and/or crossing the pathway.
6. 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.
7. 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 3-B: Electrical Scope and Supply &Services
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.

13. Contractor shall seek owner's approval for connecting solar array earth mesh with any other earth mat/earth grid of the solar PV plant.
14. 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.
15. 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 EARTHING SCHEME FOR FLOATING SOLAR SYSTEM

Bidder shall propose earthing scheme for Floating solar arrays and other floating equipment along with necessary design calculations during detailed engineering as per system requirements and applicable standards. The same will be reviewed by GAIL/BHEL.

B-9 PLANT ILLUMINATION SYSTEM

1.0 GENERAL

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.

2.0 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.

3.0 LIGHTING SYSTEM DESCRIPTION FOR CMCS AND INVERTER ROOM

4. 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.
5. 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.

4.0 LIGHTING FIXTURE, LAMPS & ACCESSORIES

1. All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site.
2. 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.
3. 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 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.

4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified alongwith finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere.

5.0 LED LUMINAIRES:

5.1 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 lighting Services. Part-2 Performance Requirements.
16103(Part I):2012 LED modules for General lighting Safety Requirements.
15885(Part 2/Sec. 13) :2012 Lamp 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 Luminarie 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 (Part 3/Sec. 2) Electromagnetic compatibility (EMC) – Limits for Harmonic emission – THD < 15% (equipment, input current < 16 Amps. per phase.
IS 9000 (Part 6) Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
IS 15885 (Part 2/Sec. 13) Lamp control gear: particular requirements for DC or AC supplied electronic control gear

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
IES-LM 80 along with TM 21/ IS 16105 Lumen Depreciation and Rated life of LED chip
IES-LM 79 / IS 16106 Luminaire optics and color parameter and electrical parameter

5.2 LED LIGHTING SYSTEM

1. 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.
2. 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.
3. 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.
4. 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%.

5. 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.
6. 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.
7. 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
8. 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).
9. Wires of different phase shall normally run in separate conduit.
10. 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.
11. Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location.
12. Incandescent lamps may be used only with DC Lighting.
13. Electrification of all building shall be carried out as per IS 732-1989, IS 4648-1968 and other relevant standards.
14. 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.
15. All luminaries and their accessories and components shall be of type readily replaceable by available Indian makes.
16. 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

6.0 JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES

1. Junction box for indoor lighting shall be made of fire-retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.
2. 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.
3. All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.
4. Conduits, Pipes and Accessories:
5. 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.
6. 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: 55 degree of protection and those used indoor shall be suitable for IP: 4X degree of protection.

7.0 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

8.0 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 hot-dip galvanized as per relevant IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall

be min. 70 micron. 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 (Avg 10 Lux).

Hot dipped Galvanized hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable

9.0 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.

10.0 AVERAGE ILLUMINATION LEVEL

Location	Average Illumination Level (Lux)	Type of Fixture
Control Room	300	LED Luminaries
Store Room	200	LED Luminaries
Switchgear Room	150	LED Luminaries
Inverter Room	150	LED Luminaries
Street lighting	10	LED Luminaries
Yard and other locations	20(general)	LED Luminaries

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

B-10 AUXILIARY POWER SUPPLY SYSTEM

1.0 GENERAL

1. Auxiliary power supply arrangement shall be in line with tender indicative AC SLD. Each Inverter Room/local 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. Alternately, 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.
2. 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
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		✓	✓
13	switchgear space heater	✓		
14	Illumination, Fan supply etc	✓		
15	Module washing system	✓		
16	Other non-critical auxiliary loads	✓		

3. 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.

4. 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.
5. 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.
6. The Bidder can provide alternate arrangement with suitable redundancies such as power pack with required backup for switchgears located at local pooling/inverter station.
7. 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.
8. 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.
9. 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 per actual.
    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.

2.0 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

1. The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The overall efficiency of UPS shall be at least 80% on full load.
2. 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.
3. 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
4. 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 charger shall be design for input supply variation of ± 10% and frequency variation of ± 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.
5. 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.
6. 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.

7. 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.
8. Equipment enclosures shall match and line up in assemblies of freestanding floor mounted cabinets designed for indoor service.
9. 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.
10. UPS and Battery Bank should be kept in separate enclosures. Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings. The location and enclosures of UPS and Battery banks shall be finalized during detail Engineering after approval from GAIL/BHEL.
11. The cabinets shall be IP-42 protection class for indoor application and IP55 or better for outdoor application.
12. The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.
13. 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.
14. One set of tools shall be provided for maintenance and testing purposes.

3.0 BATTERY CHARGER

1. 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 minimize 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 ± 10% and frequency variation of ± 5%.

2. Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle or Boost charging.
3. 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.
4. 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.
5. When on automatic control mode during Trickle charging, the Charger output voltage shall remain within +/-1% of the set value for AC input voltage variation of +/-10%, frequency variation of +3/-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.
6. 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 limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be Vernier type.

7. 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.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. 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.
14. 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.

15. 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.
16. The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective Charger.
17. Digital or analog indicating instruments shall indicate DC current, DC voltage & AC voltage.
18. 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.
19. 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.
20. 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.
21. All acceptance and routine tests as per the manufacture recommendations and relevant standards shall be carried out.
22. The cabinets shall be IP-42 protection class for indoor application and IP55 or better for outdoor application.
23. 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.

4.0 BATTERY: NICKEL-CADMIUM BATTERY

4.01 BATTERY PARAMETER

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

4.02 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 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	

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.

4.03 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.

4.04 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 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

4.05 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.

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.

5.0 BATTERY: LEAD –ACID PLANTE BATTERY

5.01 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

5.02 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).
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 and Indian Electricity Acts

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.

5.03 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.

5.04 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.

5.05 Construction Features: -

a) 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.

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.

b) Vent Plugs

Vent plugs shall be provided in each cells. They shall be ant splash 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.

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 : 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.

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) 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.

f) 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.

g) 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.

h) 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.

i) 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 plante 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.

6.0 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 No.s
b	Set of hydrometer syringes suitable for the vent holes in different cells	2 No.s
c	Thermometer for measuring electrolyte temperature	2 No.s
d	Specific gravity correction chart	2 No.s

e	Wall mounting type holder made of teak wood for hydrometer & thermometer	2 No.s
f	Cell testing voltmeter (3-0-3 V)	2 No.s
g	Alkali mixing jar	2 No.s
h	Rubber aprons	5 No.s
i	Pair of rubber gloves	
j	Set of spanners	5 No.s
k	No smoking notice for each battery room	2 No.s
l	Goggles (industrial)	2 No.s
m	Instruction card	2 No.s
n	Temperature indicator	1 No. per room
o	Cell lifting facility	1 set per room

7.00 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**
(i)	Closing Coil	Actual as per datasheet	First minute load
(ii)	Tripping Coil	Actual as per datasheet	Last minute load
(iii)	Spring Charging Motor	Actual as per datasheet	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
(i)	Closing Coil	Actual as per datasheet	First minute load

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.

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.

8.00 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.

8.01 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:

a) Output voltage, frequency and the correct operation of meters;

b) Operation of all control switches and other means to put units into operation.

c) Functioning of protective and warning devices.

8.02 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.

8.03 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.

8.04 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.

8.05 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.

8.06 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.

8.07 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.

8.08 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.

8.09 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.

B-11 LIGHTNING PROTECTION SYSTEM

1.0 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 earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

1.1 LIGHTNING PROTECTION DESIGN REQUIRMENT

The object of a lightning protection system is to protect buildings/structure and equipment 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.

1.2 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 4759	Hot-dip galvanized steel coating on structural steel and other elements
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: 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 and latest amendments *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 ink, 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.

2.0 DOWN CONDUCTORS

1. Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.
2. 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.
3. All joints in the down conductors shall be welded type.
4. 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.
5. 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.

6. All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.
7. Lightning conductors shall not pass through or run inside GI Conduits.
8. Testing link shall be made of galvanized steel of size 25x 6mm.
9. Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths oxide layer or foreign material.

3.0 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY

4.1 Codes and Standards

• IS/IEC 62305: PROTECTION AGAINST LIGHTNING
• NF C 17-102: LIGHTNING PROTECTION WITH EARLY STREAMER AIR TERMINATION ROD

3.2 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 earthling 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 lighting protection system.

3.3 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY WITH E.S.E AIR TERMINAL

a. Solar array shall be protected from direct lightning stroke with Early Streamer Emission air terminal in accordance to NF C 17-102.

b. 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 BHEL for approval.

c. 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.

d. 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.

e. 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.

f. 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 failure. Foundation for the mast shall be M20 Grade concrete or better with minimum depth of 1200 MM.

4.0 LIGHTNING PROTECTION SYSTEM FOR BUILDING AND ENCLOSURE

1. 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.
2. ESE Air Terminal shall not be used for lightning protection of Metering yard, if applicable.

5.0 LIGHTNING PROTECTION FOR FLOATING SOLAR SYSTEM

1. Bidder shall propose lightning protection scheme for Floating solar arrays and other floating equipment along with detailed calculations during detailed engineering as per system requirements and applicable standards. The same will be reviewed by BHEL.

B-12 METERING SYSTEM

1.0 GENERAL

1. Energy meter (0.2s accuracy class) suitable for ABT requirement with metering panel as required shall be conforming to STU/CTU/PGCIL requirement. The quantity of the energy meters shall be as per indicative tender SLD.
2. For measurement of Auxiliary power consumption, MFM in ACDB incomer shall be provided by the bidder.
3. Meter shall be suitable for interfacing for synchronizing the built-in clock of the meter by GPS time synchronization equipment. Bidder shall synchronize the meter using GPS time synchronization equipment. All the hardware required for synchronization shall be in scope of bidder.
4. The ABT meters supplied under this contract shall also meet the requirement of respective RLDC/State power Utilities.
5. This metering system shall have following features:

   a) Meters shall be microprocessor-based MWH meters having an accuracy class of 0.2S or better. MVARH meters shall have accuracy class of 0.5 or better.

   b) These meters shall have provision for downloading of data through an optical port and /or through RS 232/485 port.

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

2.0 TECHNICAL REQUIREMENTS OF ENERGY METERS FOR ABT REQUIREMENT

Contractor shall supply energy meters along with metering station, MRI as per the technical specification given below:

1. Shall be microprocessor-based conforming to IEC 62052-11, IEC 62053-22, IS 14697
2. Shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4 wire principle suitable for balanced/ unbalanced 3 phase load.
3. Shall have an accuracy of energy measurement of at least Class 0.2S for active energy and at least Class 0.5 for reactive energy.
4. The active and reactive energy shall be directly computed in CT & VT primary ratings.

5. The reactive energy shall be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (Lag) when active import, MVARh (lead) when active export, MVARh (Lead) when active import.
6. Two separate registers shall be provided to record MVARH when system voltage is >103% and when system voltage is < 97%.
7. Shall compute the net MWh and MVARh during each successive 15-minute block metering interval along with a plus/minus sign, instantaneous MWh, instantaneous MVARh, average frequency of each 15 minutes, net active energy at midnight, , net reactive energy for voltage low and high conditions at each midnight.
8. Each energy meter shall have a display unit. It shall display the net MWh and MVARh with a plus/minus sign and average frequency during the previous metering interval; peak MWh demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with a plus/minus sign, date and time; and instantaneous current and voltage on each phase.
9. All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable. All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.
10. At least the following data shall be stored before being over-written for the following parameters.

	Parameters	Details	Min No of days
1.	Net MWH	15 min block	40days in meter
2.	Aver Freq	15 min block	40days in meter
3.	Net MVARH for V > 103%	15min block	40days in meter
4.	Net MVARH for V < 97%	15min block	40days in meter
5.	Cumulative Net MWH at every midnight		10 days in meter/ 40 days in PC
6.	Cumulative Net MVARH for V> 103% at every midnight		10 days in meter/ 40 days in PC
7.	Cumulative Net MVARH for V < 97% At every midnight		10 days in meter/ 40 days in PC
8.	Date and time blocks of VT failure on any phase.		

11. Shall have a built-in clock and calendar with an accuracy of less than 15 seconds per month drift without assistance of external time synchronizing pulse.

12. Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment being supplied by the contractor.

13. The voltage monitoring of shall be inbuilt feature provided to signal failures to the Substation Automation System, The meter shall be suitable to operate with power drawn from the VT supplies. The burden of the meters shall be less than 2 VA.

14. The power supply to the meter shall be healthy even with a single-phase VT supply. An automatic backup, in the event of non-availability of voltage in all the phases, shall be provided by a built-in long-life battery and shall not need replacement for at least 10 years with a continuous VT interruption of at least 2 years. Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meter. Incase data downloading is not possible

15. In absence of VT supply, meter with provision of 220V DC auxiliary power shall be provided. Date and time of VT interruption and restoration shall be automatically stored in a non-volatile memory.

16. Shall have an optical port on the front of the meter for data collection from either a hand held meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software. The contractor shall supply the MRI and/or notebook complete with all optical interface unit required.

17. The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ and test terminal blocks shall be provided for the same.

18. Each meter shall have a unique identification code provided by the Owner and shall be permanently marked on the front of the meter and stored in the non-volatile memory of the meter.

3.0 TYPE TEST REQUIREMENT FOR ENERGY METER

All Type Test Reports shall be provided as per IEC 62052-11, IEC 62053-22, IS 14697.

4.0 Suitable PQ meters (0.2 accuracy class) shall be provided at plant output for measurement of required electrical parameters such as active power, reactive power, power factor, voltage, current, frequency, power quality paraments, etc. PQ meter shall have TCP/IP port for SCADA and PPC communication. Selected PQ meters shall be able to measure grid frequency with minimum two digit after decimal point. CT and PT/CVT core used for PQ meters shall have accuracy class of 0.2S and 0.2 respectively.

SECTION-6 : TECHNICAL SPECIFICATIONS

C – CIVIL WORKS

C-1 BATHYMETRY, TOPOGRAPHY SURVEY & SOIL INVESTIGATION

1.0 TOPOGRAPHICAL SURVEY

The bidder shall conduct the Topographical Survey for the allocated Area in the proposed solar project. The scope of work and technical specification for the same is as below:

1.1 Scope of Work

- The bidder shall carry out the Topographical Survey/Bathymetry survey (if required) and preparation of Plans (Maps) and report of the assigned entire area/areas indicated for locating the Solar PV Power plant and its other systems.

- Carrying out the Benchmark (GTS) to site/sites under survey by parallel levelling, establishing, and constructing benchmark, grid and reference pillars in the field, and spot level survey of the entire area/areas at specified intervals and development of the contours. Bidder can also use Differential Global Positioning System (DGPS) for establishing the coordinates.

- Carrying out cross-section of river/canal taking spot levels at on an average 20 meters intervals or less depending upon the site conditions.

- Furnishing all field data & drawings in soft copy (on CDs) apart from hard copies.

- Furnishing of the survey report as described in detail in the succeeding paragraphs is also included in the scope of this work.

- The given google co-ordinates in specification indicates the tentative location of the area/areas to be surveyed for locating Solar PV Project/s.

- The location/area(s) indicated in Indicative layout, is subject to change that may be necessary during actual execution of the work.

- The work shall be executed according to the specifications and good standard practice necessary to fulfil the objective of the survey work, strictly in accordance with the instructions and satisfaction of the Owner.

- The Contractor shall carry out Benchmark by fly-levelling from nearest GTS Benchmark or available source as approved by the Owner and establish the same at two permanent Benchmark at each block. All subsequent transfer of levels shall be carried out with respect to these Benchmark. The work shall also include constructing permanent reference pillars at suitable locations as approved by the Owner. These reference pillars shall be labelled permanently with their respective coordinates and reduced levels for future use. The Bench Marks and reference pillars shall be shown on the survey drawings.
- While carrying benchmark to the project site, levels shall be established on the permanent objects like culverts etc. at least on one object in every one km. if available along with route with an adequate

description about the objects and levels shall be maintained & mentioned in the survey report to facilitate locating these objects later on.

- Latitude and Longitude: The work shall be carried out in UTM grids system. The contractor shall also establish the latitudes and longitudes of the corners of the project site. At least 50-meter width of the adjoining area shall also be covered in the survey for correlation with adjoining plots.

1.2 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 kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably, symbols of survey of India Maps), all hills and valleys within the area/areas is to be surveyed and plotted on maps by contours. Necessary levelling work of the entire area/areas are to be surveyed and plotted on maps by establishing horizontal location so that location and sketching of contours for the area/areas can be done at specified intervals and in specified scales on maps. Method of the survey, contour intervals etc. shall be decided by an owner on site 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.

- The field work shall be done with Total Station Equipment or DGPS 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) or the Plant North as directed by the Owner.

1.3 Contouring

- Contractor shall carry out spot level surveying at an interval of on an 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. The contours shall not be just interpolated but properly surveyed on the ground so that features falling between the two successive levels are also picked up. Sufficient points properly distributed over the entire area shall be located and levels taken so that accurate contouring can be done at places of sharp curvature or abrupt change in direction and elevation, points selected shall be close to each other. Salient points on ridge lines and valley lines shall also be measured.

- Transfer of levels shall always start from Main/Subsidiary stations whose levels are based on benchmark established in the survey area.

1.4 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. The topography drawing shall also cover at least 50-meter-wide area of the adjacent area (beyond the assigned plot area) and match the grids of the adjacent solar plot.
- All the maps should be prepared in digitized forms using computer software like AutoCAD – Release 2016 or as directed by Owner. The block of nameplate of all the drawings should be as per BHEL/GAIL standard. The Bidder has to submit AutoCAD .dwg file to the owner on demand in suitable drawing scale as required.
- Contractor shall have to submit all data pertaining to the Survey and Array layout in original (.dwg & .pdf format) to the Owner including all levels & co-ordinates in X-Y-Z format for the entire area in CD in scale.
- 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. Details of earlier uses of the site i.e. mining, quarrying, agriculture etc. The Existing drainage pattern of the site, the possibility of water-logging and high flood level of the area shall also be captured in the documents.

2.0 BATHYMETRIC SURVEY (if required)

Bidder shall conduct the Bathymetric Survey of the reservoir for the proposed floating solar project. The scope of work and technical specification for the same is as below:

2.1 Scope of Work

The Contractor shall carry out the Bathymetric Survey and prepare Plans (Maps) and report of the assigned entire area/areas indicated for locating the Floating Solar PV Power plant and its other systems. Intent of bathymetry survey is the mapping of the water body bed, with depth contours providing the size, shape, and distribution of underwater features.

Depth study may be carried out by the agency in entire identified pockets at an interval of 25m grid spacing using continuous echo sounding (single beam or multi beam) or profiler or any other sophisticated instrument. Necessary proposal for boundary of the floating solar blocks based on depth study at the identified locations shall be included in the assigned jobs.

Work shall cover mobilization of necessary equipment all other tools and materials, providing necessary engineering supervision and technical personnel, skilled and unskilled labour, necessary transport, demobilization, etc. as required to carry out the entire survey and interpretation of data and results, tables, charts and drawings. Carrying out the Benchmark (GTS) to site(s) under survey, 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. Mandatory permission/ statutory clearances required, if any, from local authorities shall be obtained by the agency.

After establishing Depth to Surface Area relations, the pocket area shall be studied with respect to water variation in the reservoir as per MDDL and FRL. The selected water body area shall always be below MDDL of Reservoir.

The bathymetric survey requires a wide range of base data. The report of the Bathymetric survey should include following points:

1. All the bathymetry data shall be plotted on scale of 1:1000.

2. Water depth chart with co-ordinates and water depth/level variation (Maximum & Minimum). Physical verification for water depth is to be shown in the bathymetry report along with photograph.

3. Highest & Lowest water level w.r.to TBM, also provide co- ordinates of water level measuring points and its date.

4. Bed area profile, levels with cross section is required. River center line with cross section profile at each 50m interval. Pictures/photos of the unusual conditions or formations under water to be provided.

5. Bathymetric report with recommendations (i.e., feasibility/usability, accessibility, impact of underwater streams/obstructions, requirement of wave barriers etc.,) for floating solar power plant.

6. AutoCAD drawings with co-ordinate and corresponding bed profile.

7. Location map, bathymetry map & contour map with all co- ordinates of survey area & boundary.

8. All the maps should be prepared in digitized forms using computer software like AutoCAD – Release 2020 or the latest.

9. All data pertaining to the Survey and Array layout in original (.csv, .dwg & .pdf format) including all levels & co-ordinates in X-Y-Z format for the entire area in scale in Pen Drive (3 nos.) and hard copy (3 no’s in A0 size).

10. 3D view of reservoir/riverbed.

Topographical survey of banks of water body/ lake shall also be carried out so as to decide suitable location of launching ramps.

The enclosed Vicinity Map indicates the tentative location of the area/areas to be surveyed for locating Solar PV Project/s.

The location/area(s) indicated in the **Vicinity Map**, is subject to change that may be necessary during actual execution of the work.

The work shall be executed according to the specifications and good standard practice necessary to fulfil the objective of the survey work, strictly in accordance with the instructions and satisfaction of the Owner.

3.0 GEOTECHNICAL INVESTIGATION SCHEME.

3.0.1 Geotechnical investigation for the scope of work shall be done by the bidder. The scheme for geotechnical investigation shall be as given at Clause 3.1 and shall be approved by the 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 proposed by him from the Owner before undertaking the geotechnical investigation work.

3.0.2 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.

3.0.3 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.

3.0.4 Detailed Geotechnical Investigation including geotechnical investigation of reservoir bed has to be carried out by the bidder in line with the Technical Specification. Bidder shall carry out the design of foundation, selection of anchoring system etc. based on the approved geotechnical report.

3.1 Scheme of Geotechnical Investigation

3.1.1) Minimum 1 No. of borehole of 5m depth (in ground) shall be carried out in every 12.5 acres of land & 40 acre of reservoir as applicable. Few ERT & TPs shall be carried out as per layout. Tampering/damaging of reservoir bed is not allowed.

3.1.2) The depth of boreholes shall be 5.0m. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20%, met within a borehole. 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 1.5 m interval or at change of strata.

3.1.3) The laboratory tests shall be conducted on soil, rock & water samples collected during field investigations in sufficient numbers as approved by Employer. 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 Owner's 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.

3.1.4) Geotechnical investigation work shall be executed by NABL accredited Contractor/labs.

3.2 Foundation System

Foundation systems for various facilities shall be designed and adopted as per approved geotechnical investigation report.

C-2 SITE LEVELLING AND GRADING

1. SITE LEVELLING AND GRADING:

1.1 Site levelling works involves the following works:

1) All works related to site clearance including removal of bushes, trees, levelling, grading, finishing and other additional works shall be carried out by the Contractor. Mandatory permission/ licenses/ statutory clearances from Competent Authorities for site levelling activities like removal of tree and bushes, undertaking blasting related works, disposal of cutting material etc. shall be carried out by the contractor.

2) Site grading level shall be fixed with due reference to site drainage of the whole area, existing drainage pattern, and system requirements.

3) 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.

4) Consideration from the boundary and fencing requirements.

2.2 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 levelling 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 ensure 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 Contractor, 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 BHEL/GAIL for approval.

2.3 Fill shall normally be made up of Cohesive Non-swelling material capable of being compacted upto 95% Standard Proctor density. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Contractor himself. The slope at the edge of graded areas shall not be flatter than 1:1.5 (1 vertical to 1.5 horizontal) in cutting and 1:2 in filling. In case of fill by rock material, the same shall be done in line with relevant Indian Standard.

2.4 All buildings 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.

2.5 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 roadside slope, storm water ditches/drainage, embankment slopes, inter levelled patches slopes etc. as per design requirements.

2.6 Suitable sand erosion control measure shall be provided in case any sand dune falls inside the plot area. The same may be made with Random rubble/boulder/stone pitching/concrete blocks etc. Bidder shall also provide sufficient grass/buses/trees covers on these dunes.

2.7 Bidder shall also provide suitable sand erosion protection measure around the foundation as mentioned at relevant places in the technical specification.

C-3 FENCING AND GATE

1.0 General

The scope of work includes providing either or combination of following for the proposed Solar Plant for the peripheral and common boundary.

1.1 Chain Link Fencing for Yard (Inverter Platforms, Transformer Yard, Switch Yard, etc.)

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. The minimum size & requirements of the Gate's including all items shall be decided during detail engineering.

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.

C-4 SEDIMENATION TANKS

1.0 GENERAL

Bidder to follow following De-sedimentation plan for the project and construct the 3 nos. of de-sedimentation tanks for the project accordingly (Refer proposed De-sedimentation plan attached in tender drawings):

a) R-3 shall be fully converted to sedimentation tank for PC-I reservoirs.

b) In addition to this, new sedimentation tanks with silting chamber will be constructed one each before inlet to Reservoirs R-1, R-2, and another in between the inlet of Reservoirs R-5 & R-6 as per De-sedimentation plan.

c) New Sluice gates are also to be placed before new sedimentation tanks for control on flow of water in siltation tanks.

1.1 Descriptions of sedimentation tank (tentative min capacity of 35 cum) with desilt pump (as per tender drawing/spec):

i. The top of the UG tank shall be minimum 250 mm above FGL.

ii. The tank shall have clear free board of 300 mm above Maximum Water Level (MWL).

iii. The tank bottom shall have a slope of 1:100 towards drainage sump (500x500x500 mm deep). The slope shall be provided either in structural slab or in screed concrete (1:2:4) trawl finished. 1000x1000 mm size Manhole in roof slab and 20 mm MS/CI rung ladder shall be provided for easy access to the storage tank and silting chamber for periodic cleaning. The manhole shall be covered with RCC precast cover.

iv. 50x50x6 mm MS angle with lugs shall be provided around precast cover and tank slab opening for edge protection. Rungs shall be painted with 2 coats of epoxy paint over 2 coats of primer. One dewatering pump of required HP with power connection shall be provided for cleaning purpose.

v. The underground RCC tank shall be designed for following load conditions:
   a) External earth pressure + hydrostatic pressure due to ground water table (to be considered at FGL for design purposes) + Surcharge of 20 kN/Sqm and Tank Empty.
   b) Tank full up to MWL and no external loads

vi. The design shall conform to IS: 3370 with maximum crack width of 0.1mm for wall, bottom slab and roof slab. Min. grade of concrete shall be M30 conforming to IS: 456. Suitable construction joints shall be provided as per provisions of IS: 3370 (Part 1). Water proofing admixture conforming to relevant BIS standard and of approved make shall be added to concrete as per manufacturer's recommendations.

vii. The underground tank shall be tested for water tightness as per the provisions of IS 3370 (Part-4). In case any leakage is noticed the same shall be repaired by injection of cement grout installing suitable nozzles around affected areas.

viii. Channel required for diversion of water during construction of sedimentation tank to be planned accordingly by contractor.

ix. The Design calculations, Layouts, drawings of sedimentation tanks, sizing calculation of Pumps etc. shall be submitted for review and approval of BHEL/GAIL before the start of works.

C-5 CIVIL & STRUCTURE WORKS - GENERAL DESIGN CRITERIA

1.0 GENERAL

This chapter covers the Specific technical and functional requirements. The design calculations and drawings for RCC structure, PEB Inverter Rooms, Steel structure, foundation system, road work, drainage, etc. shall be submitted for prior approval of BHEL/GAIL before the commencement of construction. The construction methodology for road works, drains shall also be submitted for BHEL/GAIL approval before the start of works.

All design of RCC and Steel structures shall be carried as per IS 456 and IS 800 respectively and other specific code as applicable to specific structures. Refer appendix-D1 for site specific design parameters.

2.0 CMCS, INVERTER ROOMS, SECURITY ROOM & STORE ROOM

The following structures shall be designed and provided by the bidder:

A. CMCS Building: For the operation and maintenance of SPV Plant one Central Monitoring and Control Station (CMCS) shall be provided. The CMCS building shall consist of the following:

1. Air-conditioned SCADA Room.
2. UPS and battery bank, ACDB Room (As applicable).
3. Store Room.
4. Supervisor room.
5. Toilets (Male and female).
6. Pantry.

UPS and battery bank, ACDB room shall be based on manufacturer recommendation, easy passage of O&M persons and cable trench layout required. The CMCS shall be RCC framed structure with bricks/concrete blocks masonry walls or PEB Type. The CMCS shall have entry lobby and portico with a roof for vehicle stoppage.

The minimum size & requirements of the CMCS Building & all items shall be as tender drawing title: **"Details of Central Monitoring & Control Station".**

B. Inverter Rooms/Inverter platform: Inverter rooms consist of PCU's, SCADA, LT panels, UPS &batteries, etc. shall be provided based on manufacturer recommendation, easy passage of O&M persons and cable trench layout required.

The inverter rooms/platforms shall be made of as mentioned below:

a) RCC framed structure with bricks/concrete blocks masonry walls, (Or)
b) Pre-Engineered Building in line with PEB technical specification. (Or)
c) outdoor platform with shed/canopy, subject to approval during detailed Engineering stage.

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 so as to provide sufficient space for their maintenance.

The layout, design, and drawings for all RCC/PEB buildings/outdoor platform, etc. and foundation system shall be approved from BHEL/GAIL before the start of works.

All buildings and allied works shall be designed to meet **NATIONAL BUILDING CODE** (SP: 07 2016) requirements. The finish floor level of all building shall be minimum 450 mm above from Finish graded level.

2.1 SPECIFICATION FOR RCC BUILDING FOR CENTRAL MONITORING AND CONTROLS STATION (CMCS) OR OTHER FACILITIES.

The CMCS building shall be made of RCC framed structure with bricks/concrete blocks masonry walls. The thickness of outer masonry walls shall be minimum 230mm in case of bricks and minimum 200mm thick in case of concrete blocks. The following detailed specification shall also be followed for RCC works:

2.1.1 Floor Finishes:

Switchgear/ Inverter rooms:	Cement concrete flooring with ironite hardener and epoxy floor paint finish.
SCADA room:	Heavy duty vitrified ceramic tiles
Battery room:	Acid Alkali resistance tile flooring or acid alkali resistant
Lobby	Heavy duty vitrified ceramic tiles and skirting
Toilet	Heavy duty anti-skid ceramic Tiles and dodo 2100 mm
Steps	Kota stone/Granite- 20 mm thick
Storeroom	Cement concrete flooring with ironite hardener.

(a) Flooring for air-conditioned areas area shall be provided with vitrified ceramic tiles of size 600X 600 mm of min 9 mm thickness, laid with 3 mm ground joints as per approved pattern. Cement concrete flooring shall conform to IS 2571.

(b) The floor finish for toilet shall be vitrified ceramic anti-skid tiles and Dado glaze ceramic tiles upto 2.1m shall be used. The normal size of Ceramic tiles shall be 300mm x 300mm x 9mm and shall comply IS 15622.

2.1.2 False Celling:

The SCADA room shall be provided with false ceiling of 15 mm thick mineral fiber board, in tile form of size 600mm x 600mm, along with galvanized light gauge rolled form supporting system in double web construction pre painted with steel capping, of approved shade and colour, to give grid of maximum size of 1200x600 mm as per manufacturers details including supporting grid system, expansion fasteners for suspension arrangement from RCC, providing openings for AC ducts(if required), return air grille (if required), light fixtures, etc., all complete.

2.1.3 Roof Finishes:

a) Roof of the Building shall consist of Cast-in-situ RCC slab with decking sheet (RCC slab with permanent formwork)/temporary removal staging. The slab formwork decking sheet shall be permanently colour coated profile sheet with minimum 0.6mm thickness of grade SS255 as per ASTM A653M / grade G250 as per AS 1397 coated with zinc of class designation Z275 or aluminium zinc alloy of class designation AZ150 or similar. The decking sheet shall meet the strength, deflection, and other functional requirements.

b) The Bidder can also provide Roof of the building as Cast-in-situ RCC slab conforming to Indian code.

c) The roof of the building shall be waterproof with Polymeric membrane type waterproofing as per DSR. The roof shall be designed for a minimum superimposed load to 150 kg/m2.

d) For efficient disposal of rainwater, the runoff gradient for the roof shall not be less than 1:100 and the roof shall be provided with RCC/PVC water gutter, wherever required. Gutter shall be made watertight using suitable watertight treatment. This gradient can be provided either in structure or subsequently by screed concrete 1:2:4 (using 12.5 mm coarse aggregate) and/or cement mortar (1:4). However, minimum 25 mm thick cement mortar (1:4) shall be provided on top to achieve smooth surface. The roof of a building projection may be flush with the building external walls. The parapet wall shall be provided above the roof beam. The Height of parapet wall shall be minimum 300 mm above the top of roof level. Structural steel hand railings of minimum 700 mm height shall also be provided over the parapet wall.

e) The bidder shall also provide rainwater harvesting system for CMCS building roof.

2.1.4 Viewpoint:

RCC terrace of CMCS building shall also work as viewpoint. Viewpoint shall be used for security purposes and a viewing gallery. Suitable RCC half landing staircase shall be provided for access to the roof of the CMCS building.

2.1.5 Windows, Doors, Ventilators and Rolling Shutters:

a) Doors, windows and ventilators of air-conditioned areas, entrance lobby of all buildings, and all windows and ventilators of CMCS building shall have, powder coated (minimum thickness of powder coating 50 microns) aluminium framework with glazing. The window shall be provided with suitable aluminium grills.

b) Doors of toilet areas shall be made of steel framed solid core flush shutter as per IS 2202. The minimum size of the door provided shall be 2.1 m high and 1.2 m wide. However, for toilets minimum width shall be 0.75 m and office areas minimum width shall be 1.20 m.

c) The Bidder can also propose **uPVC** extruded casement/ sliding windows and doors with complete fitting and accessories as per items mentioned in DSR latest.

d) Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sunshade over the openings with 300 mm projection on both sides of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and door openings except for main entrance door of the control room where the projection for portico shall be provided.

e) Rolling shutter (Mechanical gear operated). Rolling shutters shall be fabricated from 18-gauge steel and machine rolled with 75 mm rolling shutter with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS: 2108 and shall be designed to withstand a wind load without excessive deflection. Metal rolling shutters and rolling grills as IS: 6248

2.1.6 Glazing:

a) All accessible ventilators and windows of all buildings shall be provided with min. 4mm thick float glass, tinted for preventing solar radiations, unless otherwise specified.

b) For single glazed aluminium partitions and doors, toughened float glass of 10 mm thickness shall be used. All glazing work shall conform to IS 1083 and IS 3548.

c) The glass to used should be from a reputed brand/manufacturer and as approved by BHEL/GAIL. The glass should be free from distortion and thermal stress.

2.1.7 Paintings of wall and ceilings: Internal wall surfaces: SCADA room	-Acrylic Emulsion
All other rooms in plant buildings	-Acrylic Distemper
External faces of walls:	-Exterior emulsion paint
Walls of battery room (applicable for acid battery not applicable for dry battery)	-Acid alkali resistant paint, an exposed wall above Dado -2100 mm high Dado of acid alkali resistant tiling.
All Ceiling	-Acrylic Distemper

a) The paint shall be an anti-fungal quality of reputed brand suitable for masonry. All painting on masonry or concrete surface shall preferably be applied by a roller. If applied by brush, then same shall be finished off with roller. For painting on concrete, masonry, and plastered surface, IS 2395 shall be followed. Minimum 2 finishing coats of paint shall be applied over a coat of primer.

b) For painting on steelwork and ferrous metals, BS: 5493 and IS: 1477 shall be followed. The type of surface preparation, thickness, and type of primer, intermediate and finishing paint shall be according to the painting system adopted.

c) Ceiling of all rooms except Battery room shall be whitewashed. The ceiling of Battery room (if provided) shall be acid/alkali resistant paint. A standard colour scheme for the different buildings/structures shall be prepared by the Contractor and the approval of the Owner shall be obtained before the commencement of work.

2.1.8 Plumbing and sanitary:

CMCS building room shall have attached toilet for both genders. Each toilet shall have the following minimum fittings of ISI approved of a reputed brand (subject to approval from Engineer in charge).

1) Wall mounted WC (Western type) 390 mm high with toilet paper roll holder and all fittings.

2) Wall mounted Urinal (430 x 260 x 350 mm size) with all fittings for the male toilet only.

3) Washbasin (550 x 400 mm) above the platform with all fittings.

4) Bathroom mirror (600 x 450 x 6 mm thick) hardboard backing.

5) CP brass towel rail (600 x 20 mm) with C.P. brass brackets.

6) Soap holder and liquid soap dispenser.

Wash basin provision for hand wash shall also be provided in the Battery room.

All fittings, fastener, grating shall be brass with chromium plated as per relevant IS code. Necessary plumbing lines shall be provided for CMCS room building.

The bidder shall design & provide packaged sewerage treatment plant/septic with soak pit for CMCS and Security room assuming that a total of 15 people shall use the facility. The wastewater/effluents from the sewerage plants/septic tank shall meet the state pollution control board requirement.

2.2 SPECIFICATION OF PEB:

The architectural and civil works drawing of Pre-Engineered Buildings are provided in the technical specifications. Bidder shall prepare the detailed fabrication and civil construction drawings based on tender specifications and submit to BHEL/GAIL for approval before the start of work. PEB shall be manufactured, supplied, and erected by the bidder/PEB agency. The PEB shall be made of structural steel construction with double skinned metal roofing and wall cladding of approved profile. PEB shall be complete with painting/GI coat, metal facia, metal gutter, rainwater down comers, sunshades, openings, etc., along with associated structural steel, cladding and roofing work insulation, Trims & Flashings. Each item of PEB like panels, masonry, plastering, flooring, foundation, fittings etc. shall be suitable for the complete life of the solar plant.

The layout of the PEB shall be designed so as to divert the heat generated from each equipment outside the room. The PEB shall be designed for a life of 25 years. The PEB shall have a robust water tightness at all joints and connections. The building shall have a high-class durability and performance during the adverse weather conditions. The PEB supplied shall be complete in all respect meeting all the requirements of tender drawings and other technical and functional requirements like lighting, ventilation system etc. to ensure effective functioning.

PEB length can be determined based on actual requirement, however, the grid spacing shall be maintained as per tender specifications.

2.2.1 Structure and material specification:

The PEB inverter room structural members shall meet the requirements of tender drawings. All hot rolled primary structural members and Rod/Angle/Pipe bracing etc. shall conform to IS: 2062, minimum Grade E250 Quality A. Secondary members for Purlins and Girts shall conform to the specification of IS 811 or ASTM A1003-12 made from steel sheets conforming to ASTM A1011-12b Grade 50 having a minimum

yield strength of 350 MPa. All other miscellaneous secondary members shall have the minimum yield strength of 250 MPa.

Insulated wall cladding or roofing shall consist of double skin metal cladding with Poly Urethane Foam (PUF). PUF must be made of continuous method PU foam and must be CFC free, self-extinguishing, fire retardant type with density 40 +/-2 kg/m3 and thermal conductivity 0.019-0.023 W/(m.K) at 10°C. The PUF panels shall be a factory-made item ready for installation at site.

2.2.2 Fasteners & Connections:

Special coated self-drilling screws/fastener shall be used conforming to class 3 as per AS 3566.1 and AS 3566.2. Steel bolts, nuts and washers complying with AS 1112:2000. High Strength Bolts for Primary Connections IS 1367 (Part III) Gr. 8.8 / ASTM A325. Bolts for Secondary Connection IS 1367 (Part III) Gr. 4.6 / ASTM A307. Anchor/foundation Bolts shall conform to IS 5624 and relevant IS code.

2.2.3 Roof and Wall cladding:

PUF panels shall be made of troughed permanently colour coated metal sheets of steel for roofing and side cladding (internal and external) shall conform to the requirements of Table-1 and IS: 513 for Hot-dip Zinc coated or Al/Zn coated sheets. The insulation material thickness and details shall be as specified at the relevant para in the specification.

PUF insulated panels Metal Sheet for Roofing and side cladding consist of an external sheet as troughed permanently colour coated sheet & internal sheet as plain permanently colour coated sheet.

The chemical composition of Troughed permanently colour metal sheet for roofing and side cladding shall conform to the provisions of same reference code to which the mechanical properties conform to.

Plain permanently colour coated steel metal sheet for ridge and hips, flashing, trimming, closure for vertical and horizontal joints, capping etc. shall conform to the same requirements as those of troughed permanently colour coated metal sheet for roof and side cladding.

The maximum spacing of the fastener shall be 390 mm c/c along the length of purlins/runners. However exact spacing shall be as per the design was done by the bidder of the fastener considering the wind load, self-load and other associated load. The minimum diameter of the fastener shall be 5.5 mm and at-lest 3 nos. of fastener shall be used per sheet.

Fillers blocks as a trough filler shall be used to seal cavities formed between the profiled sheet and the support or flashing. The fillers blocks shall be manufactured from black synthetic rubber or any other material approved by the engineer.

2.2.4 Roof Insulation and type:

Both metal sheets shall have an under insulation of minimum 60 mm thick PUF with density 40 +/- kg/m3 and thermal conductivity 0.019-0.023 W/(m.K) at 10°C with gutters and down take pipes along with Flashing & Top cap of the required size and colour complete with all necessary hardware complete. The roof shall be projected at-least 300 mm from the wall.

Stiffening ribs / subtle fluting for effective water shedding and special male / female ends with full return legs on side laps for purlin support and anti-capillary flute inside lap.

Both upper and lower sheets shall be separated through spacers and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations.

2.2.5 Wall Insulation:

All voids of external and internal metaled walls shall have an under insulation of minimum 40 mm thick PUF with density 40 +/- kg/m3 and thermal conductivity 0.019-0.023 W/(m.K) at 10°C with proper supports etc. as approved.

Both the walls should be separated by spacers system made up of cold- formed steel bars and fastened through zinc /zinc-tin coated self-drilling screws.

The external wall of PEB facing the transformer area shall be as per IS: 1646 - Code of practice for fire safety of buildings (general): electrical installations.

2.2.6 Doors Frames:

Door frames shall be of the iron frame of mild steel sections. All doors shall be provided necessary fittings like hinges, handles, mortice locks, tower bolts, stopper, hydraulic door closer, etc. of CP brass complete fixed to Pre-Engineered structure including necessary filling up of gaps at junctions with required PVC/neoprene felt etc. including hinges / pivots and double action hydraulic floor spring of approved brand and manufacture IS: 6315 marked, lock, handle and all necessary fittings as detailed in tender drawing or submitted by bidder in shop drawing and approved by BHEL/GAIL.

The door entrance shall include Mild Steel single leaf door. The structural steel shall conform to IS 7452 and IS 2062. The holdfasts shall be made from steel flats (50 mm and 5 mm thick). The fixtures, fastenings and door latch are to be made with same materials.

Bidder can also propose uPVC extruded casement/ sliding doors, with complete fitting, accessories, and panels as per items mentioned in DSR LATEST.

2.2.7 Windows Frame:

Aluminium black powder coated section, frame shall be of 92x31 mm, minimum 16G thick as per approved design. Tinted glass and aluminium grill shall be provided.

The Bidder can also propose uPVC extruded casement/ sliding windows with complete fitting and accessories as per items mentioned in DSR LATEST.

2.2.8 Ventilators:

Aluminium black powder coated frame of minimum size 62x25 mm and 16G thick as per approved design. Ventilators/duct shall be provided with bird guard. Size of opening at the wall for ducts shall be as per PCU manufacture and min 18-gauge GI sheet. Ducts shall be supported with suitable means, as approved during detail engineering.

All accessible ventilators and windows of all buildings shall be provided with min. 4mm thick float glass, tinted for preventing solar radiations. Suitable sunshades made out of approved colour sheet will be provided to all external windows and door. The minimum projection for the sunshades will be 450 mm and 300mm wider than the width of the opening.

2.2.9 Rolling shutter:

Rolling shutter (Hand operated) shall be fabricated from 18-gauge steel and machine rolled with 75 mm rolling Shutter with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS:2108 and shall be designed to withstand a wind load without excessive deflection. Metal rolling shutters and rolling grills as IS: 6248.

2.2.10 Plinth Protection:

500 mm wide plinth protection minimum with 75 mm thick of cement concrete 1:3:6 (1cement: 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) over 75 mm bed of dry brick ballast 40 mm nominal size well rammed and consolidated and grouted with fine sand including finishing the top smooth, shall be provided around the Pre-Engineered Building.

2.2.11 Floor Finish:

Flooring, including preparation of the surface, cleaning etc. shall be of cement concrete flooring as per IS: 2571 with ironite hardener. The PEB floor shall be at least 450 mm above the ground level.

2.2.12 Paint and Coating:

Metal sheet shall be colour coated with total coating thickness of 25 microns (nominal) dry film thickness (DFT) comprising of silicon modified polyester (SMP with silicon content of 30% to 50 %) paint or Super Durable Polyester (XRW) paint of 20 microns (nominal) on one side (exposed face) on 5 micron (nominal) primer coat and 10 microns (nominal) SMP or Super Durable Polyester paint over 5 micron (nominal)

primer coat on other side. SMP and polyester paints system shall conform to Product type 4 as per AS/ANZ 2728.

The structural steel shall be either painted as above or hot-dipped galvanized (minimum 80 microns), conform to IS: 4759 or relevant Indian standard

2.2.13 Lighting:

The PEB/CMCS building shall be provided with electric light to achieve an average illumination level mentioned elsewhere in the specification. However, room should be designed to utilize maximum natural light during the day.

2.2.14 Descriptions of PEB Structures:

Primary Members: Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns, beams, truss member, base pate.

Secondary Members: Secondary structural framing shall include the purlins, girts, eave struts, bracing, flange bracing, base angles, clips, flashings, and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

Sealant: Sealant used for cladding shall be butyl based, two parts polysulphide or equivalent approved, non-staining material and be flexible enough not to interface with fit of the sheets.

Closures: Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake, and other locations

Flashing and Trim: Flashing and / or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Colour shall be matching with the colour of the wall. The material shall be 26-gauge thick conforming to the physical specifications of sheeting.

Gutters and Down Comers: Gutters shall be fabricated out of same metal sheet. Material shall be same as that of sheeting. Down comers shall be of galvanized steel pipes or PVC designed to ensure proper roof drainage system.

Group	Grade/ Reference code	Yield strength (minimum) MPa	Tensile strength (minimum) MPa	Coating Class Designation	BMT (mm)	(+) ve Tolerance (mm)	Upper limit of BMT (mm)	(-) ve Tolerance (mm)	Lower Limit of BMT (mm)

I	G250/ AS1397	250	320	Z275	0.6	0.04	0.64	-0.04	0.56
	SS255/ ASTM A653M	255	360						
	S250GD/ EN10326	250	330						
II	G350/ AS1397	350	420	AZ150	0.5	0.04	0.54	-0.04	0.46
	SS340 Class 4/ ASTM A792M	340	410						
	S350GD/ EN10326	350	420						
NOTE:	Minimum elongation % shall be as per relevant Standard and Code.								

All steel materials supplied by the Agency shall be in a sound condition, of recent manufacture, free from defects, loose mill scale, slag intrusions, laminations, pitting, flaky, rust, etc. and be of full weight and thickness specified.

3.0 General civil works

3.1 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.

3.2 Plastering

All external surfaces shall have 18 mm cement plaster in two coats, underlayer 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.

3.3 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 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 BHEL/GAIL. Tolerances on dimensions up to +/- 8% shall be permitted. Dimension test to be carried out as per IS code.

e) 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 BHEL/GAIL.

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 a minimum of 40 mm.

3.4 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 final Soil Investigation report.

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 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.

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.

M 25 - All RCC structural elements above and below ground level, precast concrete, anchoring foundation/ support, cable trench, oil pit, Grade Slab, Paving, culverts & road.

M-20 (Equivalent nominal Mix of 1:1.5:3)* - Fencing work.

M-15 (Equivalent Nominal Mix of 1:2:4) - Base slab of drains.

M-10 (Equivalent Nominal Mix of 1:3:6) - Plain Concrete Cement.

The bidder shall carry out the design mix of M-25 and M-20 grade concrete on priority. The design mix shall be approved from BHEL/GAIL before the start of work.

* The use of nominal mix for M-20 grade may be accepted only in exceptional cases subject to approval of BHEL/GAIL Engineer-In-Charge.

The same shall be the adopted subject to approval from BHEL/GAIL 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.

3.5 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.

3.6 Structural Steel/Steel Sheet Painting

All non-hot dip galvanized 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. 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-D1

3.7 Grouting

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.

4.0 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/CEA requirements.

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.

5.0 PIPE /CABLE RACKS & TRENCHES

Trenches shall be constructed in reinforced cement concrete and wall thickness minimum 100 mm. The top of trenches shall be kept at least 100 mm above the gravel level so that rainwater does not enter the trench. Trench walls shall not foul with the foundations.

a) Outdoor Cable Trenches: RCC cable trenches shall be constructed in the switchyard and pre-cast RCC removable covers with lifting arrangement, edge protected with suitable galvanized angle iron designed to withstand self-weight of top slab + a concentrated load of 150 kg at center of span on each panel.

b) Indoor 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 chequered plate covers (600-1200 mm in length except at ends & bends) conform to IS: 3502 with lifting arrangement. Angle or channels shall also be grouted at distances of max 1200 mm across the indoor cable trenches to support the chequered plates.

c) Trench Drainage: The trench bed shall have a slope of approx. 1/500 along the run & 1/250 perpendicular to the run. Incase 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.

6.0 PLANT DRAINAGE SYSTEM

a) Surface drainage system shall be designed considering 'maximum hourly rainfall intensity'. The minimum value of surface run off coefficient shall be 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.

b) The drainage scheme shall be designed considering the catchment areas contributing to the plot drains. Drainage scheme with detention ponds which allows for groundwater recharge & maintains the existing drainage pattern as far as possible is desired. A network of open drains shall be designed & provided to carry surface run off. The drains shall be trapezoidal, or rectangle section lined with concrete slabs/brick masonry/stone masonry/Precast RCC drain. The minimum thickness of these lining shall be 75mm thick for concrete slab, 115mm for brick masonry, 150 mm thick for stone masonry and 50 mm thick for Precast RCC drain.

c) Suitable size drain shall also be provided at side of the road for quick disposal of water from road & solar blocks as per Plant gradients and Design requirements. Provision of culverts and their design to be submitted separately. The road on the culvert portions of the drains shall be concrete road.

d) Bidder shall also ensure that drainage from his plot does not encroach/flood in to 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.

e) Bidder in its plot shall terminate its plot drains into the nearby main approach road drainage system or the existing natural water body passing through its plot. The same shall be subject to the approval of BHEL/GAIL. Suitable strengthening of natural drain shall be done at the terminal point to avoid any erosion of soil/strata. The strengthening shall be done using stone pitching or RCC works.

f) The Bidder of each plot (in case of multiple bidders) shall also provide ‘additional drains’ to cater the drainage of the adjacent plot/plots due to natural topography. These ‘additional drains’ entry point, discharge quantity, invert levels and tentative layouts shall be as per BHEL/GAIL approval.

g) Each bidder shall also made one peripheral drain along the toe wall of the fencing in the area where the water from bidder plot tends to encroach into the adjacent bidder plot following the natural topography. The toe wall adjacent to peripheral drain shall contribute discharge to the ‘additional drain’ created by the adjoining plot bidder.

h) Bidders can also propose suitable recharge dug wells, recharge pits, recharge trenches, and recharge soak ways for quick disposal of storm water in the vicinity of the solar block/plot.

i) 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.

j) 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.

7.0 ELECTRIFICATION OF BUILDING

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

8.0 ROADS

8.1 Approach Road: The approach road to the Solar Power Plant shall originate from the main approach road and connect to CMCS building and Metering/Switch Yard. Approach road shall be 3 meter-wide with 500 mm wide shoulder on both sides. Moorum/brick, with a minimum 100 mm thick shall be provided for the shoulder along the approach road. The crown of the road shall be minimum 150 mm above FGL. The final finished roads shall have a camber of 1in50.

a) The typical approach road section up to CMCS shall be as follows

1) Topping: Wearing course of premix carpet 20 mm thick.

2) Wet Mix Macadam WMM, compacted 175 mm thick.

3) Granular Subbase, compacted 150mm thick granular sub-base (Gr-I)

SECTION-6 : TECHNICAL SPECIFICATIONS

D – GENERAL SYSTEMS

D-1 WEATHER MONITORING STATION

1.0 GENERAL

a) 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 (Trackers, Mounting and base stand etc.) provided by OEM of the sensors only.

b) 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.

c) All the instruments to be supplied shall have valid calibration certificate

d) 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.

e) Bidders are advised to ascertain themselves, the applicable regulation related to weather data which has to be transmitted to control centres 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.

2.0 SOLAR RADIATION SENSORS

Contractor shall provide Solar Radiation Sensors as per specification given in following section. Contractor has the option to provide these sensors on separate base or on a single base (radiation monitoring station) with tracker, shadow ring and transmitter etc provided by the OEM. Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with solar radiation sensors. Bidder shall provide Instrument manual in hard and soft form.

2.1 PYRANOMETER

a) Bidder shall provide minimum **02 (Two) numbers** of Secondary Standard Pyranometers as per ISO 9060 **for measuring incident solar radiation as per following**

- Global Horizontal Irradiance (GHI)- 1 Nos.
- Global Inclined Irradiance (GII)-1 Nos

Technical Requirement of Pyranometer (for GHI and GII)

Sl.No	Details	Values
1	Principle	Thermopile
2	Spectral Response.	310 to 2800 nm
3	Sensitivity	Min 7 micro-volt/w/m2
4	Time response (95%):	Max 15 s
5	Non-linearity:	±0.5%
6	Temperature Response:	±2%
7	Tilt error:	< ±0.5%.
8	Zero offset thermal radiation:	±7 w/m2
9	Zero offset temperature change	±2 w/m2
10	Operating temperature range:	0 deg to +80 deg.
11	Uncertainty (95% confidence Level):	Hourly- Max-3%, Daily- Max-2%
12	Non-stability:	Max ±0.8%
13	Response Time (95% of final value)	<5 sec

b) Additionally, 01 (one) number **second class pyranometer** as per ISO 9060 for measurement of **Diffuse Horizontal Irradiance (DHI)** shall also be supplied.

c) Shadow ring/ball for measuring DHI shall require no regular adjustment for of tracker and shadow ring/ball. Pyranometer shall be shaded throughout the day and shall be exposed to diffuse solar radiation only to provide DHI value without any calculation.

d) All the Pyranometer have to be mounted at single location at shadow free area. **The location shall be finalized during detailed engineering**. The GII Pyranometer has to be at the same inclination as the angular tilt of module mounting structure. The above quantity of pyranometers shall be installed at central weather monitoring system.

e) **Bidder shall provide 1 (One) no. Battery powered portable handheld data logger supplied by the OEM of the offered Pyranometer.**

3.0 TEMPERATURE SENSORS

3.1 AMBIENT AIR TEMPERATURE SENSOR (QTY -1 NO.)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-50 o C
3.	Accuracy	+ 0.2 o C
4.	Operating Temperature	0 to 50 o C
5.	Radiation Shield	Non-aspirated Radiation Shield

3.2 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 those 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
2.	Range	0-70 o C
3.	Accuracy	+ 0.2 o C
4.	Operating Temperature and calibration	0 to 70 o C

3.3 MODULE TEMPERATURE SENSOR (QTY – 3 NO. S OR AS PER OTHER CHAPTERS, WHICHEVER IS THE HIGHEST)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-100 o C
3.	Accuracy	+ 0.2 o C
4.	Operating Temperature	0 to 100 o C

4.0 WIND SENSORS

4.1 WIND SENSOR (QTY- 1 NO)

Sl.No	Details	Values
1.	Principle	Frequency proportional to wind speed/Ultrasonic Sensor
2.	Velocity range	0-60 m/ sec
3.	Threshold	0.3 m/s
4.	Operating Temperature	0 to 50 deg C
5.	Accuracy	3% (upto 35 m/s), 5% (Above 35 m/s) RMS

4.2 **WIND DIRECTION SENSOR (QTY- 1NO)**

Sl.No	Details	Values
1.	Principle	Potentiometric type sensor (Resistance proportional to Wind direction) /Ultrasonic Sensor
2.	Range	0-360 deg
3.	Accuracy	±5 deg
4.	Operating Temperature	0 to 50 deg C

5.0 RELATIVE HUMIDITY (%) (Qty- 1no)

Sl.No	Details	Values
1.	Range	0-100 %
2.	Accuracy	±3%
3.	Resolution	1%
4.	Operating Temperature	0 to 50 deg C

6.0 ADDITIONAL MEASUREMENT

a) As per regulatory requirement, following measurement for the Solar PV is also included in the scope of bidder. All the necessary equipment for measuring the below parameters shall be included in the scope.

i. Direct Normal Irradiance (DNI)
ii. Sunrise and Sunset time
iii. Rainfall (mm)
iv. Cloud Cover –(Okta)

v. Air density

b) 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").

7.0 CALIBRATION

a) 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 from the old calibration date or WMS installation date, whichever is the earlier. All other instruments shall be recalibrated at an interval not more than four years from the old calibration date or WMS installation date, whichever is the earlier.

8.0 DATA LOGGER

a) 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:

Processor	32 bits
Time synchronization	With Built in GPS Clock or with Solar SCADA GPC Clock
Wireless communication	GSM/GPRS Modem
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.
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

b) 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.

c) 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.

d) 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.

9.0 METEOROLOGICAL STATION

a) 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 on land.

10.0 TECHNICAL REQUIRMENTS

a) All components are provided in outdoor rated NEMA 4/IP 65 enclosures for long-term outdoor use. All cables are rated for outdoor use.

b) Following requirements are to be taken care by bidder: -

i. Data logger shall be field tested and shall be in satisfactory operation for a period not less than 6 Months.

ii. 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.

iii. 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.

iv. Datalogger shall have feature that includes but not limited to Moving Average calibration, Time Integration etc.

v. 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

11.0 PV ANALYZER (COMPLETE KIT WITH SOFTWARES)

Bidder shall provide minimum 1 Number 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

D-2 FIRE FIGHTING AND ALARM SYSTEM

1.0 GENERAL:

The SPV plant shall be equipped with suitable fire protection & firefighting systems for protection of entire equipment, 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.

2.0 The firefighting system for the proposed power plant for fire protection shall consist of:

i. Sand buckets
ii. Portable fire extinguishers
iii. Microprocessor based fire alarm panel.

2.1 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	**DCP Type (ABC type) (10 Kg. Capacity)**	**CO2 Type 9 kg capacity**	**Foam Type Hand 9 kg**	**Hand Portable pressurized water C02 9 Liter**	**Sand Buckets**
Control Room	2	2	1	1	1
Each Inverter Platform	1	1			
ACDB Room (If applicable	1	1			
Each Transformer Yard	1	1	1		1

2.2 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

1. Fire Alarm control Panel
2. Multi Sensor smoke detector
3. Heat Detectors
4. Hooter cum strobe
5. Manual call Point
6. Hooter
7. Fault isolation modules
8. Control Modules
9. Cables from Sensors to Fire panels.
10. Digital output from the fire detection system shall be integrated with SCADA
11. Network Control Module
12. 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.

2.3 Fire Alarm Control Panel Indication:

a. 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.

b. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.

c. If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.

d. 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.

3.0 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 also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

4.0 Bidder shall submit document to employer for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report.

5.0 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.

6.0 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.

D-3 MODULE CLEANING SYSTEM

1.0 CONVENTIONAL WET MODULE CLEANING SYSTEM:

1. The raw water found in reservoir is not suitable for PV Module cleaning due to high turbidity. The water test report of the reservoir water is attached in Tender Drawings. However, bidders are requested to conduct their own water sample testing for its use.
2. The Contractor shall design and install the effective module cleaning system for the project to meet minimum guaranteed generation.
3. Bidder shall provide permanent arrangement for module washing in the SPV Plant. This shall include installing storage tank with pump and motor, 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. A regular supply of suitable quantity of water shall be ensured by the Contractor to cater day-to-day requirement of cleaning of PV modules.
4. 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 for measurement of water consumption.
5. The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at regular frequency in order to operate the plant at its guaranteed plant performance. However, minimum consumption of 1 litre / sq.m of surface area of SPV module shall be considered in estimation of required quantity of water storage.
6. As the reservoir water at site is not suitable for module cleaning purposes directly due to high Turbidity and P^H Levels. Suitable water for module cleaning purposes by providing water treatment plants/RO plants of requisite capacities and quantities including storage facilities as above shall be arranged by the bidder for reservoir water to be used for Module Cleaning.
7. Only treated water can be used for module cleaning purposes. The treated water quality shall be suitable for washing of the Solar Modules as per below requirement:

Sr. No.	Parameters	UOM	Test Method	Maximum Permissible Limit
1	PH	-	IS: 3025 (Part- 11): 1983	7 – 8.5
2	Turbidity	NTU	IS: 3025 (Part- 10): 1984 Reaffirmed 2012	1
3	TDS	Mg/l	IS: 3025 (Part- 16): 1984 Reaffirmed 2012	1200
4	Chlorides As CL	Mg/l	IS: 3025 (Part- 12): 1988 Reaffirmed 2009	250
5	Nitrate As NO3	Mg/l	IS: 3025 (Part- 34): 1988 Reaffirmed 2009	45
6	Fluoride as F	Mg/l	IS: 3025 (Part- 60): 1988 Reaffirmed 2008	1
7	Sulphate as SO4	Mg/l	IS: 3025 (Part- 24): 1986 Reaffirmed 2009	200
8	Total Hardness as CaCO3	Mg/l	IS: 3025 (Part- 21): 1988 Reaffirmed 2009	200
9	Calcium Hardness as Ca	Mg/l	IS: 3025 (Part- 40): 1991 Reaffirmed 2009	75
10	Magnesium Hardness as Mg	Mg/l	IS: 3025 (Part- 46): 1994	30

The details of the layout, storage tanks, water treatment plants, water test reports etc. shall be submitted by the contractor to the GAIL/BHEL for approval.

8. Supply and erection of necessary pumps, water-line and water tanks are in the scope of the Contractor. Contractor shall furnish calculations based on the head and discharge requirements of the pump rating and the water-line details. Contractor shall provide the single line diagram of water washing arrangement with location of pump to GAIL for approval during detailed engineering.
9. The Contractor shall propose a suitable module cleaning system which shall include installation of ground mounted/offshore polyethylene tank(s) of required storage capacity, pumps (including 1 No. standby pump), water supply mains and flexible hose pipes, taps, valves (NRV, Butterfly valve, Ball valve, Gate valve, PRV, scour valve etc.), Water hammer arrester(s), pressure gauge, flow meter etc. as per the planning & design.
10. The Polyethylene storage tank shall conform to IS 12701. The valves shall conform to IS 778. A suitable metal sheet canopy for protection from direct sunlight shall be provided over the tank area.

11. The water supply mains shall be of HDPE material with suitable UV resistant additives.
12. Module cleaning frequency (Min. 2 cycles per month), procedure and pressure requirement at discharge point (for manual cleaning) shall be as per the recommendation of PV module manufacturer.
13. After laying and jointing, testing of main pipe, service pipe and fitting shall be checked by charging with water. The test pressure shall be minimum 0.5 N/mm2 or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump or, in the case of long mains or mains of a large diameter, by a power-driven test pump, provided the pump is not left unattended.
14. End of the branch pipes/tapping points to be bent horizontal/downward to avoid entry of foreign materials like, earth, sand leaf, gravels, etc.
15. 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.
16. Bidder shall ensure that the complete module washing system is integrated suitably with bore wells, RO System, motor and water pipe line coming at the periphery of the plant.
17. 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), RO System and water storage tanks and submit for approval during detailed engineering.

2.0 AUTOMATED SPRINKLERS MODULE CLEANING SYSTEM

18. In addition to above, Automated Sprinkler System may also be proposed by bidders for effective cleaning to meet NEEG, if the wind conditions are suitable for such module cleaning system. The sprinkler system may be programmed to operate during night or early morning, when solar panels are relatively cold & moist, for 30-60 minutes.
19. Sprinkler water umbrella of optimum height for FSPV Installations uses gravitation force and inner pressure (2-5 Bar) to be designed to clean the modules.
20. The system should have angular sprinklers to offer water throw of minimum 8 meter covering 90 / 180 / 360 degree ensuring optimal usage of sprinklers and water.
21. The system includes Micro controller which helps in programming of cleaning schedule for a day and Automatic rain sensor for cancelling cleaning cycle during actual raining should also be available.

22. Bidder to provide design calculations of Automated Sprinkler System for approval of GAIL.

D-4 CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

1.0 GENERAL

1. The intent of the specification is to define the functional & design requirements for the CCTV System meant for gathering video information from the various areas of the power plant with display and recording facilities with night vision and motion sensors as per requirement.

2. The Contractor shall be responsible for selection, design, engineering, manufacture, testing at manufacturer's works/site, installation of all the equipment supplied as covered in this specification and commissioning of the system meeting the intent & functional requirements of the specification. All the power supply (UPS), cables, cable trays, power packs, erection hardware (viz. junction boxes, brackets glands, nut-bolts, conduits etc.) and mounting are also included in Contractor's scope.

3. The Contractor's scope shall also include successful demonstration of functional requirements specified herein complete in all respects.

4. The Contractor shall guarantee satisfactory performance of the equipment under stipulated variations of voltage and frequency.

5. The design and manufacture shall be such that equipment / components of same type and rating are interchangeable.

6. The number of camera units, servers, network switches, wireless equipment etc. and their locations shall be finalized during detailed engineer for effective functional requirements.

7. Any other equipment, module, software required for the safe and satisfactory operation, control, protection, monitoring, testing and maintenance of the system shall also be included by the Bidder within the lump sum quoted price.

8. The equipment furnished under this section shall meet the requirements of all the applicable international codes and standards or their latest amendment Codes and Standards. Camera certification has to be CE/FCC/UL or equivalent.

9. Comprehensive warranty for 10 years to be provided for complete CCTV offerings.

2.0 .POWER SUPPLY ARRANGEMENT

1. The CCTV System along with all its components i.e., network switches, storage devices, servers, LAN switches, cameras etc. shall be powered from UPS system. The contractor shall also provide local power distribution boxes as required for sub-distribution of UPS supply.

2. For cameras to be located in remote areas where the UPS power supply cannot be extended due to voltage drop etc., then such cameras can be grouped and fed from mini-UPS. Individual mini-UPS shall be provided for the cameras which cannot be grouped. Mini UPS are to be provided by the contractor within his quoted lumpsum price. The contractor shall also provide local power distribution boxes as required for sub-distribution of supply from these mini-UPS to cameras. The location of mini-UPS & power distribution scheme shall be finalized during detail engineering.

3. If the offered equipment is operating at voltage level other than what is available as auxiliary supply, the Contractor shall provide all required hardware, to make the offered system compatible with specified power supply arrangement.

3.0 DESIGN, TECHNICAL REQUIREMENTS AND CYBER SECURITY

1. The CCTV system shall be able to provide surveillance of different locations in the plant, entry gate and all across periphery. The exact locations shall be decided during detailed engineering.

2. The CCTV system shall be designed as a standalone IP based network architecture. The system shall use video signals from different cameras at different locations, process the video signals for viewing on monitors at different locations and simultaneously record all the video streams using H.264 or better compression technique. Joystick and mouse-keyboard controllers shall be used for Pan, Tilt, Zoom and other functions of desired cameras.

3. The monitoring of these cameras shall be done at main Control Room or as finalized in detailed engineering. The required no. of hardware/software licenses to meet the requirements shall be supplied by the contractor.

4. Camera and database servers shall offer both video stream management, video stream storage management. These servers shall also manage and store configuration information/database for the whole system. Recording frame rate & resolution in respect of individual camera shall be programmable. It shall be possible to view and record at different resolutions and frame rates and this shall be individually programmable on every camera.

5. It shall be possible to take back-up of system configuration and database on portable media device and restoring the same if required.

6. System shall ensure that once recorded, video cannot be altered.

7. Camera server shall be provided with a minimum of 28 TB of storage space to store recordings of all cameras. All recordings shall have camera ID, Location, Date and time of recording.

8. Camera server shall be provided with minimum 28 TB of storage space to store recordings of all cameras. All recordings shall have camera ID, Location, Date and time of recording.

9. It shall be possible to view, record, search and replay simultaneously without affecting the performance of the system.

10. The system supplied shall be complete in all respects for reliable performance. The Contractor shall submit the detailed block schematic, video, signal & power wiring diagram, describing the connections between the network switch/camera server Systems and various cameras, monitors, keyboard, and joystick.

11. The camera & Video Management Software shall conform to ONVIF profile S, G, T and M or latest available applicable ONVIF profile at the time of detail engineering.

12. The camera OEM Should have valid H.265 HEVC Certificate and should be listed on following official website of HEVC.

13. The network cameras supplied must be manufactured in accordance with the ISO 9001&14000 standards.

14. Centralized certificate management: Camera should provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates

15. Hardware encryption to secure digital certificates

16. The use of a secure boot process, based on the use of signed firmware, ensures that the camera can boot only with authorized firmware

17. The use of digitally signed firmware to validate the firmware's integrity before accepting to install it.

18. The product shall include a tamper-resistant hardware module, certified to at least Common Criteria EAL4.

19. The proposed camera should have NIST SP500-267 Approval.

20. The proposed camera should have Brute force delay protection.

21. Digitally signing each video frame for validating the video's authenticity and origin.

22. The camera OEM shall provide centralized certificate lifecycle management, with both pre-installed CA certificates and the ability to upload additional CA certificates. It should be able to a) Issue CA-Signed certificates when no other CA is available, b) Easily deploy certificates to Axis devices c) Easily deploy HTTPS or 802.1X configurations on devices d) Monitor certificate expiration dates e) Easily renew certificates prior to expiration.

23. The Camera to be provided by the bidder all the components / parts / assembly / software used in the offered hardware and software, should not be complying to GB28181, GB/T 28181-2011; GB/T28181-2011; GBT 28181-2011; GBT28181-2011 standards. There should be no option to activate or deactivate these standards in the camera web page/Settings.

4.0 DETAILED DESCRIPTION OF THE SYSTEM COMPONENTS:

4.01 Application Software for Video Monitoring, Recording & Management:

a) The application software shall be used to display, store, control & manage the entire surveillance system.

b) It shall be possible to control all cameras i.e., PTZ, auto/manual focus, selection of presets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitors for live video.

c) The system shall support video analytics in respect of the following server/edge based.

i. Video motion detection,
ii. Auto tracking
iii. Object classification (Human & Vehicle)
iv. Cross line counting

v. Line crossing

vi. Loitering

The feature can be an integral part of camera or a part of camera server. The features shall be user configurable for each camera. It shall be possible to activate recordings automatically based on events generated by video analytics. These events shall also be logged and suitably alarmed on the monitors.

4.02 Cameras:

All the cameras shall be color, suitable for day and night surveillance and network compatible. There will be two types of cameras viz. PTZ & Fixed. PTZ cameras shall be high speed integrated dome type.

The camera shall be directly connected to network and use of external encoder for connecting to network is not acceptable. The cameras shall be rugged, high performance color cameras. These cameras shall provide high resolution and high sensitivity suitable for operation in a power plant, both in natural and artificial lighted areas.

Detailed technical specification is given below.

a) **PTZ Dome Cameras**

High Definition (HD) PTZ cameras

Image Device	1/2.8-1/3" Progressive scan CMOS
Lens	4.45-4.7 /- 130-137 mm focal length
Optical Zoom	30x or better
Digital Zoom	12x or better
Number of Pixels/Effective	1920X1080 (Full HD)/2 MP at 25/30 IPS
Video compression	H.264, H.265 Main Profile/High profile
Sensitivity	color mode 0.6 lux, B/W mode 0.04lux @30IRE, F1.6
Horizontal Angle of	55.4 deg(wide)- 3.5 deg (Tele) minimum
Focus	Auto with Manual Override
Iris Range	F1.6-F2.9
Iris Control	Auto with Manual Override
Backlight Compensation	Required
White Balance	Automatic with mode selection options
Electronic Shutter	1/50 to 1/10000 Auto
S/N Ratio	>50dB

Audio	Full Duplex or 2-way
Automatic Gain Compensation	Up to 18 dB
Power Supply	The camera power supply should be of the same make as that of camera and suitable for the model no. offered. If the Power supply from the Camera OEM is not available,
Gain Control	Auto/Off
Day/Night selection	Auto On-Off
IR cut-filter	Yes
Protocols	IPV4/IPV6, RTP, UDP, TCP, IP, HTTP, HTTPS, FTP, DHCP, IGMP V2/V3, ICMP, ARP, SMTP, SNTP, SNMP, MQTT or equivalent.
Security	Password protection, Digest authentication, centralized certificate management, camera can boot only with authorized firmware and signed firmware to validate the firmware's integrity before installing.
Auto Resume after Power Failure	Yes
Multiple Streams	H.264 /H.264 & H.264/Motion JPEG, H.265 with HEVC Certificate.
Operating resolution	4 streams at 25 FPS in H.265/H.264
Analytics	Motion detection, Line crossing, Cross line counting, Loitering, Object detection (Human and Vehicles & Tamper alarm via shock detection and Camera should support installation of 3 party edge-based analytics.
PoE supply IEEE 802.3af compliant or	Yes
Rate Control	VBR/CBR
Other Features	
	On screen Menu display, and, WDR 120 dB, ONVIF Profile G, S, T and M compliant.
WDR	Automatic Picture Enhancement to give a balanced picture where there is too much/too little light
	Minimum 2 Alarm I/Ps & 1 alarm output
PTZ Specifications	

Pan	360 Deg Continuous
Tilt	180 deg
Manual Tilt Speed	0.1 deg/sec to 280 deg/sec
Manual Pan Speed	0.1 deg/sec to 250 deg/sec
Preset Positions	Minimum 256
Preset Pan Speed	280 deg/sec min
Preset Tilt Speed	250 deg/sec min
Maximum Operating conditions	-10 °C to 55 °C

b) **Fixed Cameras**

High Definition (HD) Fixed Camera

Image Device	1/2.8-1/3" Progressive scan CMOS
Number of Pixels	1920X1080 (Full HD)/2 MP at 25/30 FPS
Sensitivity (at f1.2,6dB)	0.21 Lux color & 0.05 Lux B/W (at 30IRE)
Lens	Varifocal Lens f=8-50/11-29 mm, Board/CS-Mount
Lens Mount	Board/CS-Mount
Focus	Auto with Manual Override
Multiple Streams	4 streams at 2MP, 25 FPS in H.264/H.265
IR Range	External/Built-in 70 Meters.
cybersecurity platform	Secure element minimum EAL 4+ rating
Iris Range	1.7
Audio	Full Duplex or 2-way
IR cut-filter	Yes
Protocols	IPV4/IPV6, RTP, UDP, TCP, IP, HTTP, HTTPS, FTP, DHCP, IGMP V2/V3, ICMP, ARP, SMTP, SNTP, SNMP, MQTT or equivalent
Security	Password protection, Digest authentication, centralized certificate management, camera can boot only with authorized firmware and signed firmware to validate the firmware's integrity before installing.
Iris Control	Auto with Manual Override
Analytics	Motion detection, Line crossing, Cross line counting, Loitering, Object detection (Human and Vehicles & Tamper alarm and Camera should support installation of 3 party edge-based analytics.

PoE supply IEEE 802.3af compliant	Yes
SD/SDHC/SDXC in Camera (For Local alarm recording & scheduled local recording)	Yes, minimum 256 GB capability
Rate Control	VBR/CBR
Back Light Compensation	Required
White Balance	Automatic with mode selection options
Electronic Shutter	1/50 to 1/10000 Auto
S/N Ratio	>50dB
Automatic Gain Compensation	Up to 18 dB
Power Supply	The camera power supply should be of the same make as that of camera and suitable for the model no. offered. If the Power supply from the Camera OEM is not available, power supply shall be endorsed by the OEM.
Gain Control	Auto/Off
Day/Night selection	Auto On-Off
Other Features	
	WDR 120 dB, ONVIF Profile G, S, T and M compliant.
WDR	Automatic Picture Enhancement to give a balanced picture where there is too much/too little light
	Minimum One Alarm I/P
	Minimum One Alarm O/P
Maximum Operating conditions	-10 °C to 55 °C

4.03 Camera Housing & Mount

a) All the cameras and accessories are to be housed in Weather Proof IP 65 environmental housing made of aluminum and Sun shroud. The housing, with heater and blower installed, shall provide protection for camera/lens assemblies in the ambient temperature range of - 0 deg. C to 50 deg. C.

b) For non-Dome type cameras, the housing shall also have a thermostatically controlled heater kit. Continuous duty blower kit (with suitable filters) for purge air arrangement / Window wipers shall be available within the housing for cameras as indicated against each application.

c) The camera mount, camera housing and camera power supply should be of the same make as that of camera and suitable for the model no. offered as specified by the manufacturer.

4.04 Keyboard & Joystick-

The keyboard shall have full function used for system control and programming for selection of various Network switches, camera/database servers, camera functions including pan, tilt and zoom lens controls and shall be ergonomically designed.

Joystick shall be provided for achieving all control functions.

4.05 Work Station

Operator work station & network switch station shall be in Control Room or as finalized during the detailed engineering. The size of the display screen shall be minimum 55 inches. Bidder must ensure that the LED screen pixel density shall match with the offered camera pixel density or higher.

4.06 Wireless connection equipment (for camera specified on wireless connectivity):

If contractor offer any camera with wireless connectivity, Access points for these cameras shall be mounted on lighting mast/pole. Wireless equipment and type of wireless connectivity shall be decided during detailed Engineering. Wireless communication for the above should be subscribing to the latest Cyber security standards including encryption. The wireless modem should support dynamic encryption techniques.

4.07 Network Switch:

All the network switches shall be of high quality and shall be sized to meet the functional requirements as specified. The common switch to which all networks are connected shall be Layer-III switch/router. All the interconnecting cables between network switches shall be fiber optic only. All fiber optic cables shall be terminated directly to network switches through optical fiber port without using media converters. Bidder to ensure that minimum 100% cores are kept as spares in all type of optical fiber cables

5.0 CABLES:

5.01 Cables shall be of FRLS PVC sheathed cables for use in CCTV and shall conform to latest edition of Indian/International standards. Fiber optic cables are to be provided (as applicable). The remaining cables can be as per CCTV supplier's standard. For details of Fiber Optic cables, refer subsection INST CABLE. All the cables and the hardware required for powering the system are also in the scope of Contractor. All cables required for interfacing alarm contact inputs (to be provided by employer) to CCTV system are also in scope of contractor.

5.02 For estimation of cable quantities, erection hardware, hardware for wireless communication etc., the Bidder shall refer to General Layout Plant, Equipment Location Plans drawings & other relevant drawings to be finalized during detailed engineering. All the cables are to be provided by the Contractor on as required basis.

6.0 LOCATION OF CCTV:

Bidder to note:

I. Location of the CCTV cameras shall be reviewed during detailed engineering.

II. The relevant drawings pertaining to location and the location of the console shall be finalized during the detailed engineering.

SECTION-7: PROJECT COMMISSIONING AND OTHER REQUIREMENTS

1.0 GENERAL CONDITIONS FOR FINAL COMMISSIONING:

1. All strings as per approved design shall be connected to inverter DC side.

2. Corresponding AC side works shall be completed for arranging dispatchable power to Grid along with data communication till RLDC (If applicable).

3. The commissioning procedure for 17.5 MW (AC) Solar PV Power Plant at Pata shall be as per

UPNEDA/UPPCL/UPPTCL/DISCOMS /UPERC/GOI / MNRE/CERC/CEA/CEI and / or any other agency as and when applicable. The Contractor shall also ensure the following:

- Obtaining written certificate of commissioning of the facility and permission to connect and synchronize with the grid from the office of the Chief Electrical Inspector of the state and any other authorized representative from Government of India (GoI) / UPNEDA/UPPCL/UPPTCL/DISCOMS /UPERC/ GAIL/ GOI / MNRE/CERC/CEA/CEI and / or any other agency as and when applicable.
- Inspection and successful electrical commissioning certificate from the Company.
- Obtaining all certificates required by DisCom from agency appointed by them.
- Satisfactory completion certificate towards completion of all other contractual obligations by the Contractor as stipulated from the Company.
- Ensuring Agreements and contracts in place for wheeling and set off of power to GAIL.

SECTION-8: OPERATION AND MAINTENANCE

1.0 GENERAL

The scope of work includes Operation and Maintenance (O&M) of the 17.5 MW (AC) Solar PV Power Plant for three (3) years wherein the plant shall generate at least equivalent to the guaranteed Performance of the plant. The Bidder shall submit in the Bid a comprehensive project execution schedule as well as Operation and Maintenance (O&M) schedule with resource planning in the form of Gantt chart and shall be liable for abiding by the schedule. It is the responsibility of the Contractor to perform the necessary maintenance/ timely replacement of all Civil/PV Module/Equipment's /Mechanical or Electrical Damage components of the project during this O&M period.

During O & M period due care is taken such that the guaranteed performance of the plant is not compromised. Any damage to CIVIL/ ELECTRICAL/ MECHANICAL components of the plant is to be reworked/ replaced/ supplied without any extra cost and time by the Contractor during complete O&M period. In short Operation and Maintenance of the project/plant shall be comprehensive. The maintenance service provided shall ensure project functioning of the Solar PV system as a whole and Power Evacuation System to the extent covered in the Contract. All preventive/ routine maintenance and breakdown/ corrective maintenance required for ensuring maximum uptime shall have to be provided. Accordingly, the Comprehensive Operation and Maintenance shall have two distinct components as described below:

1.1. Preventive / Routine Maintenance: This shall be done by the Contractor regularly and shall include activities such as cleaning and checking the health of the Plant, cleaning of module surface, tightening of all electrical connections, maintenance of all equipment and systems as per OEM recommendations / applicable standards, all applicable legal compliances for the plant and any other activity that may be required for proper functioning of the Plant as a whole. Necessary maintenance activities, preventive and routine for Transformers and associated switchgears also shall be included.

1.2. Breakdown/ Corrective Maintenance: Whenever a fault has occurred, the Contractor has to attend to rectify the fault, the fault must be rectified within 48 hrs time from the time of occurrence of fault failing which the Contractor will be penalized as per terms and conditions of this Tender.

1.3 **The Comprehensive Operation and Maintenance Contract period of the Plant shall start after successful completion of OAT or 90 days from commissioning, whichever is the earliest.**

2.0 TARGET ENERGY GENERATION AND LD FOR SHORTFALL IN GENERATION:

1. Contractor to achieve guaranteed Generation in respective O&M year and following factors may be noted for computing the guaranteed Generation during O&M period:

a) Generation loss due to grid outage (or power evacuation system after the metering point of the Receiving Substation which is not in the scope of the Contractor): The measured global Horizontal solar radiation i.e. GHI of the period of the outage of the power evacuation system shall be excluded to give relaxation in the target generation value to that extent only. The Grid Outage hours data shall be verified from the concern Authority for the period of O&M.

b) Effect due to variation in annual insolation shall only be considered for computing the Target generation.

c) Effect due to variation of meteorological parameters e.g. ambient temperature, wind speed, humidity etc. shall not be considered.

d) If there is any Energy shortfall in Performance Guarantee test (PGT), Accordingly O&M target shall be revised based on the PGF (Performance Guarantee Factor).

PGF=Performance Guarantee Factor which is ratio of achieved generation to modified target generation during the PG Test. It shall be always less than or equal to 1(one), if contractor has not met their guaranteed generation during the PG Test. PGF maximum value shall be 1 even if generation achieved during PG Test is more than guaranteed generation.

2. Methodology for calculation of LD on shortfall in stipulated generation shall be as follows:

- Generation for corresponding O&M year as per guaranteed target generation of 17.5MW (AC) =G1
- Reference Global Horizontal Insolation= H1
- Measured Generation during the O&M period=G2
- Measured Global Horizontal Insolation during the O&M period= H2
- Modified target Generation during the O&M period(G2')

$$G2' = (H2/H1) \times G1 \times PGF$$

Then ΔG= Shortfall in generation = G2'-G2

In case G2' < or = G2 then no liquidated damages for the corresponding O&M period.

3. In case, the GHI is not available because of instrumentation or SCADA problem, the corresponding insolation and generation shall be excluded from the time block for estimation of loss of generation. Generation loss (during generating hours) due to the grid outage/non-dispatch of power due to back down or other reasons which are not attributable to the contractor shall also be excluded for arriving loss of generation.

One day shall be equally divided into 96 blocks of 15 minutes each starting from 00:00 Hrs, i.e. 42nd time block shall be from 10:15-10:30 Hrs.

3.0 GUIDELINE FOR OPERATION AND MAINTENANCE (O&M):

1. O&M Contract shall cover complete Solar PV Power plant and power evacuation system) as specified in the Contract.

   Further, it is the responsibility of the Contractor to liaison with the following authorities:

   i. Liaison with State/Central Government.
   ii. Liaison with State Power Utilities.
   iii. Liaison with State Renewable Agency.
   iv. Any other department / agency as may be required.

2. Comprehensive Operation & Maintenance of the Solar PV plant including supply of spare parts, consumables, repairs/replacement of any defective equipment etc. shall be performed by the Contractor for a period of three (3) years.
3. During O&M period, Company personnel shall have unrestricted entry to the solar plant and Control Room any time. Company may depute its personals to associate with O&M activities. The Contractor shall assist them in developing expertise through their day-to-day O&M activities and all records of maintenance must be maintained by the Contractor which can be accessed by Company on demand. These recordings are to be handed over to Company after the O&M period of contract.
4. During O & M period, all the annual charges related to UPPCL/UPTCL/DISCOM, Area Load Dispatch Centre (ALDC) and State Load Dispatch Center (SLDC) except wheeling charges shall be in the Scope of Contractor.
5. During the O&M period, the Contactor shall be responsible for any defect in the work due to faulty workmanship or due to use of sub-standard material in the work. Any defects in the work during the warrantee period shall there be rectified/replaced by the Contractor without any extra cost to the

employer within a reasonable time (48 Hrs.) as may be considered from the date of receipt of such intimation from employer failing which employer shall take up rectification work at the risk and cost of Contractor.

6. The Contractor shall be responsible for supply of all spare parts, repairs / replacement of any defective equipment(s) including civil works at his own cost as required from time to time during the O&M period.

4.0 O&M OF PLANT:

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 BHEL for approval. Further, Floating system O&M shall be done as per relevant sections of this specification and OEM manuals.

1. Ensuring successful operation of SPV Plant for optimum energy generation.
2. Ensuring Breakdown maintenance, Preventive maintenance overhauls, arranging visit of O&M experts (when required) to maximize the availability of the solar plant.
3. 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
4. Hot-spot detection of Solar panels by using thermal imaging camera to be carried out as per schedule and report shall be submitted indicating PV modules number wise.
5. Operation & Maintenance of constructed Sedimentation Tank, its Pumps and accessories as per schedule minimise the silt deposition in reservoirs.
6. The operator shall record monthly energy output of each array and transformer and reports shall be prepared on performance of SPV plant
7. Submission of periodical reports to the owner on the energy generation & operating conditions of the SPV plant.
8. Ensuring Safety and protection of the plant by deputing sufficient security personals
9. Monitoring, controlling, troubleshooting, maintaining of records, registers.
10. 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.

11. Cleaning of the plant including array yard on regular basis and as and when required.
12. Cleaning of drains, cable trenches, box culverts etc.
13. Module washing as per as per approved schedule.
14. Herbicide spray and grass cutting on a periodic basis
15. The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
16. 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.
17. 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.
18. 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.
19. 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.
20. Deployment of Plant in Charge, adequate number of technical support staff and other supporting personnel during the O&M period
21. 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 GAIL, the contractor shall have to return/replenish the spare(s) of the matching quality, quantity and rating within shortest possible time.
22. At the time handing over of the plant by the contractor to GAIL, the contractor shall handover equipment and spares in healthy condition.
23. Bidder shall have to fill at least 65% of post in supervisory and managerial cadres and 80% of posts in other cadres by the local persons. The expression "Local person "shall mean a person domiciled in Uttar Pradesh state for minimum 10years shall be considered as local person.

24. Housekeeping of complete power plant.
25. Reporting the energy generation data to GAIL, SLDC, and UPPCL/UPPTCL/DISCOM/ALDC on Daily / Monthly / Yearly for scheduling & reporting purpose.
26. Bidder to fulfil all energy reporting requirements of UPNEDA/UPPCL/UPPTCL/DISCOMS /UPERC/ GAIL/ GOI / MNRE/CERC / CEA/CEI/ALDC and / or any other agency as and when applicable during the complete O&M period to facilitate energy accounting.
27. Monitoring, controlling, troubleshooting, maintaining of records, registers etc. Recording/logging of all the operational parameters (e.g. voltage, current, power factor, energy output, temperature etc.) and preparation of daily/weekly/monthly reports etc. including submission of periodical consolidate plant performance reports to the Company.
28. Replacement of equipment/spare parts/ updating of softwares being phased out or not being supported by OEM's is also included in bidder's scope.
29. 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.
30. Coordinating, on behalf of Company, and obtaining renewal of statutory licenses, clearances and approvals from state departments such as State Electricity Supply & Transmission Boards/CEI/CEA/UPPCL/UPTCL/DISCOMS/GAIL etc.
31. Compliance of Scheduling and forecasting shall be carried by the successful EPC Contractor as per CERC/MPERC Notification for (FORECASTING, SCHEDULING, DEVIATION SETTLEMENT AND RELATED MATTERS OF SOLAR AND WIND GENERATION SOURCES) REGULATIONS and any changes from time to time. Further all the cost for hiring QCA (Qualified Coordinating Agency) for forecasting and scheduling shall be in scope of the Successful EPC Contractor.
32. Penalty due to mismatch in scheduling and forecasting shall be in scope of the successful EPC Contractor.
33. Bidder shall keep updating the spares inventory at the site every time there is consumption of spare items towards replacement.
34. Coordinating with sub-station upon grid failures, line problems etc. and implementing the needful steps to restore the plant to normal operation. Theft incidents: Immediate reporting to Company, filing FIRs with police stations on behalf of Company, coordination for site inspection by

insurance companies and clearance of insurance claims, logging of events (date, time) and maintaining records

35. Required security personnel shall be deployed for Plant security, round the clock.

4.2 All the civil defects, rectification, repairing, replacement related to civil works shall be in the scope of Contractor during the O&M period. The Contactor shall be responsible for rectification of any defect in the civil work and maintain the structure/buildings in good condition with proper maintenance. The Contractor shall be responsible for the maintenance of each civil works carried out as mentioned below.

1. Buildings Control room premises, includes:

i. Water tightness of roof and walls.
ii. Painting to the structure either PEB/ RCC Framed structure at regular interval (not more than five years).
iii. Plumbing & Sanitation related defects/replacement.
iv. Chalking / overflow of septic tank and soak pit.
v. Replacement / repairing of water tank if major/minor leakage observed.
vi. Leakage of water to be attended by suitable crack filler.
vii. Repairing/replacement of doors, windows, ventilators & rolling shutter.

2. Road (WBM or Bitumen):

i. Crack repairing of the road surface.
ii. Pot-holes over the top road surface to be rectify.
iii. Maintenance of shoulders for the rain cuts or damage due to some external reasons.
iv. Re-carpeting of the road surface at every five years interval.

3. Storm water Drainage:

i. Before and after each rain the storm water drainage shall be maintained & cleaned for smoother flow of storm water.

4. Equipment yard gate & Fencing:

i. Maintain the elegance of entry gate with painting as & when required.
ii. Repairing & painting of fencing as & when required.

5. Plaster, Masonary and Concrete surfaces: All damages, cracks, leakage shall be repaired immediately without waiting for instruction from the GAIL

6. Repairing/replacement to structural members: After every five years All structure members including fasteners are required to be checked and all corroded surfaces of the members shall be repaired by applying Zinc rich spray only not by any paint. All damaged, corroded, bend fasteners shall be replaced.

The above list is not exhaustive but indicative only. Although most of the structures are covered here in, any other system (Civil, Structural and Architectural) required for successful operation and maintenance of the works shall form a part of this contract and shall be deemed to be included in the scope of works. The scope of Bidder/EPC Contractor is including supply of all required materials, mobilization of labour, and arrangement of required tools tackles and equipment to carry out all above civil maintenance works.

5.0 INSURANCE

a) BHEL/GAIL shall take Fire & Allied Peril insurance during O&M period. Insurance for theft to be taken by contractor.

b) **Workmen's Compensation Insurance**

This insurance shall protect the Contractor against all claims applicable under the Workmen's Compensation Act, 1948 (Government of India). This policy shall also cover the Contractor against claims for injury, disability disease or death of his or his Sub-Contractor's employees, which for any reason are not covered under the Workmen's Compensation Act, 1948. The liabilities shall not be less than the following:

Workmen's Compensation - As per Statutory Provisions

Employee's Liability - As per Statutory Provisions

(c) **Comprehensive Automobile Insurance**

This insurance shall be in such a form to protect the Contractor against all claims for injuries, disability, disease and death to members of public including the Employer's men and damage to the property of other arising from the use of motor vehicles during on or off the Site operations, irrespective of the Ownership of such vehicles. The liability covered shall be as herein indicated:

Fatal Injury : Rs.100,000 each person

: Rs.200,000 each occurrence

Property Damage: Rs.100,000 each occurrence

(d) **Comprehensive General Liability Insurance**

The insurance shall protect the Contractor against all claims arising from injuries, disabilities, disease or death of members of public or damage to property of others, due to any act or omission on the part of the Contractor, his agents, his employees, his representatives and Sub-Contractors or from riots, strikes and civil commotion. This insurance shall also cover all the liabilities of the Contractor arising out of the Clause entitled "Defence of Suits" in Section General Conditions of Contract (GCC).

The hazards to be covered will pertain to all the Works and areas where the Contractor, his Sub-Contractors, his agents and his employees have to perform work pursuant to the Contract.

6.0 MINIMUM RESOURCE REQUIREMENTS FOR O&M

The following resources shall be maintained by the contractor during the O&M period as a minimum requirement:

Sl. No.	Resource	Minimum Continuous Requirement
1.	Technical (Site In-charge)	**01 (Electrical):** Diploma with 5 Year Relevant Experience OR BE/Btech with 2 Year Relevant Experience SCADA Operator (Electrical)- One No. round the clock
2.	Technical (Technician)	**01 (Electrical-GS) + 01 (Electrical-Round-The-Clock)** **Total 5 Nos.** ITI with 5 Year Relevant Experience (OR) Diploma with 2 Year Relevant Experience
3.	Unskilled Manpower	Based on requirement for Module Cleaning to meet NEEG
3.	Security personnel	**2 Nos.** (round the clock) i.e**. Total 8 Nos.**
4	Miscellaneous	For Housekeeping &Upkeeping – As per requirement

The above requirement is only an indicative minimum requirement. At any point of time during O&M, additional resources shall be deployed by the contractor as per requirement.

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.

7.0 DRONE INSPECTION WITH THERMAL IMAGING OF FLOATING SOLAR PLANT AS PART OF O&M:

a. Thermography of PV panels in the reservoir shall be carried out using RPA/UAV/drone mounted thermal/IR camera having minimum resolution of 640 x 512. The brief scope of bidder includes:

b. Identification of low performing strings.

c. Identification of reasons of low performance like hot spots on the cells/panels, diode failures, cracked cells or glass cracks, loose contacts and wiring faults, penetration of moisture and/or dirt, failed or disconnected modules, junction box heating or any other.

d. Identification of hot spots in other equipment like SCBs, Y connectors, DC cables.

e. Preparation and submission of detailed report covering physical panel location of each anomaly, summary of defect types and number of defects indicating the priority which arrays need immediate attention etc. The report should be provided in soft (pdf, images in jpeg) as well as hardcopy.

f. Recommendation on root cause of the problems.

g. Frequency of drone survey for thermography shall quarterly once for each block during the regular O&M period or as and when required by GAIL. Experienced operator shall be made available for operating and conducting the regular Drone survey of the system as above till end of the O&M period. Maintaining and upkeep of the Drone with accessories such as Thermal Camera, software and hardware for obtaining and analysing the survey inputs for O&M purpose shall be under scope of the EPC vendor. Necessary approvals shall be obtained from Owner (GAIL) for movement of the drone over the reservoir.

8.0 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 GAIL on returnable basis, such as spares parts (from mandatory spares or through procurement)), consumables, tools and plants, documents etc. shall be returned back to GAIL. Else suitable recoveries shall be made from the Contractor's bills.

After O&M period, GAIL 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.

SECTION-9: SAFETY MANAGEMENT (Applicable for both Project stage and O&M stage)

1. Bidder shall submit the Safety Plan and the Safety Coordination Procedure as per the requirement of relevant Attachments of the bidding documents.
2. HSE plan, organogram & JSA for each activity to be submitted before execution of contract.
3. During the execution of the contract, the bidder and it's 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.
4. 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.
5. Safety sign board to be provided near outdoor transformer yard, HT switchgear and all such risk zone areas.
6. For the execution of this project, deployed manpower to be trained in swimming and must having life jacket to protect from drowning.
7. Drowning Rescue arrangement must be provided at site with availability of trained swimmer and other rescue equipment.
8. A dedicated safety officer with appropriate qualification & Experience shall be deputed during execution and entire period O&M of the plant. Prior to deployment of safety officer, necessary documents/certificates of safety officer to be submitted to BHEL &GAIL
9. The scope also includes supply of required number of life jackets (Minimum 20) as per IS 6685.
10. Health checks up of all the workers to be carried out prior to start of the job.
11. All the required personnel protective equipment's like Cotton Dangri -02 Nos. to each worker, Safety shoes, Safety Helmet (blue colour), Hand gloves (rubber dotted & leather), Safety belt (full body harness with double lanyard along with test certificate), life line (8-10mm SS wire), sufficient quantity of safety net, full face shield, leather hand gloves, ear plugs, welder's helmet and all marine safety gear must be ensured at site.
12. Portable LEL detector to be made available at site for checking LEL.
13. Portable Fire Extinguishers & Fire Hoses to be made available at site for ensuring fire fighting arrangement at site.
14. All the jobs shall be executed through Work Permit System.
15. Tool box talk to be held on daily basis for all the workers and record register shall maintained by site in charge.
16. Welding machine & other electrical equipment shall be kept in a shed at distance of 15-20 meter away from the water reservoir and only marine grade and jointless electrical cables shall be used.

17. As per Factories Act / UP Factory Rule section 29, all lifting tools & tackles (Chain pulley blocks, Slings & D-shackles etc.) must be checked and certified by competent authority (notified by chief inspectorate of factories U.P.) before its use, copy of valid load test certificate to be submitted. Identification/tagging of lifting tools to be done and identification/tag no. shall be clearly mentioned on test certificates.
18. All the electrical equipment should be get checked from GAIL electrical dept. along with test certificates.
19. All hand-held power tools such as grinding/cutting machine, drilling machine must be provided with dead man's switch and proper guards.
20. **All electrical connection must be through 30 mA ELCB supply**.
21. Deployment of qualified electrician to be ensured.
22. Oxy-Acetylene cutting set must be available with proper gauges, flashback arrestors & NRV at both cylinder and torch side, both the cylinder must always be kept on cylinder trolleys chain locking arrangement.
23. Sufficient quantity of good quality fire blanket must be available at site.
24. Arrangement of first aid box at site.
25. Additional safety precautions/guidelines may be required/reviewed during execution of the job at site will be intimated accordingly.

SECTION-10: MANDATORY SPARES

Following Mandatory spares shall be supplied by EPC bidder along with main supplies. These mandatory spares shall be stored in safe place for the entire O&M period by EPC and shall be handed over to customer after 3 years of O&M.

TABLE 13: LIST OF MANDATORY SPARES

Sl.No.	Description	Quantity	UoM
1	Solar Photovoltaic (SPV) Modules	0.025 % of total DC capacity	kWp
2	Floater Unit including mooring system	0.5% of Each Type	No.
3	String Inverter with A.C. Combiner box (as applicable)	2% of total population for highest capacity	NA
4	MCCB	2 nos. of each type and raring	NA
5	33kV Indoor Circuit Breakers	1 no. of each rating	No
6	33 kV Indoor Current Transformers	1 no. of each type	
7	33 kV indoor Potential transformer	1 no. of each type	
8	33 kV Indoor Surge Arrestor	1 no. of each type	Nos.
9	Earthing Trolley (FEB & BEB)	1 no. of each type	No.
10	Power pack for HT Switchgear, if offered for Project	10% of total population or 2 Nos, whichever is higher	No.
11	Numerical relay for 33kV HT Switchgear	1 no. of each type	No.
12	Electronic Cards for PCU	5% of total population for each type	Set
13	IGBT Units for PCU	5% of total population	Set
14	Semiconductor Fuses for PCU	5% of total population	Set
15	AC Fuse of rating more than 10 Amp	25 nos. of each rating	Set
16	String Combiner/Monitoring Box (If applicable)	2% of total population	No
17	SCADA ethernet switch	5% of total population for each type	Set
18	SCADA firewall gateway	1 no. of each type	Set
19	Module Connector Set and Y-connector set	50	set
20	DC Cable (SPV Module to SI/SCB)	5	km
21	DC Cable: (SCB to PCU) of highest size	1	km
22	AC Cable: (PCU to IDT) of highest size	1	km
23	AC Cable:(IDT to HT switchgear and Local Pooling station) of highest size	1	km
24	HT Cable 33 kV (Local Pooling to Final Evacuation Point)	1	km

25	Inverter Transformer (higher size)	1	No.
26	Set of Valves for Inverter transformer	1	Nos.
27	WTI with contacts of Inverter transformer	1	Nos.
28	OTI with contacts of Inverter transformer	1	Nos.
29	Buchholz relay complete of Inverter transformer	1	Nos.
30	Pressure Relief Device of Inverter Transformer	1	Nos.
31	Magnetic Oil Gauge (MOG) of Inverter Transformer	1	Nos.
32	HV and LV Bushing with metal parts and gaskets of Inverter Transformer (Each Type)	1	Nos.
33	Inverter station Auxiliary transformer (Highest size)	1	Nos.
34	UPS/Battery charger for inverter platform/local pooling system/CMCS	1 set of highest capacity	Set
35	Spare Battery bank for inverter platform/Local pooling system UPS/charger with mounting rack	1 set	Set

SECTION-11: TOOLS AND INSTRUMENTS

EPC bidder shall provide all necessary tools and tackles, measuring instruments required for successful completion and O&M of the project. List of such tools including their make and detailed specification shall be submitted for approval by the BHEL/GAIL. Bidder shall provide all tools and instruments specified in other chapters elsewhere in the specification. The proposed list of special tools must include the following in addition to tools recommended.

TABLE 14: LIST OF MEASURING INSTRUMENTS AND TOOL KITS

MEASURING INSTRUMENTS			
Sl.No.	**Description**	**Quantity**	**UoM**
1	1500V Digital Tong Tester	2	No.s
2	1500V Digital Multimeters	2	No.s
3	500 V/ 1 kV / 2.5 kV / 5 kV user selectable digital Megger	1	No.
4	Earth Resistance Tester	2	No.s
5	PV ANALYZER (COMPLETE KIT WITH SOFTWARES)	1	No.s
6	RFID reader compatible to read the data from the RFID tag & download to computer. Also, all associated software & cables etc.- 1 set	1	Set
7	Infra-red thermal imaging camera	1	No.
8	Digital lux meter	1	No.
9	Portable handheld data logger	1	No.
TOOL KITS			
1	Crimping tool up to 10 sq-mm cable	1	No.
2	Crimping tool with Dye range 50-630sq-mm cable, mechanical gear power, hand or foot operated	1	No
3	Full kit of tools & spanners of required sizes; All spanners shall be single ended and case hardened.	1	Set
4	Tool Box	1	No.
5	Vacuum cleaner, of industrial type, for control room sweeping / cleaning	1	No.
6	Blowers for cleaning the panels	1	No.
7	Tools required for night activities	1	Set

SECTION-12: APPROVED VENDOR LIST

The list of acceptable makes for equipment / system are as listed below:

TABLE 15: LIST OF APPROVED VENDORS

Sr.	Description	Vendor Name
1	Inverters (PCU)	TBEA
		FIMER
		HITACHI HI-REL
		DELTA
		SINENG
		MEDHA
		SUNGROW
		TMEIC
2	PV Modules	As per Latest ALMM list and MNRE orders.
3	HT Panel /HT Breaker	Siemens
		L & T
		ABB
		BHEL (BHOPAL)
		Schneider
		Jyoti
4	Control and relay panel	ABB
		Siemens
		Schneider
		Alstom
5	LT Switchgear component (LT switchgear panel shall be CPRI approved vendor)	L & T
		Siemens
		ABB
		Schneider
6	Power Transformer	Voltamp
		Schneider
		ABB
		BHEL
		Silchar
		Crompton Grooves
		Danish
		Atlanta

		ALSTOM
7	Inverter Transformer	Schneider
		Electrotherm
		Voltamp
		ABB
		Silchar
		Atlanta
		Danish
		T & R
		Century Transformer
8	Auxiliary Transformer (Dry Type)	Voltamp
		Kotson
		Danish
		Silchar
		Atlanta
		Melcon
9	Solar Cable and DC Cable	M/s LAPP
		M/s Siechem
		M/s KEI Cables
		M/s UniFlex Cables
		M/s Cords Cables
		M/s Apar
		M/s Universal
		M/s KEC
10	Optical Fiber Cable	KABEL RHEYDT
		D-Link
		AKSH OPTIFIBRE LIMITED
		PIRELLI CAVI SPA
		VINDHYA TELELINKS LIMITED
		U M CABLES LTD
		HFCL LIMITED
		KEC INETRNATIONAL - MYSORE
		APAR INDUSTRIES LTD
		BIRLA CABLE LIMITED
		WEST COAST PAPER MILLS LIMITED (DIVISION:

		WEST COAST OPTILINKS)
11	Earthing Pit Materials	Ashlok
		Powertrac
		ERICO
12	SJB	M/s Hensel Electric Pvt Ltd
		M/s Trinity Solar
		M/s Eaton
		M/s Statcon
		M/s ABB
13	Lugs	Dowell
		Comet
		3D
14	SCADA System	M/s Rockwell
		M/s Siemens
		M/s Schneider
		M/s L&T
15	Weather Sensors	a.Pyranometer : i) Keep &Zonen ii) IngenieurbüroMencke & Tegtmeyer GmbH
		b.Wind Sensor: ADOLF THIES Gmbh& Co
		c.Temperature Measurement: i) Met One Inc ii) Climatronics
		d.Wind Speed & direction: i) Met One Inc
		e.Tripod Stand : i) Met One Inc ii) Climatronics
		For other reputed make – Company in charge engineer's approval is required.
16	Lightning Arrestor (ESE type)	Erico
		Nimbus
		Ashlok
		AT, Spain
		Ingesco
		Indelec
17	ABT Energy Meter (subject to approval of UPPCL/ UPTCL /State DisComs)	SEMS
		EDMI
		L&T

18	33kV Cable (subject to approval of UPPCL/ UPTCL /State DisComs)	M/s Universal (Satna, MP)
		M/s Torrent (Ahmedabad, Gujarat)
		M/s KEI (New Delhi)
		M/s Polycab (Daman, Gujarat)
19	Disc and post insulator	BHEL
		Birla
20	GI structure for the switchyard	Sujana Towers
		Kalpatru Power transmission
		OR Any other Approved vendors of UPPCL/ UPTCL /State DisComs
21	Insulator hardware	3M
		ITIPL
		Approved vendors of UPPCL/ UPTCL /State DisComs
22	Clamps and connectors	Klemenn engineering corporation
		Approved vendors of UPPCL/ UPTCL /State DisComs
23	Numerical Relay	Siemens
		Schneider Electric/L&T
		ABB Ltd.
24	Switch fuse unit	Siemens
		L & T/ABB Ltd.
25	PLCC equipments	ABB
26	Lighting fixture / system	Philips / CGL/Bajaj/Havells
27	LED Lighting	Wipro
		Bajaj
		Panasonic
		Philips
28	MCCB	SIEMENS
		ABB
		Schneider
		L & T
29	RMU (Ring Main Unit)	ABB
		Schneider
		Siemens
		L & T
30	Steel Structure for MMS	TISCO
		SAIL

		JINDAL
		RINL
		ESSAR
31	Submersible/Sump Pump	Kirlosker
		KSB
		CRI
		Jyoti
32	CCTV Camera & Monitoring System	Sony /Honeywell/Milestone
33	NIFPS	CTR/Vimal Shootfire/CEA approved
34	Fire Alarm System	Schrack Seconet
		Siemens Fire Finder
		Honeywell Notifier
		JCI Simplex (Tyco)
35	SWITCHBOARD-HV (INDOOR) WITH VCB BREAKR	LARSEN & TOUBRO LTD- TAMCO DIV.
		STELMEC LIMITED
		SCHNEIDER ELECTRIC INFRASTRUCTURE LIMITED
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
		BHEL (BHOPAL)
		SCHNEIDER ELECTRIC INFRA. LTD(FORM A347)
		SIEMENS LIMITED
		ABB INDIA LTD (NASIK)
36	SWITCHBOARD-M.V.-MCC/PCC/PMCC-DRAWOUT	ABB INDIA LTD
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		SCHNEIDER ELECTRIC INFRA. LTD(FORM A347)
		LARSEN & TOUBRO LTD-POWAI
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		CONTROLS & SCHEMATICS LTD
		SIEMENS LIMITED
37	RELAY & CONTROL PANEL	GE INDIA INDUSTRIAL PVT LTD
		DANISH PRIVATE LIMITED
		HITACHI ENERGY INDIA LIMITED

		VENSON ELECTRIC PRIVATE LIMITED
		SIEMENS LIMITED
		EASUN REYROLLE LTD
		ENPRO INDUSTRIAL AUTOMATION PVT LTD
		SIEMENS LTD - GOA
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		GE T&D INDIA LIMITED
38	SWITCHBOARD-HV-GAS INSULATED	SIEMENS LTD - GOA
		ABB INDIA LTD (NASIK)
		SCHNEIDER ELECTRIC INFRA. LTD(FORM A347)
		ABB INDIA LTD (BARODA)
39	SWITCHBOARD FIXED FOR PACKAGE EQUIPTS	TRICOLITE ELECTRICAL INDUSTRIES PVT LTD
		INTRELEC
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		ELECTRO ALLIED PRODUCTS
		NITYA ELECTROCONTROLS PRIVATE LIMITED
		MILESTONES SWITCHGEARS PVT LTD
		POPULAR SWITCHGEARS PVT LTD
		M.K. ENGINEERS & CONTROLS PVT. LTD.
		ACCUSONIC CONTROLS PVT LTD
		VIDHYUT CONTROL (INDIA) PVT LTD
		MAKTEL SYSTEMS
		POSITRONICS PVT LTD
		ZENITH ENGINEERING CORP.
		DHARIA SWITCHGEAR & CONTROL.
40	M V SYSTEM PACKAGE	GE INDIA INDUSTRIAL PVT LTD
		SIEMENS LIMITED
		LARSEN & TOUBRO LTD-POWAI
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED

41	H V SYSTEM PACKAGE	CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		SCHNEIDER ELECTRIC INFRASTRUCTURE LIMITED
		SIEMENS LIMITED
		ABB INDIA LTD (NASIK)
42	CONTROL STATIONS- WEATHERPROOF	SUDHIR SWITCHGEARS PVT LTD
		TEKMEC SWITCHGEAR & CONTROLS
		FLAMEPROOF EQUIPMENTS PVT.LTD
		FLEXPRO ELECTRICALS PVT LTD
		EX-PROTECTA
		BALIGA LIGHTING EQUIPMENTS (P) LIMITED
		FCG POWER INDUSTRIES PVT LTD
		PEPPERL & FUCHS MANUFACTURING (INDIA) PRIVATE LIMITED
		TEKNIC ELECTRIC (I) PVT. LTD.
		FCG FLAMPROOF CONTROL GEARS P. LTD(C-157
		BCH ELECTRIC LTD
		ELECTRICAL EQUIPMENT CORPORATION
		PHOENIX MECANO INDIA PVT. LTD.
43	BATTERY CHARGERS	CHHABI ELECTRICALS PVT LIMITED
		MASS-TECH CONTROLS PVT LTD
		STATCON ENERGIAA PVT. LTD.
		HBL POWER SYSTEMS LTD
		UNIVERSAL INSTRUMENT MFG CO PVT LTD
		AMARA RAJA POWER SYSTEMS LIMITED
		DUBAS ENGINEERING PVT LTD

		HITACHI HI-REL POWER ELECTRONICS PRIVATE LIMITED
		Borri S.p.A
		M/s Servilink / M/s Universal
		CHLORIDE POWER SYSTEMS & SOLUTIONS LTD
		M/s caldyne
44	BATTERIES-NICKLE CADMIUM	SAFT INDIA PRIVATE LIMITED
		HBL POWER SYSTEMS LTD
		Exide / HBL/Amaron
45	U.P.S.SYSTEM	CHLORIDE INDUSTRIAL SYSTEMS
		HITACHI HI-REL POWER ELECTRONICS PRIVATE LIMITED
		VERTIV ENERGY PVT. LTD.
		Borri S.p.A
		GUTOR ELECTRONIC LLC
		TOSHIBA CORPORATION
		FUJI ELECTRIC CO LTD
		MGE ASIA PTE LTD
		AMETEK SOLID STATE CONTROLS
46	MOTOR INDUCTION-MV (INDL.TYPE SAFE AREA)	ABB INDIA LTD-FARIDABAD
		CG POWER & INDUSTRIAL SOLUTIONS LTD.
		HAVELLS INDIA LTD
		SIEMENS LIMITED
		LAXMI HYDRAULICS PVT LTD
		MARATHON ELECTRIC MOTORS (INDIA) LTD.
		HEM INDUSTRIES
		ABB INDIA LTD (BANGALORE)
		BHARAT BIJLEE LIMITED
		KIRLOSKAR ELECTRIC CO LTD
		KIRLOSKAR ELECTRIC CO LTD
47	MOTOR-INDUCTION-M.V(ZONE 2-TYPE e & n)	ABB INDIA LTD (BANGALORE)
		BHARAT BIJLEE LIMITED
		LAXMI HYDRAULICS PVT LTD

		ABB INDIA LTD-FARIDABAD
		MARATHON ELECTRIC MOTORS (INDIA) LTD.
		CG POWER & INDUSTRIAL SOLUTIONS LTD.
		KIRLOSKAR ELECTRIC CO LTD
		KIRLOSKAR ELECTRIC CO LTD
48	TRANSFORMERS-POWER-ABOVE 5MVA	TRANSFORMERS & RECTIFIERS (I) LTD
		SCHNEIDER ELECTRIC INFRA. LTD(FORM A347)
		BHARAT BIJLEE LIMITED
		KANOHAR ELECTRICALS LIMITED
		CG POWER & INDUSTRIAL SOLUTIONS LTD.
		KANOHAR ELECTRICALS LTD.
		BHEL JHANSI
		VOLTAMP TRANSFORMERS LTD
		KIRLOSKAR ELECTRIC CO LTD
		TRANSFORMERS & ELECTRICALS KERALA LTD
		ATLANTA ELECTRICALS PRIVATE LIMITED
		GE T&D INDIA LIMITED
49	TRANSFORMERS-DISTRIBUTION-UPTO 5MVA	SCHNEIDER ELECTRIC INFRA. LTD(FORM A347)
		KANOHAR ELECTRICALS LIMITED
		KANOHAR ELECTRICALS LTD.
		RAYCHEM RPG PRIVATE LIMITED
		VOLTAMP TRANSFORMERS LTD
		TRANSFORMERS & RECTIFIERS (I) LTD
		HAMMOND POWER SOLUTIONS PRIVATE LIMITED
		CG POWER & INDUSTRIAL SOLUTIONS LTD.
		RIMA TRANSFORMERS & CONDUCTORS PVT LTD
50	TRANSFORMER-DISTRIBUTION(DRY TYPE)	BHEL JHANSI

		VOLTAMP TRANSFORMERS LTD
		KIRLOSKAR ELECTRIC CO LTD
51	LIGHTING FIXTURE & ACCESSORIES-HAZARDOUS	FCG POWER INDUSTRIES PVT LTD
		BALIGA LIGHTING EQUIPMENTS (P) LIMITED
		FLEXPRO ELECTRICALS PVT LTD
		FCG FLAMPROOF CONTROL GEARS P. LTD(C-157
		R STAHL PVT LTD
		SUDHIR SWITCHGEARS PVT LTD
		FLAMEPROOF EQUIPMENTS PVT.LTD
		KAYSONS TECHNO EQUIPMENTS PVT. LTD.
52	HIGH MAST LIGHTING SYSTEM	BAJAJ ELECTRICALS LTD
		BAJAJ ELECTRICALS LTD
		SIGNIFY INNOVATIONS INDIA LIMITED
53	EPABX SYSTEM	BPL SYSTEMS AND PROJECTS LTD
		AGC NETWORKS LTD (FORM. T-130)
54	CABLES-HIGH VOLTAGE-XLPE	APAR INDUSTRIES LTD
		HAVELLS INDIA LTD
		UNIVERSAL CABLES LTD
		POLYCAB INDIA LIMITED
		STERLITE POWER TRANSMISSION LIMITED
		GEMSCAB INDUSTRIES LTD
		TIRUPATI PLASTOMATICS PVT. LTD.
		GUPTA POWER INFRASTRUCTURE LIMITED
		KEI INDUSTRIES LIMITED
		KEC INTERNATIONAL LIMITED
		POLYCAB INDIA LIMITED
		KEI INDUSTRIES LIMITED
		TCL CABLES PRIVATE LIMITED
55	CABLES-MEDIUM VOLTAGE-POWER-PVC/XLPE	GUPTA POWER INFRASTRUCTURE LIMITED

		POLYCAB INDIA LIMITED
		HAVELLS INDIA LTD
		KEC INTERNATIONAL LIMITED
		POLYCAB INDIA LIMITED
		POLYCAB INDIA LIMITED
		APAR INDUSTRIES LTD
		POLYCAB INDIA LIMITED
		CHANDRESH CABLES LIMITED
		UNIVERSAL CABLES LTD
		POLYCAB INDIA LIMITED
		SUYOG ELECTRICALS LTD
		Special Cables Pvt. Ltd.
		KEI INDUSTRIES LIMITED
		THERMO CABLES LTD.
		CORDS CABLE INDUSTRIES LTD
		ASSOCIATED FLEXIBLES & WIRES [P] LTD
		SRIRAM CABLES PVT LTD
		GEMSCAB INDUSTRIES LTD
		SHIVPRIYA CABLES PRIVATE LIMITED
		KEI INDUSTRIES LIMITED
		CMI LIMITED
56	CONTROL CABLE (UNPAIRED) - FIRE SURVIVAL	ASSOCIATED FLEXIBLES & WIRES [P] LTD
		HAVELLS INDIA LTD
		CORDS CABLE INDUSTRIES LTD
		POLYCAB INDIA LIMITED
		CORDS CABLE INDUSTRIESLTD.
		POLYCAB INDIA LIMITED
		KEI INDUSTRIES LIMITED
		POLYCAB INDIA LIMITED
		KEI INDUSTRIES LIMITED
		THERMO CABLES LTD.
		SUYOG ELECTRICALS LTD
		ELKAY TELELINKS LTD.-
		ICON CABLE LTD.
57	CABLES - FIRE ALARM, COMMUNICATION AND CONTROL PAIRED - FIRE SURVIVAL	SUYOG ELECTRICALS LTD
		CORDS CABLE INDUSTRIES LTD
		KEI INDUSTRIES LIMITED

		DELTON CABLES LIMITED
		ELKAY TELELINKS LTD.-
		UDEY PYROCABLES PVT. LTD.
		THERMO CABLES LTD (FORM. T-150
58	CABLES COMMN. (JELLY FILLED)	POLYCAB INDIA LIMITED
		DELTON CABLES LIMITED
		ELKAY TELELINKS LTD.
		VINDHYA TELELINKS LIMITED
		BIRLA CABLE LIMITED
59	CAPACITORS-HIGH VOLTAGE	UNIVERSAL CABLES LTD
		HITACHI ENERGY INDIA LIMITED
		BHEL (BHOPAL)
		SHREEM ELECTRIC LIMITED
60	NEUTRAL GROUNDING RESISTORS-H.V.	S.R. NARKHEDE ENGINEERING PVT LTD
		BCH ELECTRIC LTD
		RSI SWITCHGEAR PVT LTD
		RESITECH ELECTRICALS PVT LTD
61	PLANT COMMUNICATION SYSTEM	INDUSTRONIC, Industrie-Electronic GmbH & Co. KG
		Neumann Elektronik GmbH
		ARMTEL LLC
62	ELECTRIC CONTROL SYSTEM (BASE LEVEL)	SIEMENS LTD - GOA
		EMERSON PROCESS MANAGEMENT INDIA PVT LTD
		HONEYWELL AUTOMATION INDIA LTD.
		ABB INDIA LTD (BANGALORE)
		SCHWEITZER ENGINEERING LABORATORIES
		EMERSON PROCES MGMT ASIA PACIFIC PTE LTD
		ABB AS
		FOXBORO SCADA SPA
		SIEMENS LTD - NASHIK
63	ELECTRIC CONTROL SYSTEM (BASE+ADVANCE)	FOXBORO SCADA SPA
		ABB INDIA LTD (BANGALORE)

		ABB AS
		HONEYWELL AUTOMATION INDIA LTD.
		EMERSON PROCESS MANAGEMENT INDIA PVT LTD
		EMERSON PROCES MGMT ASIA PACIFIC PTE LTD
		SCHWEITZER ENGINEERING LABORATORIES
64	PAGING AND INTERCOM SYSTEM - OFFSHORE	COMTROL PTE LTD
65	FIRE ALARM SYSTEM	NEW FIRE ENGINEERS (P) LTD
		EDWARD INTERNATIONAL
		HONEYWELL INC.
		HONEYWELL AUTOMATION INDIA LTD.
		TYCO FIRE & SECURITY INDIA PVT. LTD
		Schrack Seconet
		Siemens Fire Finder
		Honeywell Notifier
		JCI Simplex (Tyco)
66	AIR CIRCUIT BREAKER	SIEMENS LIMITED
		SCHNEIDER ELECTRIC INDIA P LTD-HYDERABAD
		LARSEN & TOUBRO LTD-POWAI
		GE INDIA INDUSTRIAL PVT LTD
		ABB INDIA LTD
67	AUX. RELAYS	M/S JVS ELECTRONICS PVT LTD
		GE T&D INDIA LIMITED
		HITACHI ENERGY INDIA LIMITED
		JYOTI LIMITED
		JYOTI LIMITED
68	BIMETAL RELAYS	SIEMENS LIMITED
		GE INDIA INDUSTRIAL PVT LTD
		BCH ELECTRIC LTD
		ABB INDIA LTD (BANGALORE)
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED

		SCHNEIDER ELECTRIC INDIA P LTD-HYDERABAD
		C & S ELECTRIC LTD
69	BUS DUCTS (M.V)	JASPER ENGINEERS PVT LTD
		M.K. ENGINEERS & CONTROLS PVT. LTD.
		GODREJ & BOYCE MANUFACTURING COMPANY LIMITED
		Novateur Electrical & Digital Systems Private Limited
		Stardrive Busducts Limited
		UNITED ELECTRIC CO (DELHI) PVT LTD
		NITYA ELECTROCONTROLS PRIVATE LIMITED
		GLOBE ELECTRICAL INDUSTRIES
		GODREJ & BOYCE MANUFACTURING COMPANY LIMITED
		NARMADA SWITCHGEAR PVT. LTD
		ENPRO ENGINEERING
		C & S ELECTRIC LTD
70	BUS DUCT (H.V)	GODREJ & BOYCE MANUFACTURING COMPANY LIMITED
		ENPRO ENGINEERING
		UNITED ELECTRIC CO (DELHI) PVT LTD
		Stardrive Busducts Limited
		BHEL JHANSI
		NARMADA SWITCHGEAR PVT. LTD
		GODREJ & BOYCE MANUFACTURING COMPANY LIMITED
		C & S ELECTRIC LTD
71	BUCHHOLZ RELAY	A J SERVICES
		ATVUS INDUSTRIES

72	CABLE GLANDS (HAZARDOUS AREA)	BALIGA LIGHTING EQUIPMENTS (P) LIMITED
		STANDARD METAL INDUSTRIES
		CMP PRODUCTS LIMITED
		COMET INDUSTRIES
		METAL CRAFT INDUSTRIES
		FLAMEPROOF EQUIPMENTS PVT.LTD
		AKSHAR BRASS INDUSTRIES
		KAYSONS TECHNO EQUIPMENTS PVT. LTD.
		SUDHIR SWITCHGEARS PVT LTD
		FCG POWER INDUSTRIES PVT LTD
		COMET BRASS PRODUCTS
		FCG FLAMPROOF CONTROL GEARS P. LTD(C-157
		FLEXPRO ELECTRICALS PVT LTD
		3D
73	CABLE TERMN. & JOINTING KIT	YAMUNA CABLE ACCESSORIES PVT. LTD.
		HEATSHRINK TECHNOLOGIES LTD (FORM. R136)
		RAYCHEM RPG PRIVATE LIMITED
		3M ELECTRO & COMMUNICATION INDIA PRIVATE LIMITED
74	CONTACTORS	GE INDIA INDUSTRIAL PVT LTD
		SCHNEIDER ELECTRIC INDIA P LTD-HYDERABAD
		BCH ELECTRIC LTD
		ABB INDIA LTD (BANGALORE)
		SIEMENS LIMITED
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		C & S ELECTRIC LTD
75	CONTROL SWITCHES (BREAKER)	SWITRON DEVICES
		RELIABLE ELECTRONIC COMPONENTS PVT LTD

		GE T&D INDIA LIMITED
76	CONTROL SWITCHES / SELECTOR SWITCHES	SIEMENS LIMITED
		SWITRON DEVICES
		TEKMEC SWITCHGEAR & CONTROLS
		HOTLINE SWITCHGEAR & CONTROLS
		GE T&D INDIA LIMITED
		P.P. INDUSTRIES
		RELIABLE ELECTRONIC COMPONENTS PVT LTD
		KAYCEE INDUSTRIES LTD.
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
77	CIRCUIT BREAKER SF-6 OUTDOOR HV	ABB INDIA LTD (NASIK)
78	EARTH LEAKAGE CIRCUIT BREAKER	SIEMENS LIMITED
		LEGRAND (INDIA) PVT. LTD (FORM. M-006)
		NOVATEUR ELECTRICAL & DIGITAL SYSTEMS PVT. LTD.
		SCHNEIDER ELECTRIC INDIA PVT LTD
		HAVELLS INDIA LIMITED
		GE INDIA INDUSTRIAL PVT LTD
		ABB INDIA LTD
79	FUSES	GE INDIA INDUSTRIAL PVT LTD
		NOVATEUR ELECTRICAL & DIGITAL SYSTEMS P
		SIEMENS LIMITED
		EATON POWER QUALITY PRIVATE LIMITED
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
80	HEAVY DUTY SWITCHES	SIEMENS LIMITED
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		C & S ELECTRIC LTD
81	INSTRUMENT TRANSFORMERS CT & PT (MV)	SILKAANS ELECTRICALS MFG.CO.PVT.LTD
		PRAGATI ELECTRICALS PVT LTD

		GILBERT & MAXWELL ELECTRICALS PVT LTD
		PRAGATI ELECTRICALS PVT LTD
		PRECISE ELECTRICALS
		NEWTEK ELECTRICALS
		KALPA ELECTRIKAL PVT LTD
		NARAYAN POWERTECH PVT LTD
82	INSTRUMENT TRANSFORMERS CT & PT (HV)	PRAGATI ELECTRICALS PVT LTD
		KALPA ELECTRIKAL PVT LTD
		STRATON ELECTRICALS PRIVATE LIMITED
		ELECTRICAL CONTROLS & SYSTEMS
		HITACHI ENERGY INDIA LIMITED
		GEMINI INSTRATECH LTD
		SCHNEIDER ELECTRIC INFRASTRUCTURE LIMITED
		KAPPA ELECTRICALS
83	CT/PT OUTDOOR (EHV)	HITACHI ENERGY INDIA LIMITED
		PRAGATI ELECTRICALS PVT LTD
		BHEL JHANSI
		GE T&D INDIA LIMITED
		CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
		ELECTRICAL CONTROLS & SYSTEMS
		TRANSFORMERS & ELECTRICALS KERALA LTD
		Jyoti
		ABB
84	SOLATOR & EARTHING SWITCH OUTDOOR EHV	S&S POWER SWITCHGEAR LTD
		SIEMENS LIMITED
85	ISOLATOR OUTDOOR H.V. UP TO 33 KV.	S&S POWER SWITCHGEAR LTD
		SIEMENS LIMITED
		PANICKKER SWITCHGEAR PVT LTD(FORM D-022)
86		SIEMENS LIMITED

	ISOLATORS/LOAD BREAK SWITCHES(HV INDOOR)	PANICKKER SWITCHGEAR PVT LTD(FORM D-022)
		ABB
		L&T
87	LIGHTNING ARRESTORS	CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
		W.S. INSULATOR OF INDIA
		ELPRO INTERNATIONAL LIMITED
		OBLUM ELECTRICAL INDUSTRIES (P) LTD
		ESSAR
88	LIGHTING FIXTURE & ACCESORY-NON HZARDOUS	HAVELLS INDIA LTD
		PYROTECH ELECTRONICS PVT. LTD. UNIT -1
		BAJAJ ELECTRICALS LTD
89	LIGHTING & POWER PANELS (SAFE AREA)	HAVELLS INDIA LIMITED
		NOVATEUR ELECTRICAL & DIGITAL SYSTEMS P
		ABB INDIA LTD
90	DRY TYPE LIGHTING TRANSFORMERS	INDCOIL TRANSFORMERS PVT LTD
		VOLTAMP TRANSFORMERS LTD
		AUTOMATIC ELECTRIC LTD.
		GUJARAT PLUG-IN DEVICES PVT LTD
91	MCB	STANDARD ELECTRICALS LTD
		SCHNEIDER ELECTRIC INDIA PVT LTD
		LEGRAND (INDIA) PVT. LTD (FORM. M-006)
		NOVATEUR ELECTRICAL & DIGITAL SYSTEMS PVT. LTD.
		HAVELLS INDIA LIMITED
		SIEMENS LIMITED
		POLYCAB INDIA LIMITED
		INDIANA CURRENT CONTROL LTD
		ABB INDIA LTD

		C & S ELECTRIC LTD
92	MCCB	SIEMENS LIMITED
		LARSEN & TOUBRO LTD-POWAI
		ABB INDIA LTD
		GE INDIA INDUSTRIAL PVT LTD
		SCHNEIDER ELECTRIC INDIA P LTD-HYDERABAD
93	METERS	NEWTEK ELECTRICALS
		RISHABH INSTRUMENTS PVT LTD
		SECURE METERS LIMITED
		AUTOMATIC ELECTRIC LTD.
		MECO INSTRUMENTS PVT LTD
		NIPPEN ELECTRICAL INSTRUMENTS CO.
94	MAGNETIC OIL LEVEL GAUGE	SUKRUT UDYOG
		INSTRUMENT & CONTROLS
95	OIL TEMPERATURE INDICATOR	PRECIMEASURE CONTROLS PVT.LTD.
		PERFECT CONTROLS
96	ON LOAD TAP CHANGER	ON LOAD GEARS
		CTR MANUFACTURING INDUSTRIES LTD
		EASUN-MR TAP CHANGERS P LTD
		BHEL (BHOPAL)
		TRANSFORMERS & ELECTRICALS KERALA LTD
97	PROTECTION RELAYS	GE T&D INDIA LIMITED
		SCHWEITZER ENGINEERING LABORATORIES
		SIEMENS LTD - GOA
		SCHNEIDER ELECTRIC INDIA P LTD-HYDERABAD
		ABB INDIA LTD (BARODA)
		EASUN REYROLLE LTD
98	PUSH BUTTON AND INDICATING LAMPS	TEKMEC SWITCHGEAR & CONTROLS
		SCHNEIDER ELECTRIC INDIA P LTD-HYDERABAD
		P.P. INDUSTRIES

		SHRI TULSI SWITCHGEARS PVT LTD
		ESSEN DEINKI
		TEKNIC ELECTRIC (I) PVT. LTD.
		HOTLINE SWITCHGEAR & CONTROLS
		LARSEN & TOUBRO LTD-POWAI
		SIEMENS LIMITED
		PRECIFINE PRODUCTS PVT. LTD.
		BCH ELECTRIC LTD
		C & S ELECTRIC LTD
99	FUSE SWITCH COMBINATION	NOVATEUR ELECTRICAL & DIGITAL SYSTEMS P
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
		SIEMENS LIMITED
		HAVELLS INDIA LIMITED
		STANDARD ELECTRICALS LTD
		GE INDIA INDUSTRIAL PVT LTD
		C & S ELECTRIC LTD
100	TIMERS	SIEMENS LIMITED
		ELECTRONIC AUTOMATION PVT LTD
		BCH ELECTRIC LTD
		SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED
101	VACUUM INTERRUPTER	ABB GLOBAL INDUSTRIES & SERVICES LTD
		SCHNEIDER ELECTRIC INFRASTRUCTURE LIMITED
102	WINDING TEMPERATURE INDICATOR	PERFECT CONTROLS
		PRECIMEASURE CONTROLS PVT.LTD.

NOTES:

(1) Bidder must confirm along with the offer that open bidding process shall not be followed for procurement by him and closed bidding shall be followed from Company / Consultant approved vendors only. This is one of qualifying criteria for selection of the Bidder.

(2) The final make selected out of the mandatory makes listed above shall be subject to the GAIL/BHEL approval during detailed Engineering but prior to Bidder's procurement action.

(3) Wherever the make is not specified for any other items, the Contractor shall submit credential for vendors for relevant items / equipment, out of which GAIL/BHEL shall decide acceptance of vendor based on review of credentials. This shall have no price implication. Owner reserves the right to reject the proposed vendor without assigning any reason.

(4) Bidder may suggest /request for approval of Additional vendor with credentials and details for review and approval of GAIL/BHEL. GAIL/BHEL may consider the request in case proposed additional vendor is reputed and meeting the tender specification requirements. GAIL/BHEL reserves the right to reject the proposed vendor without assigning any reason.

SECTION-13: QUALITY ASSURANCE PROCEDURE

1. INSPECTION & TESTING:

1.1. The GAIL/BHEL or its authorized representative shall have, at all time, access to the Contractor's premises and also shall have the power, at all times, to inspect and examine the materials and workmanship of project work during its manufacture, shop assembly and testing. If part of the plant is required to be manufactured in the premises other than the Contractor's, the necessary permission for inspection shall be obtained by the Contractor for GAIL/BHEL or his duly authorized representative.

1.2. The GAIL/BHEL shall have the right to serve notice in writing to the Contractor on any grounds of objections, which he may have in respect of the work. The Contractor has to forthwith take necessary actions to remove the cause to the complete satisfaction of the GAIL/BHEL otherwise, the GAIL/BHEL at its liberty may reject all or any component of plant or workmanship connected with such work.

1.3. The Contractor shall issue request letter to the GAIL/BHEL or its authorized representative for testing of any component of the plant, which is ready for testing at least 07 days in advance from the date of actual date of testing at the premises of the Contractor or elsewhere. However, the GAIL/BHEL at its own discretion may waive the inspection and testing in writing under very special circumstances. In such case, the Contractor may proceed with the tests (As per Relevant IS/IEC/Codal provisions) which shall be deemed to have been made in the GAIL/BHEL presence, and it shall forthwith forward two sets of duly certified copies of test results and certificates to the GAIL/BHEL for approval. The Contractor, on receipt of written acceptance from the GAIL/BHEL, may dispatch the equipment for erection & installation.

1.4. For all tests to be carried out, whether in the premises of the Contractor or any supplier, the Contractor, shall provide labor, materials, electricity, fuel, water, stores, apparatus and instruments etc. free of charge as may reasonably be demanded to carry out such tests of the plant in accordance with the Contract. The Contractor shall provide all facilities to the GAIL/BHEL or its authorized representative to accomplish such testing.

1.5. The GAIL/BHEL or his authorized representative shall have the right to carry out inward inspection of the items on delivery at Site and if the items have been found to be not in line with the approved specifications/drawings, shall have the liberty to reject the same.

1.6. If GAIL/BHEL desires, testing of any component(s) of the plant be carried out by an independent agency. The inspection fee, if any, shall be paid by the GAIL. However, the Contractor shall render all necessary help to GAIL/BHEL whenever required free of charge.

1.7. The Contractor has to provide the necessary testing reports to the GAIL/BHEL as and when required.

1.8. Neither the waiving of inspection nor acceptance after inspection by the GAIL/BHEL shall, in anyway, absolve the Contractor of the responsibility of supplying the plant and equipment strictly in accordance with specification and drawings etc.

1.9. The Contractor shall offer following Test / Inspection to the GAIL/BHEL

i. GAIL/BHEL may depute its Engineer or representative or hire an agency for Third-Party Inspection, for pre-dispatch inspection at the manufacturing facility of the Contractor all items under this RFP as per applicable standards, approved QAP and documents. Samples for testing shall be drawn randomly in presence of GAIL/BHEL inspecting agency from the lot offered for inspection. After Test/Inspection of the Items at factory, the Contractor is to submit the inspection & test reports to GAIL for review. After review of the inspection & test reports, GAIL will give dispatch clearance in writing. The Contractor shall not dispatch any item without dispatch clearance from GAIL, in writing. For inspection of PV modules and equipment like inverters, transformer, cables, HT Switchgear, LT Switchgear, SCADA Panel, etc. where contractor purchase it from third party, provision of PDI by GAIL & PMC shall be incorporated at the manufacturing facility of third party/ supplier.

ii. GAIL may depute its Engineer or representative or third-party inspection agency for inspection during manufacture and in assembled condition prior to dispatch in accordance with the standard practice/ QAP of the manufacturer and applicable Standards, at no additional cost to GAIL for demonstration and performing the test/inspection. The Contractor shall raise inspection call with internal test reports in advance for all items like PV Modules, Floaters, MMS, cables, SCBs, Inverters, Transformers, HT & LT switchgears, DC system, Switchyard equipment's, earthing system, SCADA etc.

iii. If required, upon delivery of the photovoltaic modules on site, they may be sampled randomly and tested for performance through an approved testing agency appointed by contractor and approved by GAIL. The result of such testing agency shall be binding to both the parties and shall be considered final performance measurement report for the guarantee / warrantee conditions of this contract.

1.10. In case of underperformance or rejection of the photovoltaic modules during above inspection or during operational life time of project, GAIL shall notify the Contractor of such underperformance or rejection by email or in writing.

i. Consecutively, the Contractor shall immediately replace such PV modules by supplying a new PV module of similar specification conforming to the required performance criteria and warranty to GAIL within a period of 10 days from the date of intimation by email or written notice.

ii. Upon receipt of the new PV module by the Company, the Contractor shall arrange to collect the rejected/defective photovoltaic module from site.

iii. The cost of transportation of the PV modules from the supplier to the site of GAIL, and return shall be borne by the Contractor.

1.11. GAIL shall have the right to serve notice in writing to the Contractor on any grounds of objections, which he may have in respect of the work. The Contractor has to satisfy the objection, otherwise, the GAIL/BHEL at his liberty may reject all or any component of plant or workmanship connected with such work.

1.12. The Contractor shall issue request letter to GAIL or his authorized representative for testing of any component of the plant, which is ready for testing at least fifteen (15) days in advance from the date of actual date of testing at the premises of the Contractor or elsewhere. When the inspection and the tests have been satisfactorily completed at the Contractor's works, GAIL shall issue a certificate to that effect. However, the GAIL/BHEL at its own discretion may waive the inspection and testing in writing under very special circumstances. In such case, the Contractor may proceed with the tests which shall be deemed to have been made in GAIL's presence, and it shall forthwith forward six (6) sets of duly certified copies of test results and certificates to the Company for approval of the Company. The Contractor, on receipt of written acceptance from GAIL/BHEL, may dispatch the equipment for erection and installation.

1.13. For all tests to be carried out, whether in the premises of the Contractor or any Subcontractor or the supplier, the Contractor, shall provide labour, materials, electricity, fuel, water, stores, apparatus and instruments etc. free of charge as may reasonably be demanded to carry out such tests of the plant in accordance with the Contract. The Contractor shall provide all facilities to GAIL/BHEL or its authorized representative to accomplish such testing.

1.14. The GAIL/BHEL or his authorized representative shall have the right to carry out inward inspection of the items on delivery at the Site and if the items have been found to be not in line with the approved specifications, shall have the liberty to reject the same.

1.15. If the GAIL/BHEL desires, testing of any component(s) of the plant be carried out by an independent agency, the inspection fee, if any, shall be paid by the GAIL. However, the Contractor shall render all necessary help to GAIL whenever required free of charge.

1.16. The Contractor has to provide the necessary testing reports to GAIL/BHEL as and when required.

1.17. Neither the waiving of inspection nor acceptance after inspection by GAIL/BHEL shall, in anyway, absolve the Contractor of the responsibility of supplying the plant and equipment strictly in accordance with specification and drawings etc.

1.18. If any item is not found conforming to standards during test / inspection, the same shall be replaced / rectified by Contractor without any cost to GAIL and shall be re-offered for inspection.

1.19. The work is subject to inspection at all times and at all places by GAIL/BHEL. The Contractor shall carry out all instructions given during inspection and shall ensure that the work is carried out according to the relevant codes of practice.

1.20. Decision of the GAIL/BHEL in regard to the quality of work and materials and **performance to the specifications and drawings shall be final.**

2. AUTHORIZED TEST CENTERS FOR TEST CERTIFICATES

The PV modules/ inverters/ cables and other Balance of system equipment deployed in the solar PV power plant shall have valid test certificates for their qualification as per above specified IEC/ IS Standards by one of the NABL Accredited Test Centers in India. In case of module types/ equipment for which such Test facilities may not exist in India, test certificates from reputed ILAC Member body accredited Labs abroad (with proof of accreditation) will be acceptable.

3. INSPECTION CATEGORISATION OF ITEMS:

3.1. Following are the Categories of Inspection various Items for FSPV at GAIL Pata.

TABLE 16: INSPECTION CATEGORIES

Inspection Category	**Methodology**
Cat-I	Physical Inspection at vendor's work by PMC/GAIL. MDCC to be issued by PMC
Cat-II	Review of inspection reports by PMC. Reports to be submitted by EPC contractor post physical inspection of EPC contractor. MDCC issued by PMC.
Cat-III	EPC Contractor shall submit internal routine test reports performed by manufacturer/supplier as per approved QAP. No MDCC will be issued by PMC. Reports shall be kept for Information only.

3.2. List of major items along with inspection category provided in below table.

TABLE 17: ITEMWISE INSPECTION CATEGORY

CAT-I ITEMS	
1	SPV Module
2	Power Conditioning Unit (PCU)/ String Inverter
3	Inverter Junction Box/AC Combiner Box
4	Inverter Transformer
5	HT Switchgear Panel & Components
6	SCADA System
CAT-II ITEMS	
1	String Monitoring Box (SMB)/String Combiner box (SCB)
2	HT Cables
3	DC and AC cables
4	Control Cables
5	ESE Lightning Arrestor
6	Battery, Battery Charger, UPS
7	Fiber optic cable
8	Weather station panel (comprising of Pyranometer, anemometer & thermometer etc.)
9	Galavanised steel structures (lattice & pipe) for switchyard and transmission line, as applicable
10	HDPE FLOATER FOR SOLAR PROJECT
11	AC Combiner/Distribution Board (ACCB/ACDB)
12	Mooring Accessories
13	Auxiliary Transformer
CAT-III ITEMS	
1	Earthing & Lightning Protection Material
2	HT Cable Termination Kit & Straight Through Jointing Kit
3	Cable Tray, fitting, accessories
4	Fire Extinguisher
5	Fire alarm panel
6	Module Cleaning System
7	Other Misc. BOS items

4. THIRD PARTY INSPECTION AGENCY (TPIA)

Bidder shall appoint a third party from the list mentioned below table-17 to carry out the stage inspections of Major equipment (Cat-1) supplied under this contract. Before raising the final inspection call, third party inspection reports to be submitted to GAIL/BHEL for review. The cost of appointment of TPI for staged inspection shall be in the bidder scope.

TABLE 18: APPROVED LIST OF TPIA

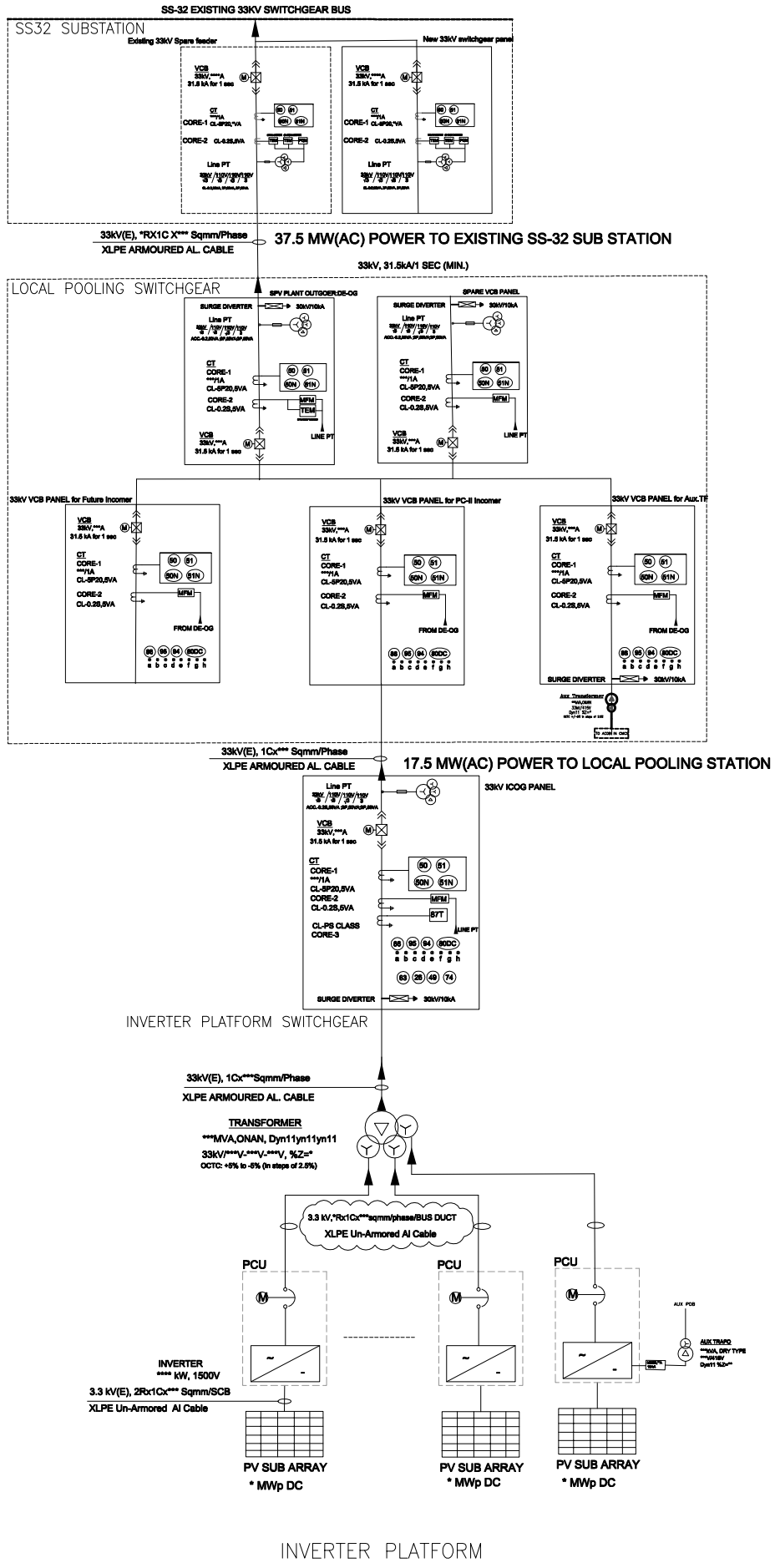
1. Lloyd Register of Industrial Services
2. Technische Ulierwachungs Verein (TUV)
3.Det Norske Veritas (DNV)
4.AB-Vincotte
5.Bureau Veritas
6.SGS
7.American Bureau Services
8.Velosi Certification Services
9.CEIL (Certification Engineers India Ltd)

ENCLOSURES:

TENDER DRAWINGS

****

INDICATIVE AC SLD FOR GAIL PATA 17.5 MW FSPV PROJECT



LEGEND DETAILS

SL. NO.	SYMBOL	DESCRIPTION
1		INVERTER DUTY TRANSFORMER
2		VCB 33kV,,630V/1250A 21kA/1SEC
3		SURGE DIVERTER, 30kV/10kA
4	86	MASTER TRIP RELAY
5	95 195 295	TRIP CIRCUIT SUPERVISION RELAY
6	94	ANTI PUMPING RELAY
7	63	BUCHHOLZ RELAY
8	26	MAGNETIC OIL LEVEL GAUGE
9	a	VCB ON
10	b	VCB OFF
11	c	SPRING CHARGE
12	d	AUTO TRIP
13	e	TRIP CIRCUIT HEALTHY
14	f	SERVICE POSITION
15	g	TEST POSITION
16	h	DC FAILURE
17	50	INST OVER CURRENT RELAY
18	51	IDMT OVER CURRENT RELAY
19	50N	NEUTRAL INSTANTANEOUS OVER CURRENT RELAY
20	51N	IDMT EARTH FAULT RELAY
21	MFM	MULTI FUNCTION METER
22		CURRENT TRANSFORMER
23		MOLDED CASE CIRCUIT BREAKER (MCCB)
24		MINIATURE CIRCUIT BREAKER (MCB)
25		POTENTIAL TRANSFORMER
26		FUSE
27		AIR CIRCUIT BREAKER (ACB)
28	TEM	TARIFF ENERGY METER
29	60DC	DC FAILURE INDICATION
30	49	WINDING TEMP INDICATOR AND OIL TEMP INDICATOR
31	74	PRESSURE RELIEF DEVICE
31	87T	TRANSFORMER DIFFERENTIAL RELAY

NOTE :

1. Scope shall include the extension of existing 33KV switchgear board of SS32 (make shall be specified elsewhere in specification).
2. The new panel for the SS32 substation shall be of same make as existing panel. Installation & Commissioning of panel shall be done in presence of OEM Engineer.
3. HT cable laying up to the new panel in existing SS-32 Substation and cable termination at final evacuation point is in EPC bidder scope.
4. As mentioned in this indicative AC SLD, the switchgear panels for spare requirement and future connections requirement shall be maintained.
5. For new switchgear in SS-32 Substation and HT cable from Local pooling station to Final evacuation point, the sizing shall be done considering the future project requirements (i.e. for total 37.5 MW). Accordingly, equipment shall be selected.
6. Bidder shall provide MAIN and CHECK Energy meters in the final evacuation point (SS-32) and STANDBY Energy Meter in final OG feeder from solar end. The meters shall have all necessary statutory and regulatory clearances. Supply and integration are in bidder's scope.
7. Suitable Auxiliary power system shall be provided in each inverter platform. Each system shall have suitably rated Auxiliary transformer, ACDB(AC distribution board),UPS and Battery bank,UPSDB.
8. In local pooling, Incomer and Aux.Panel shall take the voltage reference from DE-OG.
9. The inverter transformer arrangement shown is typical. The transformer impedance as per manufacturer recommendation.
10. Ratings of all equipment are indicative and shall be finalized during detail Engineering.
11. Differential protection for Inverter-duty transformers is applicable as per relevant standards. Accordingly Correspondingly CT cores shall be considered.
12. Solar power shall be integrated in existing 33KV spare feeder in SS-32. However, to make up for consumption of the existing spare feeder, two-panel extension, 1 in Bus-A and 1 in Bus-B of Substation-32 shall be in the scope of EPC bidder. Extension of panel shall be done by EPC bidder in presence of OEM service engineer.
13. In the existing 33KV spare outgoing feeder, existing CTs have to be changed with suitably rated CT and a Line PT/other suitable arrangement for voltage measurement and protection, shall be provided. All the necessary equipment (coils, contactors, relays and wiring) for these modifications is in bidder's scope.
14. Bidder shall extend the existing 33KV switchgear board of SS32 and new switchgear panel shall be connected to the existing switchgear.The new panel for the SS32 substation shall be of same make as existing panel. Installation & Commissioning of panel shall be done in presence of OEM Engineer.

TENDER ID- 2025_GAIL_232304_1

REV.	DATE	ALTERED / CHECKED / APPROVED

PROJECT : FLOATING SOLAR PV PROJECT in PC-2 Reservoirs.
CUSTOMER : GAIL PATA

BHARAT HEAVY ELECTRICALS LIMITED.
SOLAR BUSINESS DIVISION, BENGALURU

SINGLE LINE DIAGRAM-AC

DRAWN	JK		18.01.25
CHECKED	VJ		18.01.25
APPROVED	PM		18.01.25

BSPL CODE: PV 439
CUST DRAWG. NO.
BHEL DRG. NO.: GAIL-DFR-AC SLD-00
No. OF SHEETS: 01
SHEET: 01
REV: 00

A0 SIZE

प्रस्तुत आरेख एवं इसमें निहित डिजाइन इंजीनियर्स इंडिया लिमिटेड की संपत्ति है। ये मात्र उधार दिए गए है और उधारकर्ता ने यह स्पष्ट सहमति किया है कि न तो उन्हें पुनः मुद्रित किया जाएगा, न नकल की जाएगी, न उधार दिए जाएंगे, न प्रदर्शित किए जाएंगे और न ही सीमित और लिखित प्रयोग के अलावा इनका कोई अन्य प्रयोग होगा और यह प्रयोग उधार देने वाले द्वारा उधारकर्ता को लिखित रूप में दी गई सहमति के तहत होगा।

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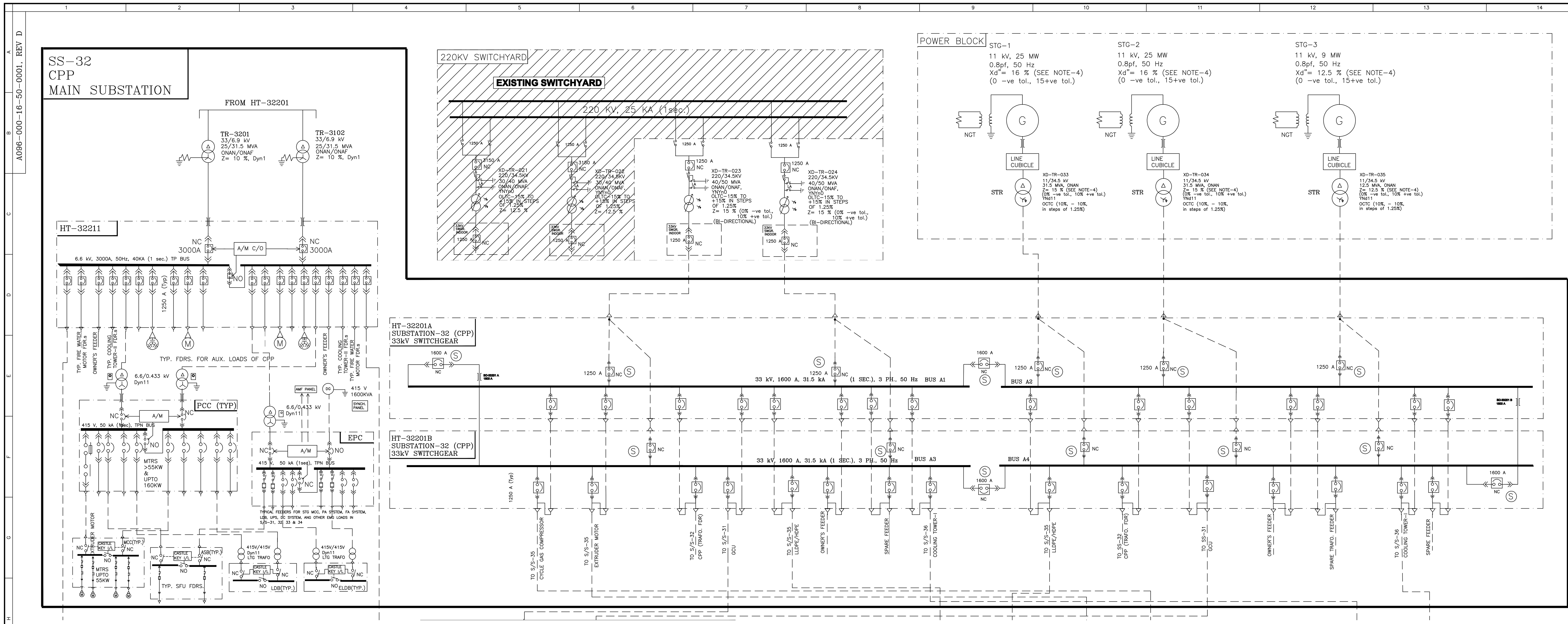

REF. DWG. NO.	REFERENCE DRAWING TITLE

NOTES :-

1. FOR EQUIPMENT DETAILS AND FEEDER DETAILS OF VARIOUS SWITCHBOARDS REFER DETAILED SLDs OF RESPECTIVE SUBSTATIONS.
2. THE EXISTING df/dt & UNDER FREQUENCY REALYS OF 220KV SWITCHYARD SHALL REPLACED WITH NEW NUMERICAL RELAYS BY SWICHYARD CONTRACTOR.
3. TWO EMERGENCY DG HAVE BEEN CONSIDERED – ONE NO. FOR POWER BLOCK AND ONE NO. FOR BALANCE COMPLEX. IN ABSENCE OF LOAD DETAILS, WE HAVE ASSUMED 415V DG FOR THE COMPLEX PRESENTLY. THE DETAILS SHALL BE INDICATED AT LATER STAGE.
4. THE RATING AND IMPEDENCE VALUES FOR THE GENERATOR, GENERATOR TRANSFORMER AND GRID TRANSFORMER ARE FINALISED AS PER SYSTEM STUDIES.
5. GENERATOR TRANSFORMER INCOMER, BUS COUPLERS & GRID TRANSFORMERS SHALL BE PROVIDED WITH SYNCHRONISING FACILITY.
6. THE RATINGS AND IMPEDENCES FOR THE EXTRUDER POWER TRANSFORMER SHALL BE INDICATED ON RECEIPT OF DETAILS FROM M/s COPERION.
7. ELECTRICAL SYSTEM SHALL BE DESIGNED FOR CONTINUOUS PARALLEL OPERATION OF ALL NEW GRID TRANSFORMERS (2NOS) & NEW STGs (3NOS).
8. THE DG KVA RATING IS INDICATIVE. FINAL RATING SHALL BE INDICATED AFTER FINALSATION OF ALL EMERGENCY LOADS.
9. ALL INCOMERS AND BUS COUPLERS SHALL BE PROVIDED WITH SYNCHRONISING FACILITY. SYNCHROCHECK RELAY SHALL BE PROVIDED IN EACH BUS PT & CONTACTS SHALL BE MULTIPLIED AND WIRED IN EACH OUTGOING FEEDERS OF EACH BUS SECTION

TRAFO	LOCATION	RATING	VECTOR GROUP	% IMP ON ONAN MVA
XD-TR-033 XD-TR-034	POWER BLOCK	33MVA, 11/34.5kV ONAN OCTC±10%@1.25%	YnD11	15 % (0% -ve tol., 10% +ve tol.)
XD-TR-035	POWER BLOCK	12.5MVA, 11/34.5kV ONAN OCTC±10%@1.25%	YnD11	12.5 % (0% -ve tol., 10% +ve tol.)
XD-TR-023, XD-TR-024	220kV SWITCHYARD	40/50MVA, 220/34.5kV ONAN/ONAF OLTC±15%@1.25%	YnYn0	15 % (0% -ve tol., 10% +ve tol.)
TR-3201 , TR-3202	S/S-32 (CPP)	25/31.5 MVA, 33/6.9kV ONAN/ONAF	DYn1	10 % (10% -ve tol., 10% +ve tol.)
TR-3101 , TR-3102	S/S-31 (GCU)	8/10 MVA, 33/6.9kV ONAN/ONAF	DYn1	8.35 % (0% -ve tol., 10% +ve tol.)
TR-3501, TR-3502	S/S-35 (LLDPE/HDPE)	16/20 MVA, 33/6.9kV ONAN/ONAF	DYn1	10 % (10% -ve tol., 10% +ve tol.)
TR-3504	S/S-35 (EXTRUDER MOTOR)	* MVA, 33/6.9kV (SEE NOTE-6)	DYn1	* % (SEE NOTE-6)
TR-3503,	S/S-35 (CG COM.)	16 MVA, 33/6.9kV	DYn1	8.35 % (10% -ve tol., 0% +ve tol.)
TR-3601 , TR-3602	S/S-36 (CT-I)	25/31.5 MVA, 33/6.9kV ONAN/ONAF	DYn1	10 % (10% -ve tol., 10% +ve tol.)

LEGEND:-

- STEAM GENERATOR
- NGT FOR GENERATOR
- HV CIRCUIT BREAKER
- GRID TRANSFORMER WITH OLTC
- POWER/DISTRIBUTION TRANSFORMER
- DRAWOUT FEATURE
- AIR CIRCUIT BREAKER
- SWITCH
- FUSE
- CONTACTOR
- MOTOR
- CABLE GLAND
- NO NORMALLY OPEN
- NC NORMALLY CLOSED
- BUS DUCT
- NEUTRAL GROUNDING RESISTOR
- A/M AUTO MANUAL CHANGEOVER
- EMERGENCY STOP PB FOR TRANSFORMER

REV.	DATE	REVISIONS	BY	CHKD	APPD	PEM/PC
D	29.06.12	REVISED & ISSUED FOR ENGINEERING	RKS	SA	SA	
C	15.12.11	ISSUED FOR ENGINEERING	RKS	SA/SA	UAP	
B	05.08.11	ISSUED FOR DEPT. REVIEW	RKS	SA	SA	
A	18.01.11	PRELIMINARY ISSUE	NK	SV	SA	

इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम) ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

गेल (इंडिया) लिमिटेड
GAIL (INDIA) LIMITED

गेल पैट्रोकैमिकल कॉम्पलैक्स-पाटा

GAIL PETROCHEMICAL COMPLEX-II, PATA

सम्पूर्ण एक्कल लाईन चित्र

OVERALL KEY
SINGLE LINE DIAGRAM

SCALE	JOB NO.	UNIT	DIVN.	DEPT.	DWG. NO.	REV.
NTS	A096	000	16	50	0001	D

3-1641-0500 REV.2 A0-1189 x 841

प्रस्तुत आरेख एवं इसमें निहित डिज़ाइन इंजीनियर्स इंडिया लिमिटेड की संपत्ति है। ये मात्र उधार दिए गए है और उधारकर्ता ने यह स्पष्ट समझौता किया है कि न तो उन्हें पुनः मुद्रित किया जाएगा, न नकल की जाएगी, न उधार दिए जाएंगे, न प्रदर्शित किए जाएंगे और न ही सीमित और निजी प्रयोग के अलावा इनका कोई अन्य प्रयोग होगा और यह प्रयोग उधार देने वाले द्वारा उधारकर्ता को लिखित रूप में दी गई सहमति से होगा ।

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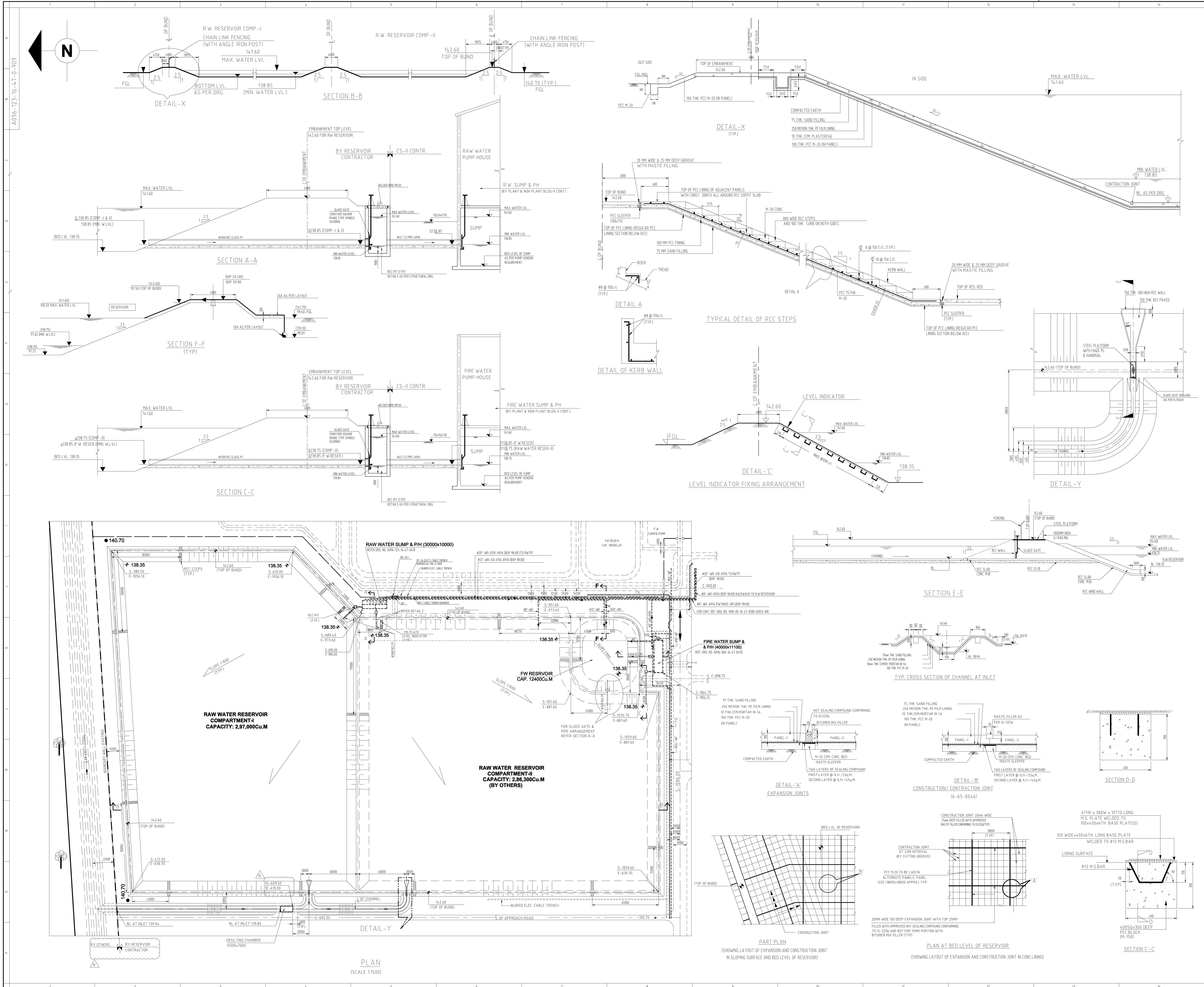

REF. DWG. NO.	REFERENCE DRAWING TITLE
A096-000-16-47-0001	OVERALL PLOT PLAN

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS EXCEPT LEVELS & COORDINATES WHICH ARE IN METERS.
2. CHAIN LINK FENCING (WITH ANGLE IRON POST) SHALL BE PROVIDED AS PER DRAWING NO. A096-000-16-47-3-701.
3. 3 M (CLEAR OPENING) WIDE AND 1.2 M HIGH GATE ON TWO EQUAL SIZED SHUTTER SHALL BE PROVIDED AS PER STD NO. 7-75-0054. THESE GATES SHALL BE PROVIDED WHEREVER CONCRETE STEPS ARE THERE, IN LINE WITH CHAIN LINK FENCING.
4. ALL SLUICE GATE SHALL BE AS PER IS:13349 AND ISI MARKED.
5. RCC HUME PIPE CONC. CRADLE BEDDING OF RCC SPUN PIPE SHALL BE IN CONFORMANCE WITH EIL STD. NO. 7-65-213(TYPE-IV)& GRADE OF PCC FOR ENCASEMENT SHALL BE M 30.
6. DELETED
7. CONTRACTION JOINT SHALL BE PROVIDED AT EVERY 3.0MC/C IN BOTH TRANSVERSE & LONGITUDINAL DIRECTIONS.
8. EXPANSION JOINT SHALL BE PROVIDED AT 18 M C/C.
9. NO CONST. JOINT SHALL BE LEFT IN BETWEEN THE PANELS. PANEL SHALL BE CAST FULL IN ONE TIME.
10. RCC PIPES SHALL BE CLASS P1 CONFORMING TO IS:458 .
11. FOR DETAIL OF RCC SUMP, PIT ETC., REFER RELEVENT STRL. DRAWING.
12. 1000mm HIGH HAND RAILING SHALL BE PROVIDED FOR THE STAIRCASES AND COMMON BUND WALL OF RESERVOIR.
13. TESTING OF RESERVOIR SHALL BE CARRIED OUT IN ACCORDANCE WITH IS:10430. THE DETAILS ARE AS FOLLOWS:
    ON COMPLETION OF THE WORK, THE RESERVOIR SHALL BE FILLED WITH WATER UPTO MAX. WATER LEVEL. LEVEL OF WATER SHALL BE RECORDED FOR A PERIOD OF 3 DAYS AT AN INTERVAL OF 24 hr. THE AVERAGE WATER LOSS SHALL NOT BE MORE THAN 0.60m3/sec. PER MILLION SQUARE METER OF WETTED PERIMETER. ANY DEFECT NOTED OR POINTED OUT BY THE ENGINEER-IN-CHARGE SHALL BE RECTIFIED BY CONTRACTOR AT HIS OWN COST TO THE SATISFACTION OF ENGINEER-IN-CHARGE.
14. LEVEL 100.00 CORRESPONDS TO LEVEL 141.10 ABOVE MEAN SEA LEVEL.
15. EXPANSION JOINT SHALL BE AT 18.0M INTERVAL IN BOTH DIRECTIONS AND SLAB SHALL BE CAST IN 18.0M ALTERNATE PANEL. 20mm x 25mm GROOVE SHALL BE MADE AT EVERY 3.0M FOR CONTRACTION JOINT.
16. SITE SHALL ENSURE SLEEPER (150mmx75mm) LOCATION BELOW CONTRACTION JOINT (GROOVE) AND EXPANSION JOINT.

This is a system generated approved document and does not require a signature

LEGEND:-

— — — BY OTHERS

———— BY RWR COMPARTMENT-I CONTR.

TOTAL DEPTH OF RESERVOIR	= 4.25M
SILTING	= 0.50M
FREE BOARD	= 1.00M EFFECTIVE
DEPTH OF RESERVOIR	= 2.75M

REV.	DATE	REVISIONS	BY	CHKD	APPD	PEM/PC
10	11.09.12	REVISED AS MARKED & ISSUED FOR CONST.	Anil			
9	10.09.12	REVISED AS MARKED & ISSUED FOR CONST.	SONU	SY	AK	
8	02.08.12	SCOPE LIMIT AS MKD & ISSUED FOR CONST.	SONU	SY	AK	
7	23.05.12	SCOPE LIMIT AS MKD & ISSUED FOR CONST.	Anil	SY	AK	
6	04.05.12	REVISED AS MKD. & ISSUED FOR CONSTR.	SKP/SONU	SY	AK	
5	06.04.12	GENERALLY REVISED & ISSUED FOR CONSTR.	Anil	SY	AK	
4	05.04.12	GENERALLY REVISED & ISSUED FOR CONSTR.	AK/SONU	SY	AK	
3	30.11.11	REVISED AS MKD. & ISSUED FOR CONSTR.	Anil	SY	AK	
2	22.07.11	REVISED AS MKD. & ISSUED FOR CONSTR.	MG	AS	AK	
1	07.07.11	REVISED AS MKD. & ISSUED FOR CONSTR.	MG	AS	AK	
0	20.06.11	ISSUED FOR CONSTRUCTION	MG	NS	AS	
A	31.01.11	ISSUED FOR BIDS	MG	NS/AS	AK	

इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम)
ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

गेल (इंडिया) लिमिटेड
GAIL (INDIA) LIMITED

गेल पैट्रोकैमिकल कॉम्प्लैक्स-II पाटा
GAIL PETROCHEMICAL COMPLEX-II, PATA

कच्चे जल के जलाशय का विस्तृत आरेख
DETAIL OF RAW WATER RESERVOIR

SCALE	JOB NO.	UNIT	DIVN.	DEPT.	DWG. NO.	REV.
~	A096	123	16	47	0909	10

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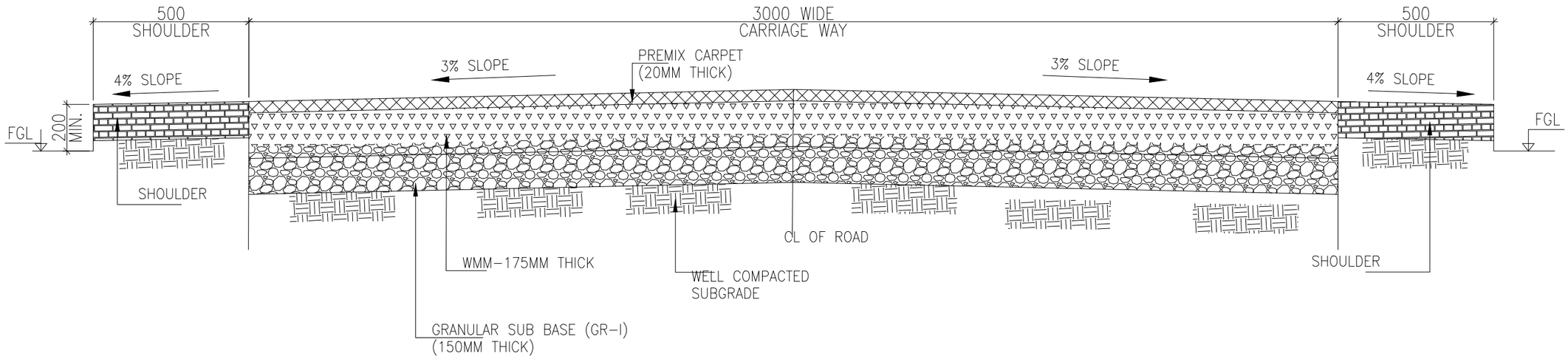


TYPICAL CROSS SECTION OF 3.00M WIDE APPROACH ROAD TO MCR & IR

TENDER DRG.
INFORMATION PURPOSE

REV.	DATE	ALTD	CHD	APPD

DEPT.
STATUS
DISTRIBUTION

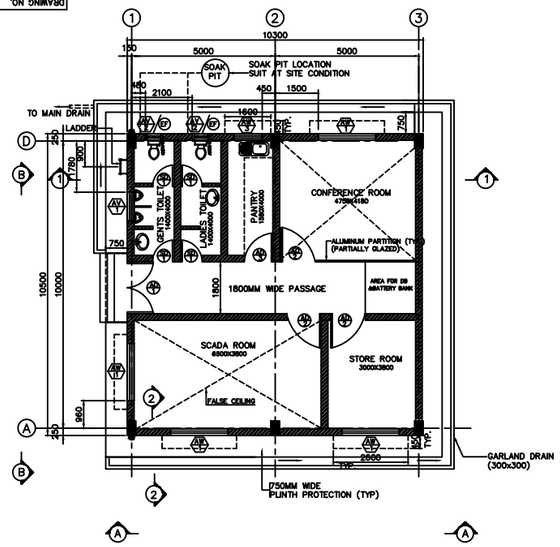
17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL PATA, UP

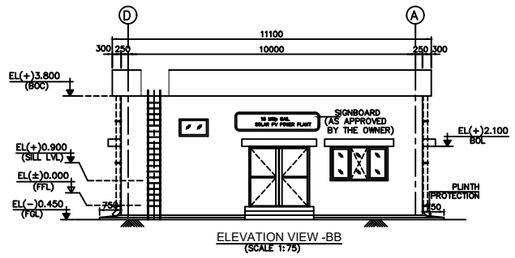
OWNER: GAIL (India) Limited — GAIL (INDIA) LTD

Consultant: BHEL — BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

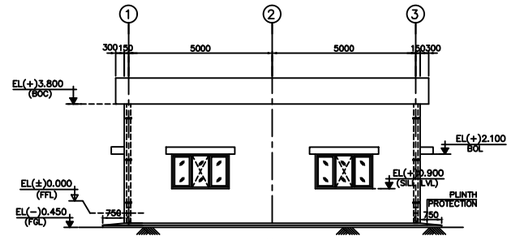
TITLE: CROSS SECTIONAL DETAIL FOR APPROCAH ROAD

SCALE 1:100 | DRAWING NO. BHEL-GAIL-ROAD | SHEET 1 OF 1 | REV. 00

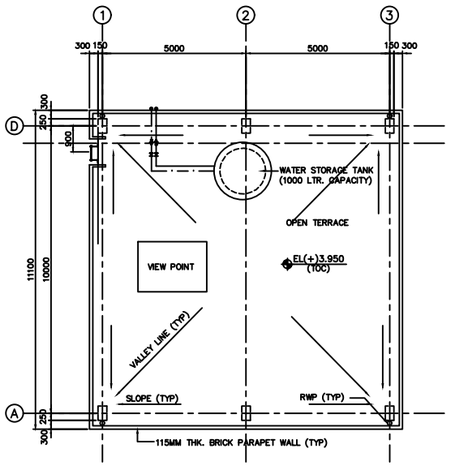




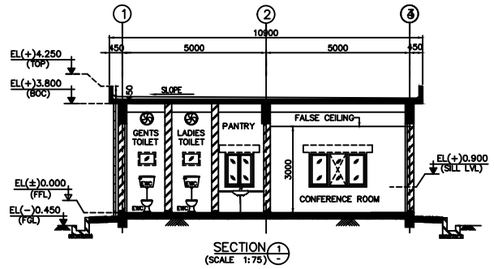
ELEVATION VIEW -BB
(SCALE 1:75)



ELEVATION VIEW -AA
(SCALE 1:75)

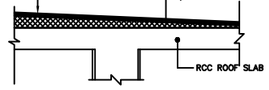


TERRACE FLOOR PLAN AT EL(+)3.950 (TOC)
(SCALE 1:75)

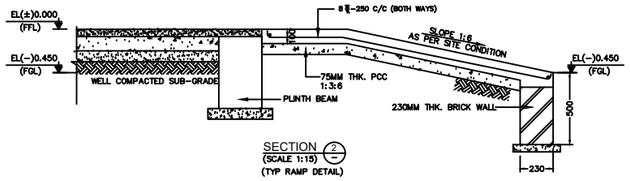


SECTION 1
(SCALE 1:75)

FIVE COURSE WATER PROOFING TREATMENT WITH APP (ATACTIC POLYPROPYLENE) MODIFIED POLYMERIC MEMBERANE OVER ROOF CONSISTING OF FIRST COAT OF BITUMEN PRIMER @ 0.40KG PER SQM, 2ND & 4TH COURSES OF BONDING MATERIAL @ 1.20 KG/SQM. WHICH SHALL CONSIST OF BLOWN TYPE BITUMEN OF GRADE 85/25 CONFORMING TO IS : 702, 3RD LAYER OF ROOFING MEMBRANE APP MODIFIED POLYMERIC MEMBRANE 2.0 MM THICK OF 3.00 KG/ SQM WEIGHT CONSISTING OF FIVE LAYERS PREFABRICATED WITH CENTRE CORE AS 100 MICRON HMHDPE FILM SANDWICHED ON BOTH SIDES WITH POLYMERIC MIX AND THE POLYMERIC MIX IS PROTECTED ON BOTH SIDE WITH 20 MICRON HMHDPE FILM 5TH, THE TOP MOST LAYER SHALL BE FINISHED WITH BRICK TILES OF CLASS DESIGNATION 10 GROUTED WITH CEMENT MORTAR 1:3 (1 CEMENT : 3 FINE SAND) MIXED WITH 2% INTEGRAL WATER PROOFING COMPOUND BY WEIGHT OF CEMENT OVER A 12 MM LAYER OF CEMENT MORTAR 1:3 (1 CEMENT : 3 FINE SAND) AND FINISHED NEAT.



TYP.DETAIL OF ROOF WATER PROOFING TREATMENT
(SCALE 1:15)



SECTION 2
(SCALE 1:15)
(TYP RAMP DETAIL)

NOTES

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH CONTRACT TERMS AND CONDITIONS, SPECIFICATION AND SCHEDULE OF ITEMS.
2. ALL DIMENSIONS ARE IN MILLIMETER AND LEVELS ARE IN METERS, UNO.
3. FINISHED FLOOR LEVEL CORRESPONDS TO EL(±)0.000M WHICH IS 450MM ABOVE FINISHED GRADE LEVEL.
4. FOR WINDOW FLOAT GLASS OF 4MM, FOR DOORS AND PARTITION FLOAT GLASS OF 6MM..
6. ALL ALUMINUM SECTION SHALL BE ANODIZED WITH MIN 15 MICRONS.
7. WINDOWS SHALL BE PROVIDED WITH ALUMINUM GRILLS.
8. WINDOWS SHALL BE PROVIDED WITH SOLID BRONZE POLISHED, CAM LOCKING HANDLE AND STRIKE.
9. SMOOTH SURFACE PLASTERING (INTERNAL WALL) 12MM AND ROUGH SURFACE PLASTERING (EXTERNAL WALL) 20MM (12MM THK. 1:4 FIRST LAYER AND 8MM THK, TOP LAYER 1:4 WITH WATER PROOFING COMPOUND).
10. CEILING PLASTERING SHALL BE 6MM THK. IN 1:3 CEMENT SAND MORTAR.
11. STEEL LADDER OR RCC STAIR TO BE CONSTRUCTED AS PER SPEC.
12. CANOPY FOR VIEW POINT AND STEPS TO BE PROVIDED SUIT TO SITE

LEGEND

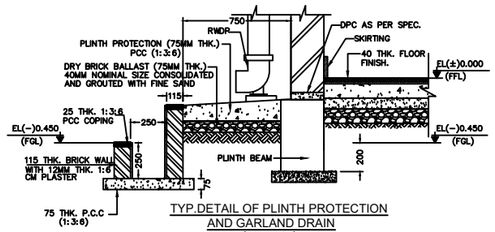
- 230 THK BRICK WALL/ 115 THK BRICK WALL
- ALUMINIUM PARTITION
- EL – ELEVATION
- FFL – FINISHED FLOOR LEVEL
- BOL – BOTTOM OF LINTEL
- LVL – LEVEL
- FGL – FINISHED GROUND LEVEL
- TOC – TOP OF CONCRETE
- TYP – TYPICAL
- TOP – TOP OF PARAPET
- BOC – BOTTOM OF CONCRETE
- UNO – UNLESS NOTED OTHERWISE

SCHEDULE OF JOINERY

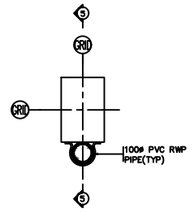
SYMBOL	Nos	SILL LVL AT EL....	MASONRY OPENING WIDTH	MASONRY OPENING HEIGHT	REMARKS
RS 1	01	+0.000	3000	3000	ROLLING SHUTTER
MD 1	01	+0.000	1500	2100	MAIN DOOR – MILD STEEL SINGLE LEAF DOOR – DOUBLE SHUTTER
AD 1	01	+0.000	1800	2100	ALUMINUM FRAMED WITH GLAZED DOOR – DOUBLE SHUTTER
AD 2	02	+0.000	1200	2100	ALUMINUM FRAMED WITH GLAZED DOOR – SINGLE SHUTTER
AD 3	03	+0.000	1000	2100	ALUMINUM FRAMED WITH GLAZED DOOR – SINGLE SHUTTER
SD 1	04	+0.000	750	2100	STEEL FRAME WITH SOLID CORE FLUSH SHUTTER – SINGLE SHUTTER
AW 1	06	+0.900	2000	1200	ALUMINIUM FRAMED GLAZED WINDOW
AW 2	02	+0.900	1500	1200	ALUMINIUM FRAMED GLAZED WINDOW
AW 3	01	+0.900	1000	1200	ALUMINIUM FRAMED GLAZED WINDOW
AV 1	01	+2.400	1000	600	ALUMINIUM FRAMED GLAZED VENTILATOR
AV 2	02	+1.650	600	450	ALUMINIUM FRAMED GLAZED VENTILATOR

FINISH SCHEDULE:

SERIAL NUMBER	ROOMS	FLOORS: 40MM THK. CEMENT CONCRETE (1PS) FLOORING (1:2:4) WITH 2MM THK EPOXY COATING	FLOORS: 40MM THK. HEAVY DUTY VITERFIED TILE FLOORING (TILE 8MM THK.)	FLOORS: ACID/ALKALI RESISTANT TILE (20MM THK. TILE) FLOORING WITH 2100 HIGH DADO (12MM THK. TILE)	FLOORS: 40MM THK. VITERFIED CERAMIC ANTI-SLIP TILE (8MM THK.) FLOORING WITH GLAZED TILE (6MM THK.) 2100MM HEIGHT DADO	FLOORS: KOTA STONE 20MM THK. FLOORING /50MM THK. CEMENT CONCRETE (1PS FLOORING)	INTERNAL WALLS – SKIRTING: CEMENT SKIRTING (100MM HEIGHT)	INTERNAL WALLS – SKIRTING: VITRIFIED TILE SKIRTING (100MM HEIGHT)	INTERNAL WALLS – PAINTING: ACRYLIC EMULSION PAINT	INTERNAL WALLS – PAINTING: ACID RESISTANT PAINT	INTERNAL WALLS – PAINTING: OIL BOUND DISTEMPER	CEILING: WHITE WASH	CEILING: FALSE CEILING (15MM THK. MINERAL FIBER BOARD FALSE CEILING WITH 600X600MM TILE)	EXTERNAL WALL: ALL WEATHER PROOF CEMENT BASED ACRYLIC EMULSION PAINT (EXTERIOR GRADE)
1	STORE ROOM	●					●		●			●		
2	SCADA ROOM		●					●	●				●	
3	CONFERENCE ROOM		●					●	●				●	
4	TOILET				●						●	●		
5	PANTRY				●				●			●		
6	STEPS					●								
7	PASSAGE		●					●	●			●		



TYP.DETAIL OF PLINTH PROTECTION AND GARLAND DRAIN
(SCALE 1:15)



TYP.DETAIL OF RAIN WATER DOWN PIPE
(SCALE 1:15)

TENDER DRG. INFORMATION PURPOSE

REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD

DEPT.
STATUS
DISTRIBUTION

17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL PATA, UP

GAIL (India) Limited

GAIL (INDIA) LTD

BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

TITLE: MAIN CONTROL ROOM–ARCHITECTURE PLANS, ELEVATIONS & FINISHING

SCALE 1:100 | DRAWING NO. BHEL-GAIL-MCR | SHEET NO. 1 OF 1 | REV. 00

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DRAWING NO.

NOTES

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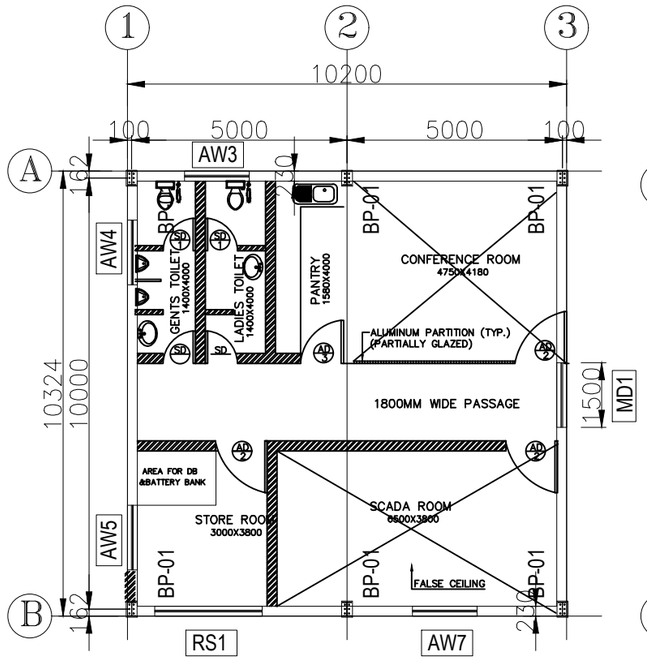
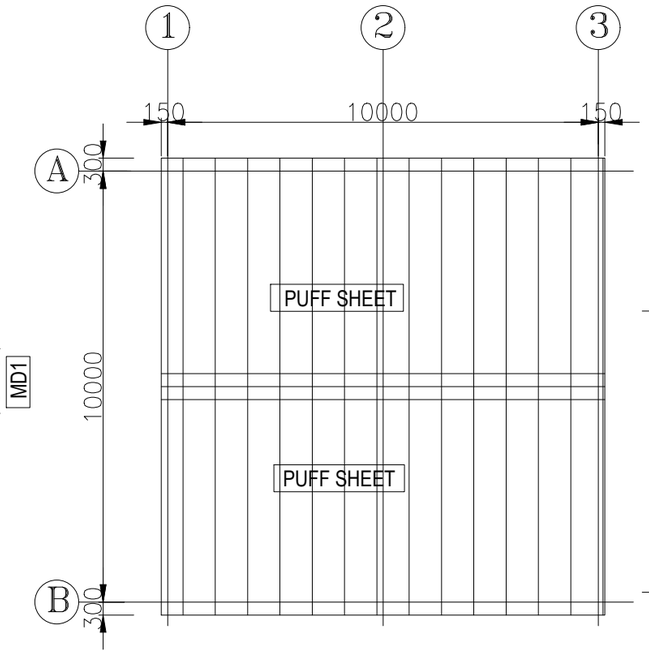
3. FINISHED FLOOR LEVEL CORRESPONDS TO EL(±)0.000M WHICH IS 450MM ABOVE FINISHED GRADE LEVEL.
4. FOR WINDOW FLOAT GLASS OF 4MM, FOR DOORS AND PARTITION FLOAT GLASS OF 6MM..
6. ALL ALUMINUM SECTION SHALL BE ANODIZED WITH MIN 15 MICRONS.
7. WINDOWS SHALL BE PROVIDED WITH ALUMINUM GRILLS.
8. WINDOWS SHALL BE PROVIDED WITH SOLID BRONZE POLISHED, CAM LOCKING HANDLE AND STRIKE.

LEGEND

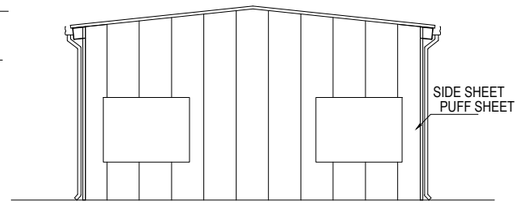
EL	– ELEVATION	FGL	– FINISHED GROUND LEVEL
FFL	– FINISHED FLOOR LEVEL	TOC	– TOP OF CONCRETE
BOL	– BOTTOM OF LINTEL	TYP	– TYPICAL
LVL	– LEVEL	TOP	– TOP OF PARAPET
		BOC	– BOTTOM OF CONCRETE
		UNO	– UNLESS NOTED OTHERWISE



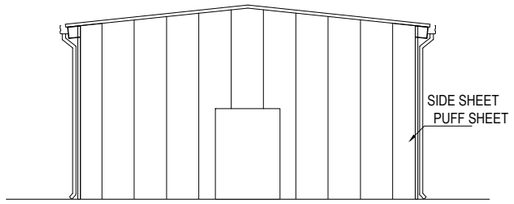
PLAN



ROOF SHEETING LAYOUT

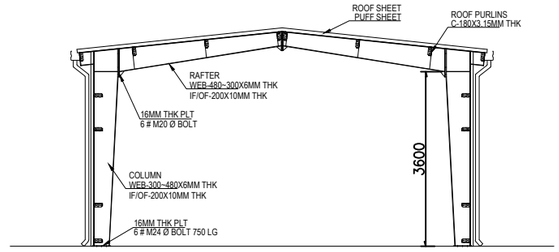


CROSS SECTION ELEVATION AT GRID LINE-1

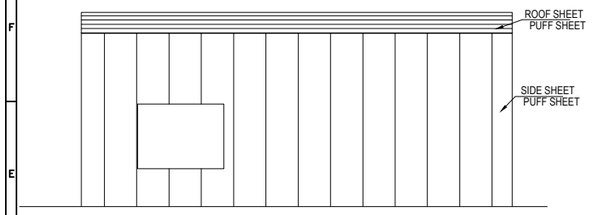


CROSS SECTION ELEVATION AT GRID LINE-3

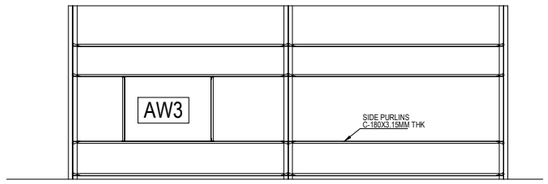
MATERIAL SPECIFICATIONS		
1.	ANCHOR/FOUNDATION BOLTS	AS PER TECH SPEC COLOR AS PER GAIL SELECTION
2.	BUILT-UP MEMBERS	
3	COLD FORMED SECONDARY MEMBERS	
4	X-BRACING MEMBERS, PIPE	
5	WELDING	
6	SURFACE PREPARATION- STRUCTURE	
7.	HIGH STRENGTH BOLTS FOR PRIMARY CONNECTION	
8.	MACHINE BOLTS FOR SECONDARY CONNECTION	
9.	ROOFING PANEL	
10.	WALL PANEL	
11.	GUTTER	
12.	DOWN TAKE PIPE	



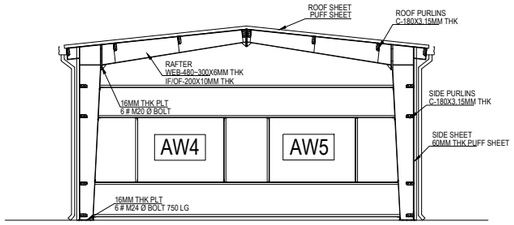
CROSS SECTION AT GRID LINE-2



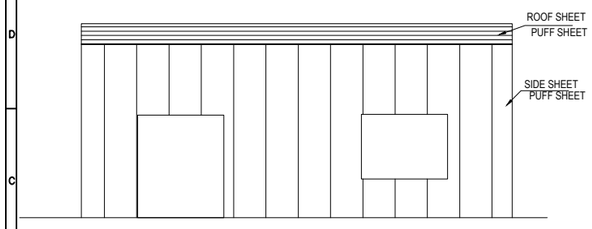
LONGITUDINAL SIDE ELEVATION AT GRID LINE-A



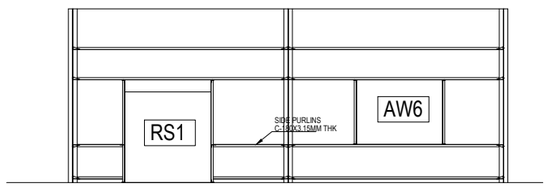
LONGITUDINAL SIDE AT GRID LINE-A



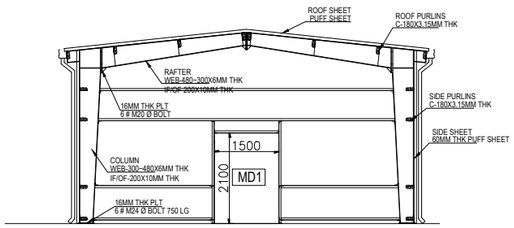
CROSS SECTION AT GRID LINE-1



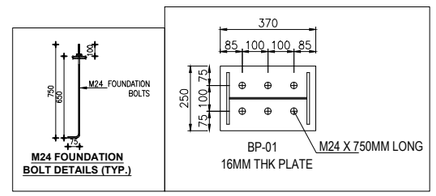
LONGITUDINAL SIDE ELEVATION AT GRID LINE-B



LONGITUDINAL SIDE AT GRID LINE-B



CROSS SECTION AT GRID LINE-3



Note:-	
AW1-AW7	2000MM X 1500MM
MD1	1500MM X 2100MM
RS1	2500MM X 2000MM

TENDER DRG.
INFORMATION PURPOSE

17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL–PATA, UP

GAIL (INDIA) LTD

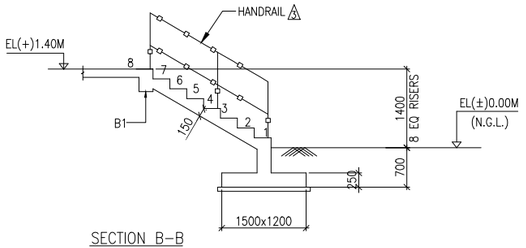
BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

TITLE: MAIN CONTROL ROOM–ARCHITECTURE PLANS, ELEVATIONS & FINISHING (PEB)

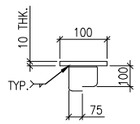
DEPT.
STATUS
DISTRIBUTION

REV.	DATE	ALTD	CHD	APPD

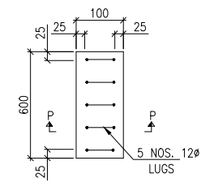
SCALE 1:100 DRAWING NO. SHEL-GAIL-PEB MCR
SHEET 1 OF 1 REV. 00



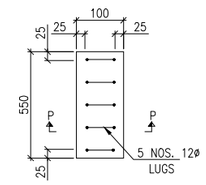
SECTION B–B
STAIR CASE



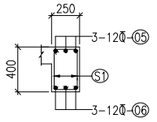
SECTION P–P



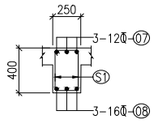
DETAIL OF INSERT PLATE
MKD. IP1 (100x600x10THK.)



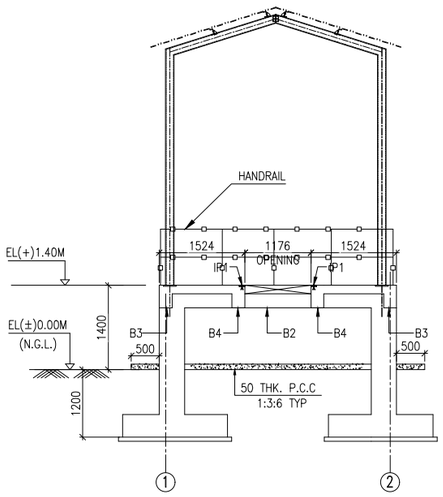
DETAIL OF INSERT PLATE
MKD. IP2 (100x550x10THK.)



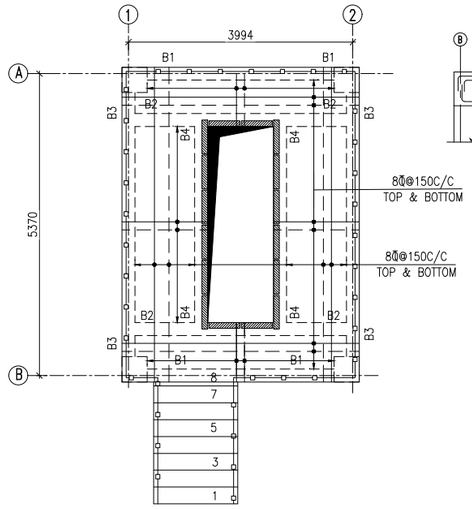
BEAM MKD B1(250X400)



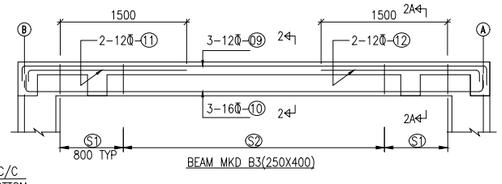
BEAM MKD B2(250X400)



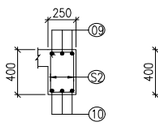
SECTION A–A



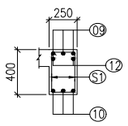
PLAN AT TOP EL(+)1.40M LVL.
FOR SHOWING SLAB R.F ONLY
BARS TO BE CUT SUITABLTY AROUND OPENING



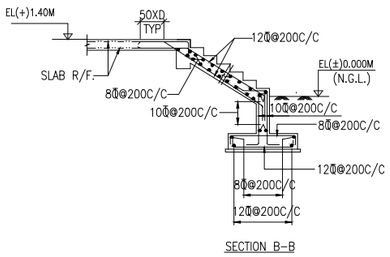
BEAM MKD B3(250X400)



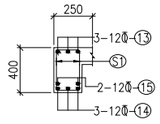
SECTION 2–2



SECTION 2A–2A

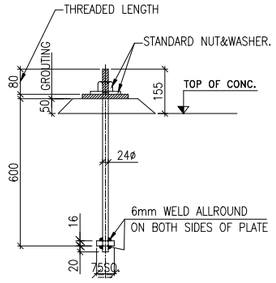


SECTION B–B
R/F. DETAIL OF STAIR CASE



BEAM MKD B4(250X400)

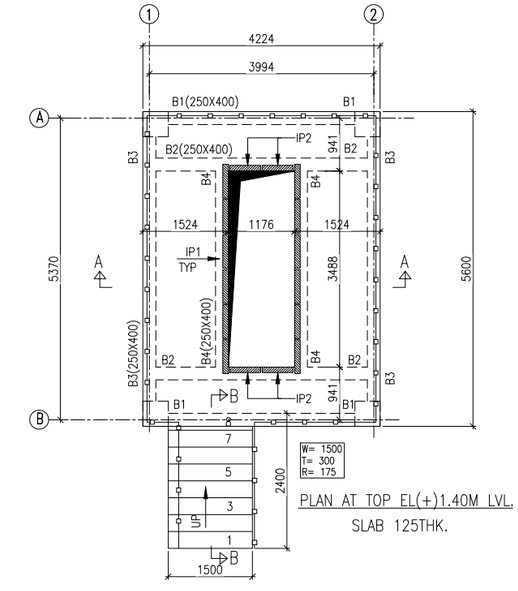
STIRRUPS SCHEDULE
S1=2L-8Ø@100C/C
S2=2L-8Ø@150C/C



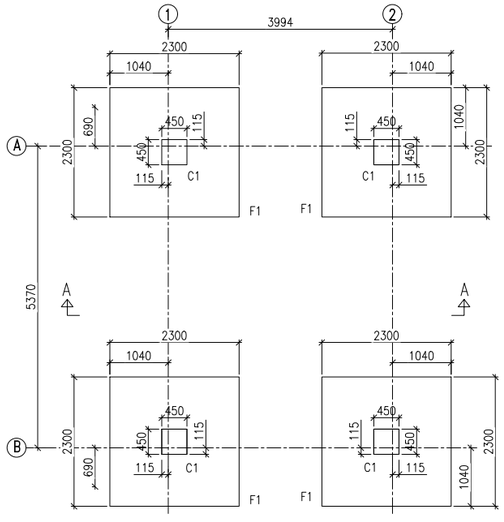
DET. OF M24 BOLTS.

NOTES:–

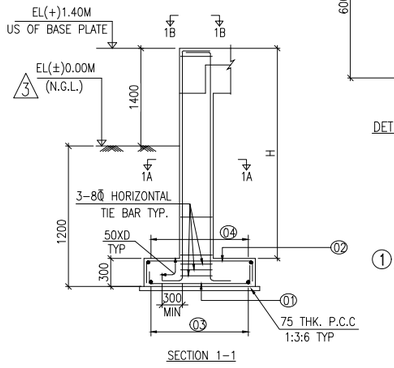
1. ALL DIMENSIONS ARE IN MM & LEVELS ARE IN METRES.
2. FIGURED DIMENSIONS ONLY SHALL BE FOLLOWED.
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH RELEVANT ARCH./MECH DWG.
4. FINISHED FLOOR LEVEL CORRESPONDS TO EL(+)1.400M, WHICH IS AT 1400MM ABOVE FGL/NGL OF EL(±)0.000M. FGL/NGL SHALL BE CONSIDERED AT EXISTING ADJOINING ROAD CENTER (OR) AS PER SITE CONDITION.
5. ALL R.C.C. SHALL BE MIX M–25
6. LAPS SHALL BE STAGGERED AND AVOIDED AT THE SECTIONS OF MAX. BENDING MOMENT
7. CLEAR COVER TO REINF. INCLUDING LINKS FOR R.C.C MEMBERS SHALL BE AS UNDER:–COLUMN=40mm,FOOTING=50mm,BEAM=25mm,SLAB=20mm
8. STANDARD 'L' HOOKS SHALL BE PROVIDED AT THE ENDS OF ALL BARS.
9. PROVIDED LAP LENTH/DEVELOPMENT LENGTH 'Ld' FOR BOTH COMPRESSION AND TENSION MAIN R/F BAR SHALL BE=50XDIA OF BAR
10. NO FOUNDATION SHALL BE REST ON FILLED UP SOIL.
11. BOTTOM BAR INDICATES :– ----------
12. TOP BAR INDICATES :– _____



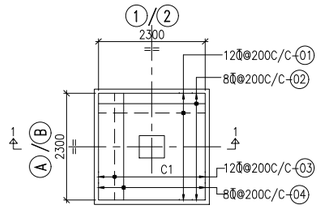
PLAN AT TOP EL(+)1.40M LVL.
SLAB 125THK.



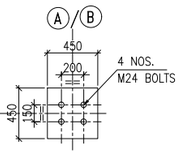
PLAN AT FOUNDATION LEVEL



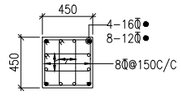
SECTION 1–1



TYPICAL DETAIL OF FOOTING



VIEW 1B–1B
COLUMN MKD C1



SECTION 1A–1A
COLUMN MKD C1
SHOWING R.F ONLY

TENDER DRG.
INFORMATION PURPOSE

17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL–PATA, UP

OWNER: GAIL (India) Limited — GAIL (INDIA) LTD

Consultant: BHEL — BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

DEPT.
STATUS
DISTRIBUTION

TITLE: GENERAL ARRANGEMENT FOR PLATFORM FOR PCU/HT PANEL

SCALE 1:100 | DRAWING NO. BHEL–GAIL–PCU | SHEET 1 OF 1 | REV. 00

REV. | DATE | ALTD | CHD | APPD

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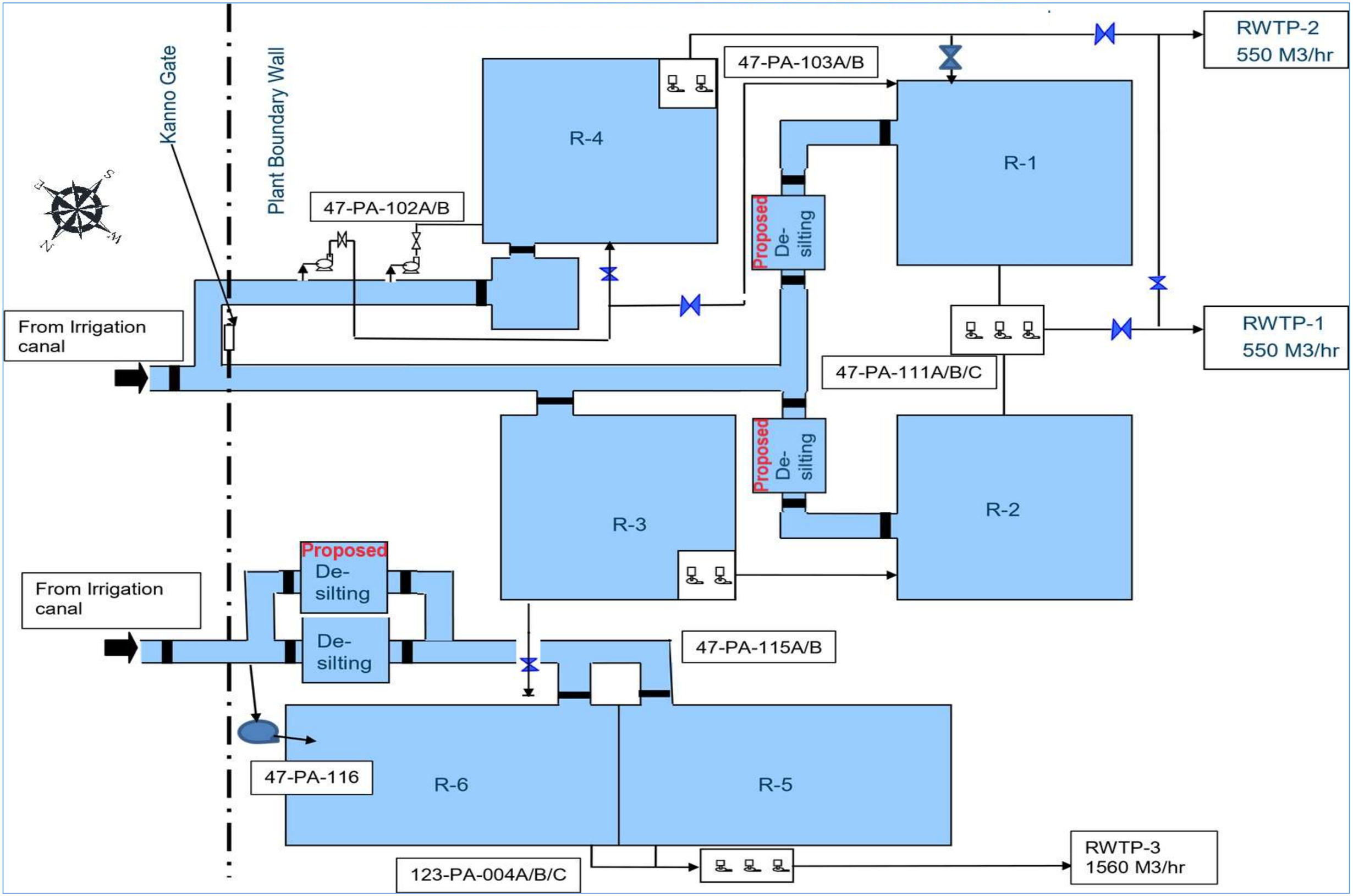
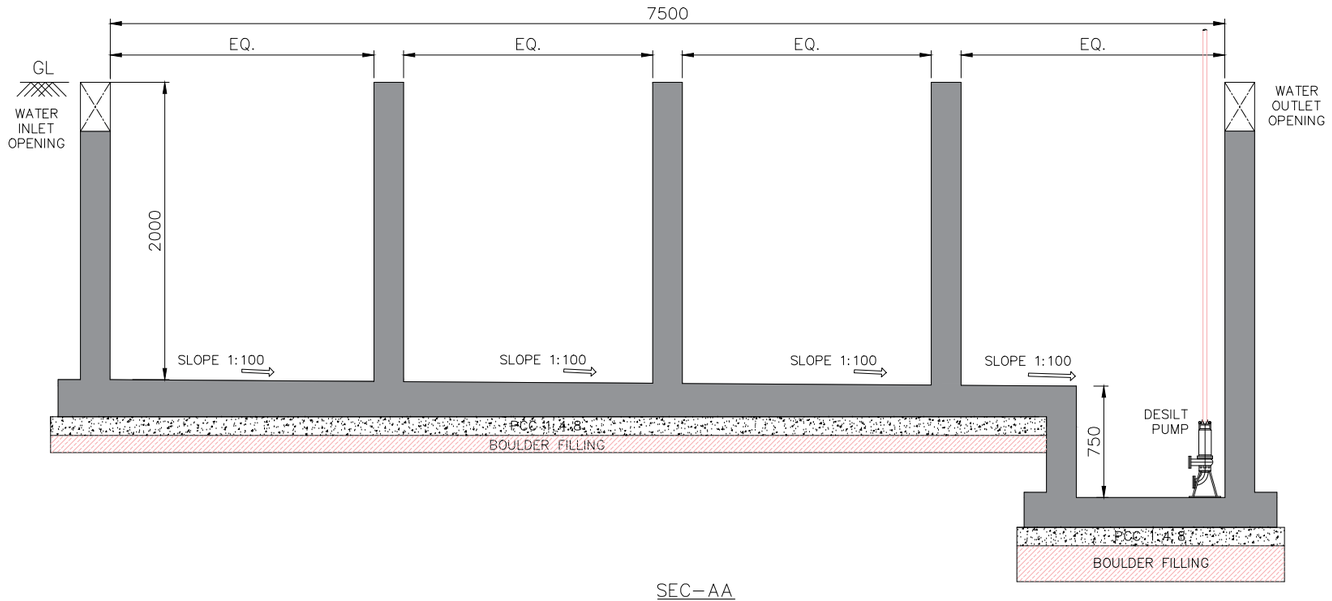
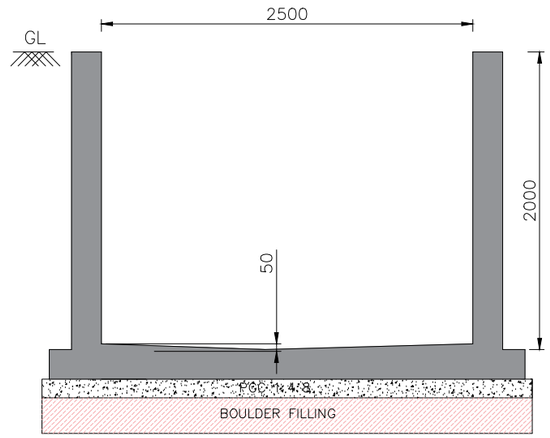
PROPOSED DE-SEDIMENTATION PLAN OF THE PROJECT

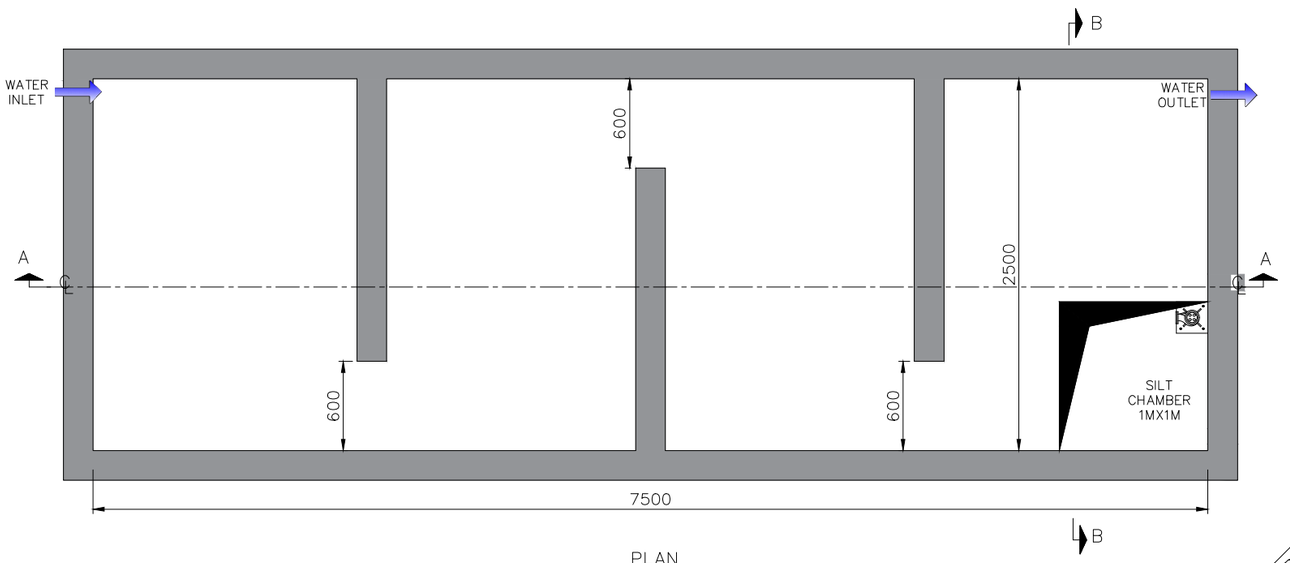




SEC–AA



SEC–BB



PLAN

CAPACITY: 35 CUM

NOTES:–

1. ALL DIMENSIONS ARE IN MM & LEVELS ARE IN METRES.
2. FIGURED DIMENSIONS ONLY SHALL BE FOLLOWED.
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH RELEVANT ARCH./MECH DWG.
4. ALL R.C.C. SHALL BE MIX M–30
5. 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–500 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
6. CLEAR COVER TO REINF. INCLUDING LINKS FOR R.C.C MEMBERS SHALL BE AS UNDER:–COLUMN=40mm,FOOTING=50mm,BEAM=25mm,SLAB=20mm
7. STANDARD 'L' HOOKS SHALL BE PROVIDED AT THE ENDS OF ALL BARS.
8. PROVIDED LAP LENTH/DEVELOPMENT LENGTH 'Ld' FOR BOTH COMPRESSION AND TENSION MAIN R/F BAR SHALL BE=50XDIA OF BAR
9. LAPS SHALL BE STAGGERED AND AVOIDED AT THE SECTIONS OF MAX. BENDING MOMENT
10. NO FOUNDATION SHALL BE REST ON FILLED UP SOIL.

TENDER DRG. INFORMATION PURPOSE

17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL–PATA, UP

OWNER: GAIL (INDIA) LTD

CONSULTANT: BHARAT HEAVY ELECTRICALS LTD, SOLAR BUSINESS DIVISION, BANGALORE

DEPT.
STATUS
DISTRIBUTION

TITLE: TYPICAL DETAILS OF SEDIMENTATION TANK–3 NOS

SCALE 1:100 DRAWING NO. BHEL–GAIL–TANK

SHEET 1 OF 1 REV. 00

REV. | DATE | ALTD | CHD | APPD

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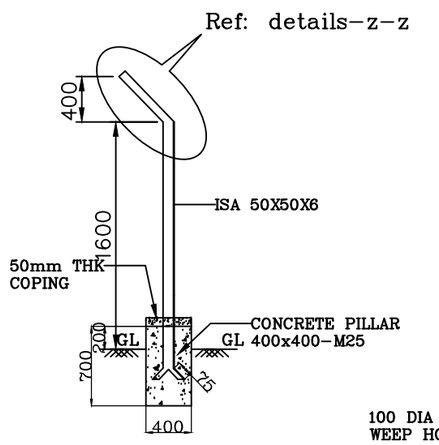
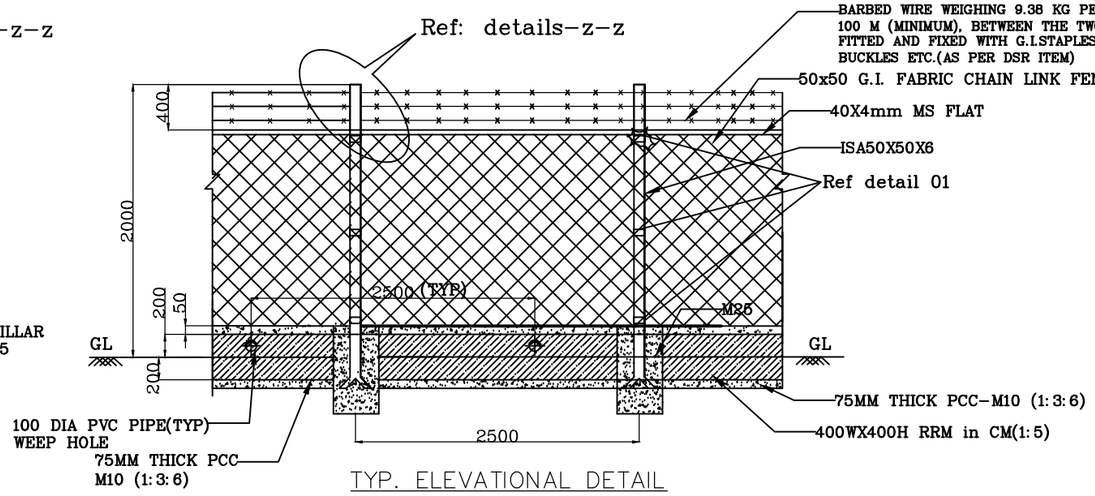
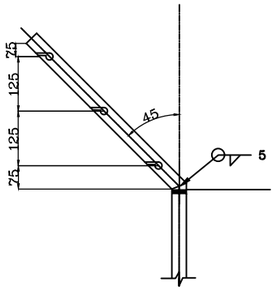


TYP.SECTION AT PILLAR

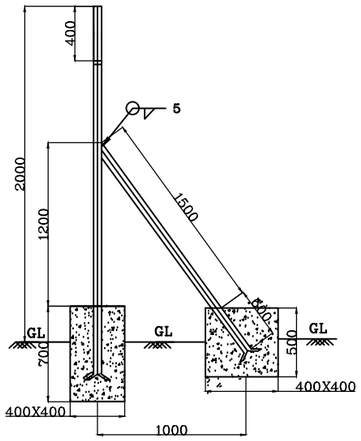


TYP. ELEVATIONAL DETAIL

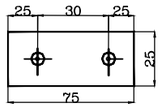


DETAIL Z-Z

PERIPHERAL FENCING POST WITH 45' INCLINATION @ TOP.

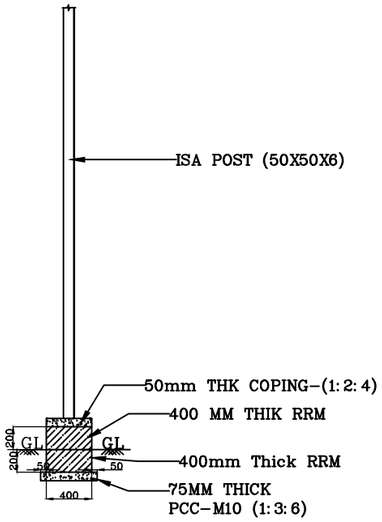


SIDE-C/S OF STAY POST DETAILS

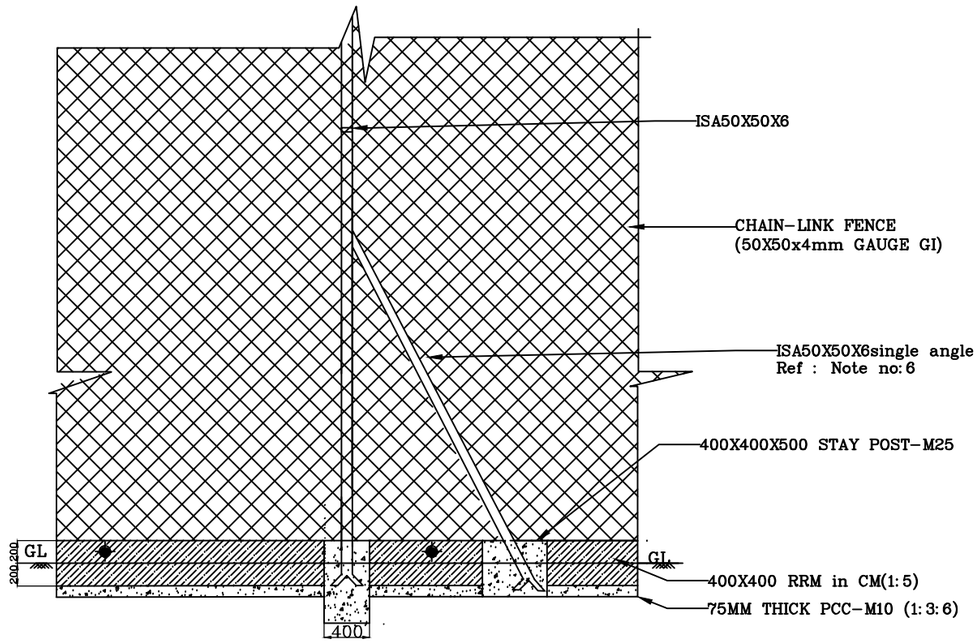


**75X25X4MM THICK PLATE SHOULD BE BOLTED WITH CHAINLINK FENCING & EACH VERTICLE POST (3NO'S PER POST).

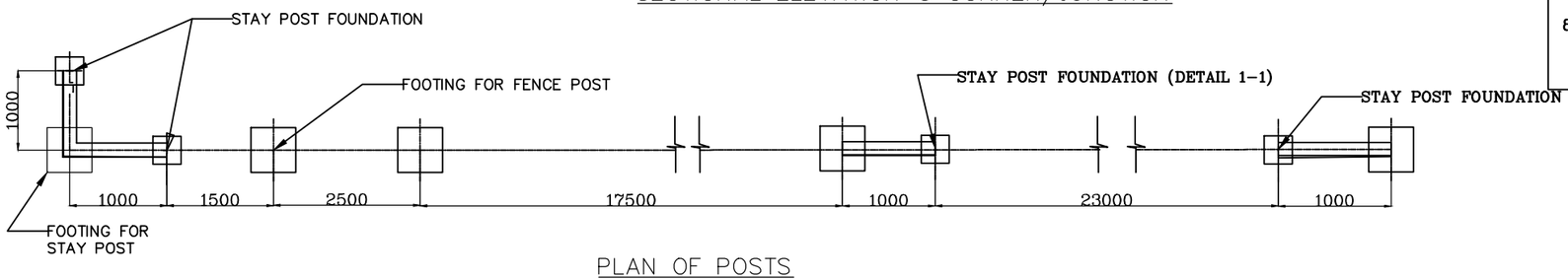
DETAIL : 01



SECTION AT TOE-WALL



SECTIONAL ELEVATION @ CORNER/JUNCTION



PLAN OF POSTS

NOTES:

1. ALL DIMENSIONS ARE IN MM UOS.ALL MS ANGLES CONFIRMING TO IS 2062
2. VERTICAL POSTS SHALL HAVE SUITABLE PROVISIONS BY WAY OF NOTCHES OR HOLES TO FIX BARBED WIRES.
3. CHAIN LINK FENCE SHALL BE CONFIRMING I.S. 4826 AND BARBED WIRE SHALL CONFIRMING TO I.S. 278.
4. VERTICAL POSTS SHALL BE GIVEN A TWO (2) COATS OF PRIMER WILL BE APPLIED FOLLOWED BY TWO (2) COATS OF EPOXY BASED SYNTHETIC ENAMELLED PAINT.
5. MASONRY ABOVE GROUND LEVEL SHALL BE PLASTERED IN 12mm THICK CEMENT MORTAR 1:6.
6. 1500MM LONG STAY POST SHALL BE PROVIDED AT CORNER (REFER PLAN OF POST)/JUNCTIONS AND EVERY 10TH POST WILL HAVE A STAY POST IN THE DIRECTION OF FENCE. STAY POST SHALL BE AFFIXED TO VERTICAL POSTS AT ONE END AND EMBEDDED IN CONCRETE M25 (400X400X500MM POCKET) AT THE OTHER END.
7. CORNER POSTS SHALL BE PROVIDED USING THE METHODOLOGY AS MENTIONED IN POINT-6.
8. THE G.I. CHAIN LINK WIRE MESH WILL BE STRETCHED AND ATTACHED BY CLIPS AND KEPT UNDER TENSION WHICH IN TURNS ARE ATTACHED TO THE FENCE POST WITH SECURITY NUTS AND BOLTS.

TENDER DRG. INFORMATION PURPOSE

DEPT.					
STATUS					
DISTRIBUTION					
REV.	DATE	ALTD	CHD	APPD	

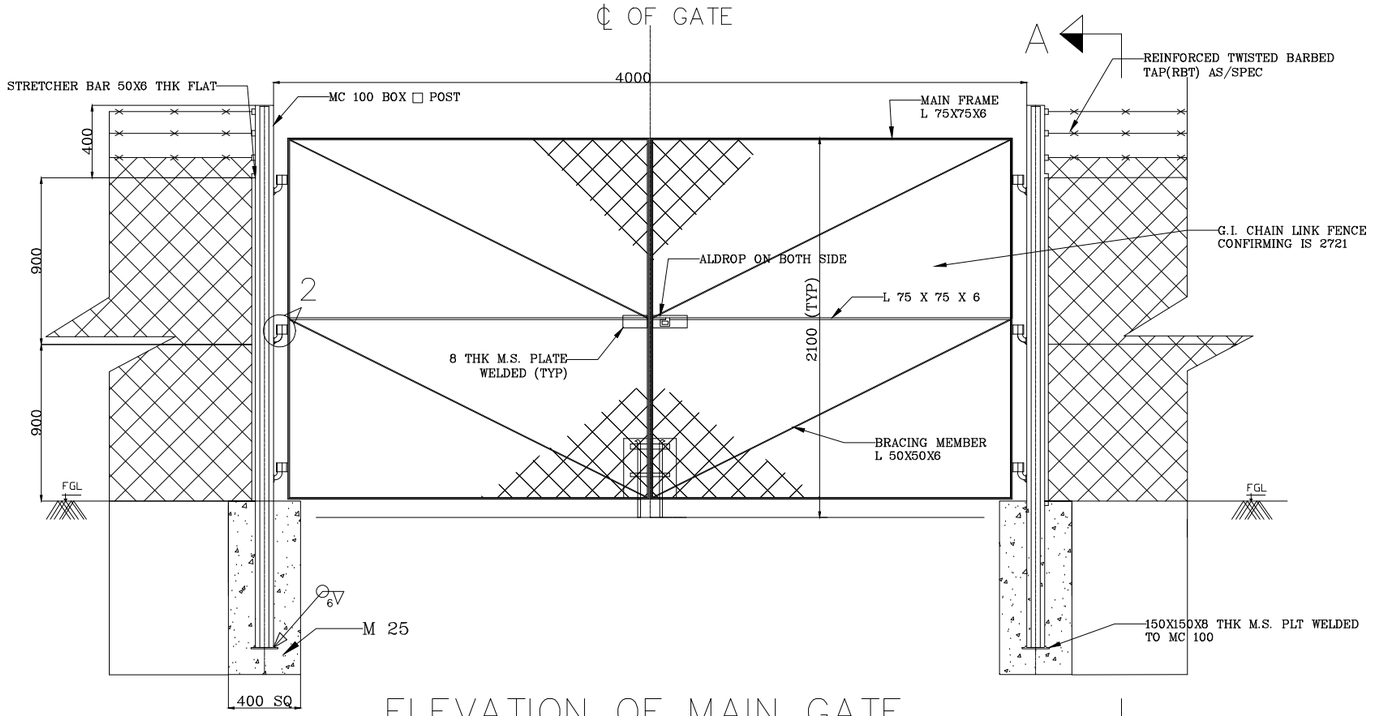
17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL PATA, UP

GAIL (INDIA) LTD

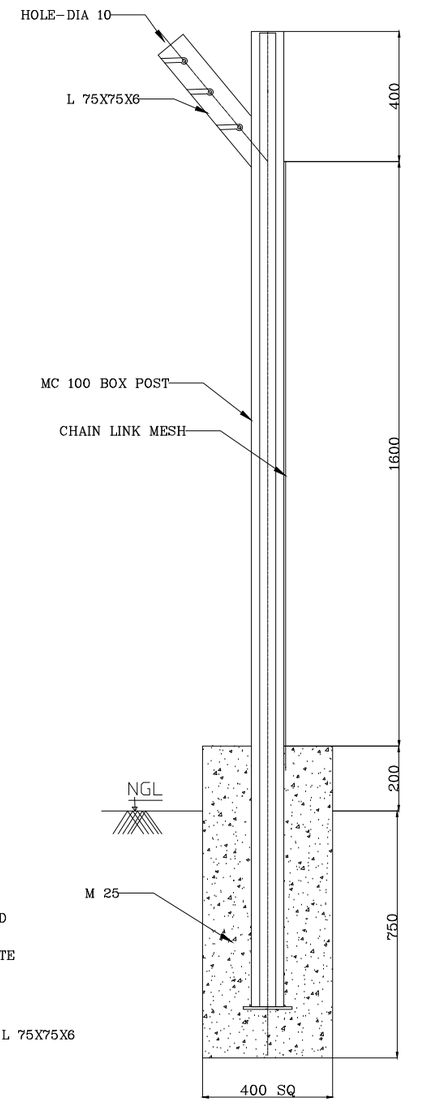
BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

TITLE: TYPICAL FENCING DETAILS

SCALE 1:100 | DRAWING NO. BHEL-GAIL-FENCE | SHEET 1 OF 1 | REV. 00

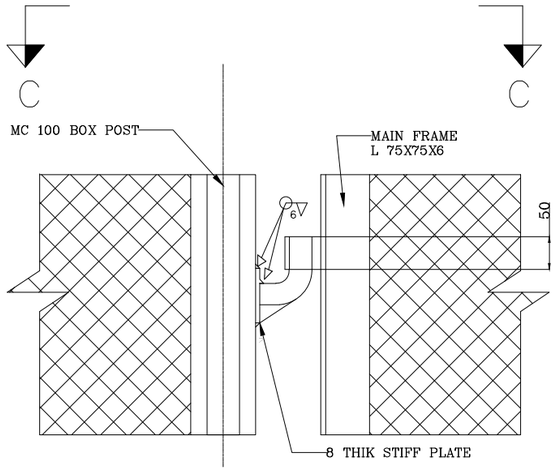


ELEVATION OF MAIN GATE

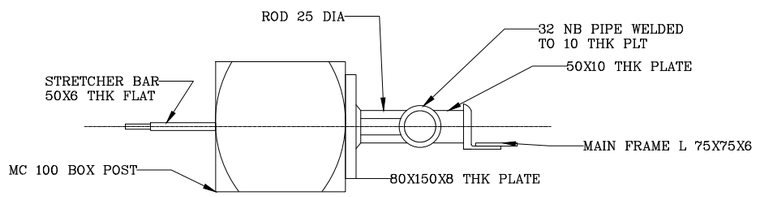


VIEW--A

(DETAILS OF STEEL GATE POST)



DETAIL-2



VIEW-C-C

LEGEND

FGL---- FINISH GROUND LEVEL
NTS---- NOT TO SCALE
TYP---- TYPICAL
EL ---- ELEVATION

NOTE

1. ALL LEVELS ARE IN METERS & DIMENSIONS ARE IN MM
2. CHAIN LINK FENCE & FIXING DETAILS INCLUDING MATERIALS FOR THE WORKS SHALL BE AS PER IS: 2721
3. HTSS WIRE AND CHAIN LINK FENCE SHALL BE ERECTED ONLY AFTER ERECTION OF EACH SEGMENT OF FENCE POST AND STAY POST
4. CONCRETE / MSONRY TOE WALL SHALL BE PROVIDED BETWEEN FENCING POST
5. GRADE OF CONCRETEMIX SHALL BE PCC NOMINAL MIX OF 1:1:5:3
6. THE DEPTH OF FOUNDATION SHALL BE TAKEN FROM NGL AND HEIGHT OF STRUCTURE SHALL BE TAKEN FROM FGL

TENDER DRG.
INFORMATION PURPOSE

17.5 MW (AC) FLOATING SPV POWER PLANT
AT GAIL PATA, UP

OWNER: GAIL (India) Limited — GAIL (INDIA) LTD

CONSULTANT: BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

DEPT.
STATUS
DISTRIBUTION

REV.	DATE	ALTD	CHD	APPD

TITLE: TYPICAL FENCE GATE DETAILS

SCALE 1:100 | DRAWING NO. BHEL-GAIL-GATE | SHEET 1 OF 1 | REV. 00

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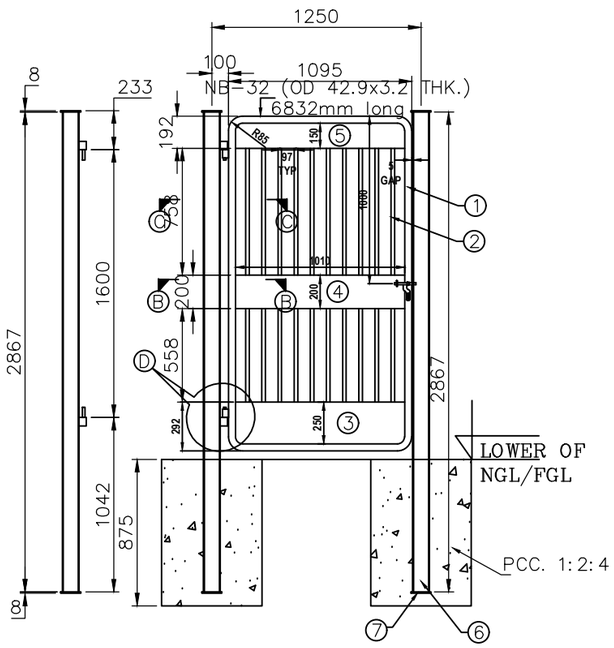
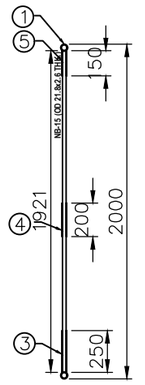
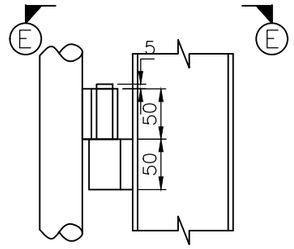


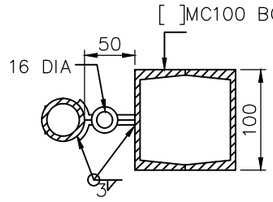
ELEVATION OF GATE 'G'



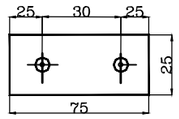
SECTION A–A



DETAIL–D

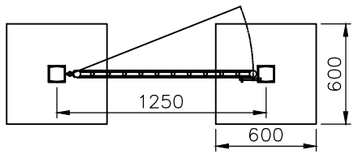


SECTION – EE



**75X25X4MM THICK PLATE SHOULD BE BOLTED WITH CHAINLINK FENCING & EACH VERTICLE POST (3NO'S PER POST).

DETAIL : 01

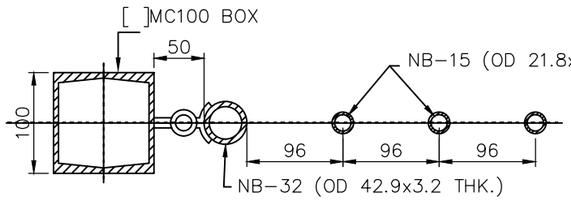


PLAN OF GATE 'G'

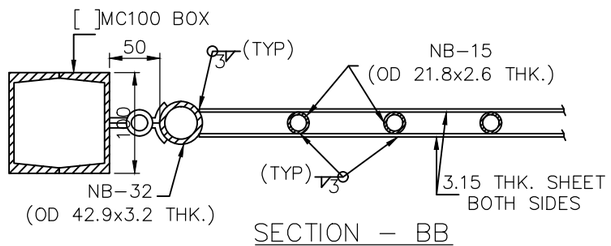
BOM FOR GATE

TOTAL WEIGHT -235.85 KG

ITEM NO.	DESCRIPTION	MATERIAL SPECN.	QTY IN NOS	UNITWT. (KG)	GROSSWT (KG)	REMARKS
7	PL8X120X120	IS2062-1992 Fe410 WA	4	0.90	3.60	
6	ISMC100 - 2867	IS2062-1992 Fe410 WA	4	31.23	124.92	
5	3.15THK.SHEET -150X1010	IS2062-1992 Fe410 WA	2	3.75	7.50	
4	3.15THK.SHEET -200X1010	IS2062-1992 Fe410 WA	2	5.00	10.00	
3	3.15THK.SHEET -250X1010	IS2062-1992 Fe410 WA	2	6.24	12.48	
2	NB15(OD21.8x2.6 THK) -2321	IS2062-1992 Fe410 WA	20	2.81	56.17	
1	NB32 (OD42.9x3.2 THK)-6832	IS2062-1992 Fe410 WA	1	21.18	21.18	



SECTION – CC



SECTION – BB

NOTES:

1. ALL DIMESNSIONS ARE IN MM UOS.ALL MS ANGLES CONFIRMING TO IS 2062

2. VERTICAL POSTS SHALL HAVE SUITABLE PROVISIONS BY WAY OF NOTCHES OR HOLES TO FIX BARBED WIRES.

3. CHAIN LINK FENCE SHALL BE CONFIRMING I.S. 4826 AND BARBED WIRE SHALL CONFIRMING I.S. 278.

4. VERTICAL POSTS SHALL BE GIVEN A TWO (2) COATS OF PRIMER WILL BE APPLIED FOLLOWED BY TWO (2) COATS OF EPOXY BASED SYNTHETIC ENAMELLED PAINT.

5. MASONRY ABOVE GROUND LEVEL SHALL BE PLASTERED IN 12mm THICK CEMENT MORTAR 1:6.

6. 1500MM LONG STAY POST SHALL BE PROVIDED AT CORNER (REFER PLAN OF POST)/JUNCTIONS AND EVERY 10TH POST WILL HAVE A STAY POST IN THE DIRECTION OF FENCE. STAY POST SHALL BE AFFIXED TO VERTICAL POSTS AT ONE END AND EMBEDDED IN CONCRETE M25 (400X400X500MM POCKET) AT THE OTHER END.

7. CORNER POSTS SHALL BE PROVIDED USING THE METHODOLOGY AS MENTIONED IN POINT–6.

8. THE G.I. CHAIN LINK WIRE MESH WILL BE STRETCHED AND ATTACHED BY CLIPS AND KEPT UNDER TENSION WHICH IN TURNS ARE ATTACHED TO THE FENCE POST WITH SECURITY NUTS AND BOLTS.

TENDER DRG. INFORMATION PURPOSE

REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD

DEPT.
STATUS
DISTRIBUTION

17.5 MW (AC) FLOATING SPV POWER PLANT AT GAIL–PATA, UP

GAIL (India) Limited — GAIL (INDIA) LTD

BHARAT HEAVY ELECTRICALS LTD
SOLAR BUSINESS DIVISION, BANGALORE

TITLE: TYPICAL DETAILS OF WICKET GATE

SCALE 1:100 | DRAWING NO. BHEL–GAIL–WICKET GATE | SHEET 1 OF 1 | REV. 00

CIVIL FQP FOR 17.5 MW FLOATING SOLAR PHOTOVOLTAIC POWER PLANT AT GAIL PATA								
Sl. No	Activity and operation	Characteristics / instruments		Class of Check	Type of Check	Quantum Of check	Reference Document	Remarks
1	2	3			4	5	6	7
1.0	**EXCAVATION AND FILLING IN FOUNDATION WORKS (For Buildings, Transformer foundation, Cable Trench, Drains, Switch Yard, UG Water Tank and Septic Tank)**							
	Excavations:							
1.1		Nature, type of soil/rock before and during excavations	As required	B	Visual	Random in eah shift	Tech Specs or Const. Drawings	
1.2		Initial ground level before start of excavations	As required	B	Measurement	100%	Tech Specs or Const. Drawings	
1.3		Final shape and Dimensions of excavations.	As required	B	Measurement	100%	Tech Specs or Const. Drawings	
1.4		Final excavation	As required	A	Measuement	100%	Tech Specs or Const. Drawings	
	Filling:							
1.5	**Standard proctor Test**	Optimum moisture content and max. dry density before fill	As per IS: 2720, Proctor needle apparatus,etc.	B	Physical	One in each source of approved filling material	IS 2720 (Pt.VII), Tech Specs and Const. Drawings	
1.6	**Degree Of Compaction Of Filling**							
i		Dry density by core cutter method	As per IS: 2720/compaction test (core cutter), balance, rapid moisture meter etc.	A	Physical	One Sample in each pit/ filling location. It may be increased as per requirement of GAIL/BHEL.	IS 2720 (Pt. XXIX), Tech Specs and Const. Drawings	
2.0	**MATERIALS**							
2.1	**CEMENT**							
		Retesting of cement	as per IS:4031	A	Third party lab test	Review of MTC for fresh cement bags upto storage period of 90 days. Retest - once per 5000 bags for more than 90days storage.	As per relevant IS Codes & Each consignment of cement shall be duly correlated with TC of manufactureres .	Approved brand
2.2	**Coarse Aggregate**							
ii		Specific gravity, water absorption	IS:2386	A	Physical	Once for each source & for every change of source & in between as per requirement of GAIL/BHEL	IS: 2386 Part-III, IS:456, IS:383	
iii		Sieve analysis, flakiness index, elongation index,	IS:2386	A	Physical	One per 500 cum., or part thereof as per requirement of GAIL/BHEL	IS: 2386 Part-I, IS:383	
iv		Deleterious materials (coal & lignite, clay lumps, material finer than 75 micron sieve, soft fragment, shale)	IS:2386	A	Physical	Once per source/ on every change of source as per requirement of GAIL/BHEL	IS: 2386 Part-II, IS:383	
v		Soundness	IS:2386	A	Physical	-do-	IS: 2386 Part-V, IS:383	
vi		Crushing value abrasion value and impact value	IS:2386	A	Physical	-do-	IS:383, IS-2386 Part IV	
2.3	**Fine Aggregate**							
i		Moisture content	balance , oven, rapid moisture meter etc	A	Physical	to be done every day before start of work	IS: 2386 Part-III, IS:383	
ii		Deleterious materials (coal & lignite, clay lumps, material finer than 75 micron sieve, soft fragment, shale)	IS:2386	A	Physical	Once per source& for on every change of source	IS: 2386 Part-II, IS:383	
iii		Sieve analysis for Zone - I to IV Suitability for concrete	IS:2386	A	Physical	Once for each source & for every change of source & in between as per requirement of GAIL/BHEL	IS: 2386 Part-I, IS:383	
iv		Silt content	IS:2386	A	Physical	Once for each source & for every change of source & in between as per requirement of GAIL/BHEL	IS: 2386 Part-I, IS:383	
2.4	**Water**							
i		Complete tests as per IS:456	as per IS:456	B	Testing	One for each source.	IS:3025 part 22 & 23 (for test procedure) IS:456 (for acceptance criteria)	
2.5	**CONCRETE (For Buildings, Transformer foundation, Cable Trench, Drains, Switch Yard, Water Tank and Septic Tank)**							
i		Crushing strength (works Tests cubes)	IS:516	A	Physical	As per IS-456	IS:516, IS:456.	Min. 6 cubes for each shift shall be taken / as per IS 456
ii		Workability - slump test	IS:1199	A	Physical	At the time of concrete pouring at site. Random	IS:456	
		Workmanship, verticality and alignment of RCC member, Compaction etc..		A	Physical	At the time of concrete pouring at site. Random	IS:456	
		Mix proportion weigh batch report		A	Physical	Before pouring of concrete and during concrete pouring at site. Random	IS:456	
		Curing for concrete surface		A	Physical	Random	IS:456	
2.5.1	**Admixtures for Concrete (if applicable)**	Type of admixture	As per IS:9103	A	Review of MTC	For each lot received at site	Designed mix and IS:9103	APPROVED BRANDS FOSROC,SICA,PIDILITE

2.6	**REINFORCEMENT STEEL**							
i		Physical and Chemical Properties.	As required	A	Third party lab test	Review of MTC	IS : 1786, IS:432, IS:1566, Tech Specs and Const. Drawings	APPROVED BRAND. Each consignment of steel shall be reviewed with MTC.
2.7	**PLACEMENT OF REINFORCEMENT STEEL**							
i		Bar bending schedule with necessary lap, Spacers & Chairs	As required	B	Visual & Measurement	Random in each shift	Approved Drawings, Tech Specs and Const. Drawings, IS:2502	
ii		Bending of bars, cutting tolerance	As required	A	Visual & Measurement	Random in each shift	Approved Drawings, Tech Specs and Const. Drawings, IS:2502	
iii		Acceptance - Cover, spacing of bars, spacers and chairs after the reinforcement cage is put inside the formwork	As required	A	Visual & Measurement	Random in each shift	Approved Drawings, Tech Specs and Const. Drawings	
2.8	**STAGING AND FORMS**							
i		Materials and accessories	As required	B	Visual	Once before start of work	As per relevant IS, Tech Specs and Const. Drawings	
ii		Soundness of staging, shuttering and scaffolding including application of mould oil / release agent	As required	A	Visual	Once before start of work	As per manufacturer's spec.and as per 3696,4014, 4990, Tech Specs and Const. Drawings	
iii		Acceptance of formwork before start of concreting		A	Physical / visual	Before start of each concreting	As per provisions and tolerances, Tech Specs and Const. Drawings	
2.9	**BRICK MASONARY**							
2.9.1	**Test on Bricks/ block**							
		Dimensions , shape, compressive strength, water absorption, efflorescence.	As required	B	Measurement/ Physical Test	As per relevant IS Code/ One Sample for 30,000 nos. & each source.	IS: 1077, IS:13757, IS: 12894 / Tech Specs and const. Drawings	
2.9.2	**Masonry construction**	Workmanship, verticality and alignment	As required	B	Visual/ Physical	100%	IS 2212, IS 1905 , Tech Specs and Const. Drawings	
		Mix proportion	Using volumetric measuring box only	A	Physical	Random		
		Curing for Brick Masonary surface		A	Physical	Random		
3.00	**FINISHING AND ALLIED WORKS**							
3.1	**PLASTERING - WORKMANSHIP**							
i		Curing	As required	B	Physical	100%	Tech specifications, construction drawings and agreed methodology	
ii		Thickness and finishing of plaster, grooves etc	As required	B	Visual/physical	Random in each shift	Tech Specs and Const. Drawings	
iii		Truness of plastering system	As required	B	Visual/ Physical	Random in each shift	Tech Specs and Const. Drawings	
iv		Mix proportion	Using volumetric measuring box only	B	Visual/ Physical	Random in each shift	Tech Specs and Const. Drawings	
v		Surface preparation (hacking to concrete surface, Chicken wiremesh fixing, watered surface)	As required	B	Visual/ Physical	Random in each shift	Tech Specs and Const. Drawings	
4.2	**FLOOR FINISHES AND ALIED WORKS**							
4.2.1	**Tiles**							
i	**Ceramic, vitrified, glass mosaic, acid alkali resistant, heavy duty cement concrete tiles**	Materials	As required	A	Physical	Each lot of delivery	Tech Specs and Const. Drawings	As per approved vendor list
ii		Finishing and acceptance	As required	A	Physical	100%	Tech Specs and Const. Drawings	
5.00	**DOORS , WINDOWS VENTILATORS & GRILL**							
5.1	**Steel doors**							
i		Materials (MS sheet, fasteners, hinges, jambs, lock strike plate etc	As agreed / required	A	Visual/ Physical dimensions report	For each lot received at site	Tech Specs and Const. Drawings,	As per approved vendor list
ii		Flush Door shutters, teak beading	As agreed / required	A	Visual/ Physical	For each lot received at site	Tech Specs and Const. Drawings	
iii		Hollow metal doors (material and dimensions)	As agreed / required	B	Visual/ Physical	For each lot received at site	Tech Specs and Const. Drawings	
iv		Acceptance	As agreed / required	A	Visual/ Physical	Random	Tech Specs and Const. Drawings,SR/LB	
5.2	**Aluminium works**							
i		Materials- Aluminium sections	As agreed / required	A	Visual/ Physical	For each lot received at site	Tech Specs and Const. Drawings	Hindalco, Jindal, Vedanta
ii		Particle Door ,Toilet doors	As agreed / required	A	Visual/ Physical	For each lot received at site	Tech Specs and Const. Drawings	

5.3	**Steel windows / Grills/ Louver/ Rolling shutter**							
i		Material fabrication and fixtures	As agreed / required	B	GAIL/BHEL Approved source	Each lot of delivery	Tech Specs and Const. Drawings	As per approved vendor list
ii		Finishing and acceptance	As agreed / required	B	Visual / physical	Random	Tech Specs and Const. Drawings	
5.4	**False Ceiling**							
i		as per supplier specification	As agreed / required	A	GAIL/BHEL Approved source	Physical inspection	Tech Specs and Const. Drawings,SR	
ii		Installation finishing and acceptance	As agreed / required	B	Visual / physical	Random	Tech Specs and Const. Drawings,SR	
6.0	**ROAD WORKS**							
6.1	**Construction of Sub-Grade and earthen/hard soulders**							
i		Coordinate and center line marking and checking of thickness as per ground profile	As agreed / required	A	Visual/ Physical dimensions report	Random	Tech Specs and Const. Drawings	
ii		Property of Materials to be use for sub-grade (CNS property)	As agreed / required	A	Third party lab test	Random	Tech Specs and Const. Drawings	
iii		Standard proctor Test	As per IS: 2720	A	Physical	One in every 2000 cum for each type and source of fill materials	As per Tech Specs and Const. Drawings,Section 900 of MORTH specification 5th Rev., IS 2720 (Pt.VII)	
iv		Moisture content of fill before compaction	As per IS: 2720	B	Physical	One in every 2000 cum for each type and source of fill materials & in between as per requirement of / GAIL/BHEL	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification latest Rev., IS 2720 (Pt.II)	
v		Dry density by core cutter method	As per IS: 2720	A	Physical	One in every 500 SQM area of subgrade & 1000 SQM area of embankment for each compacted layer.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification latest Rev., IS 2720 (Pt. XXIX)	
6.2	**Wetmix Macadam (Non-Bituminous) for base course and sub-base course**							
i		Aggregate Impact value	Agrregate Impact value Test Apparatus	A	Physical	One test per 1000 cum of Test aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification 5th Rev.	
ii		Grading	Set of IS Sieves	B	Physical	One test per 250 cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification 5th Rev.	
iii		Flakiness index and elongation index	Flakiness test gauge	B	Physical	One test per 500cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification,	
iv		Atterberg Limits of binding material	Atterberg limits determination	A	Physical	One test per 50 cum of binding material	As perTech Specs and Const. Drawings, Section 900 of MORTH specification 5th Rev.	
v		Atterberg Limits of screenings	Atterberg limits determination	A	Physical	One test per 100cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification 5th Rev.	
vi		Thickness of the compacted course	As agreed / required	A	Physical			
6.3	**Bituminous Surfacing - Open graded premix carpet and Seal coat**							
i		Bituminous material	Various test as per MORTh	A	Physical	No. of samples as per MORTH	As perTech Specs and Const. Drawings.	
		Thickness of the compacted course	As agreed / required	A	Physical			
		Bituminous course mix design	As agreed / required	A	Physical			
6.4	**Tack Coat/ Prime coat/ fog coat**							
i		Quality of binder	Various test as per MORTH	A	Physical	No. of samples as per MORTH	As perTech Specs and Const. Drawings.	
7.00	**Anchor pile/ dead weight works:**							
i		Coordinates of anchor pile/dead weight	Marking with Total station	B	Physical & Third Party Lab Tseting	100%	Tech Specs or Const. Drawings	
ii		Placement of Pile/ dead weight	DTH/Auger/ gun	B	Physical & Third Party Lab Tseting	100%	Tech Specs or Const. Drawings	
iii	Dimensions of Pile/ dead block	Depth and Dia (or) size of dead weight		A	Physical	Random	Tech Specs or Const. Drawings	
iv		Verticality	Spirit Level	A	Physical	Random	Tech Specs or Const. Drawings	
vi		Verticality and alignment	Spirit Level	A	Physical	Random	Tech Specs or Const. Drawings	
vii		acceptance of pile and pile cap	Visually	A	Physical	Random	Tech Specs or Const. Drawings	
8	**MECHANICAL WORK**							
i	**Floater assembly**							

MASTER DRAWING & DOCUMENT LIST (MDL)	
Sl. No.	**Drawing / Document Description**
1	Plot Plan (Overall Solar Array Layout)
2	Geotechnical Investigation Report including ERT, CBR report
3	Bathymetry Survey report, if applicable
4	Topography Survey report, if applicable
5	Pile load test report
6	Roads and pathways - layout and cross-section
7	Plant drainage system - layout and design
8	Fencing & Gate GA and layout for Transformer Yard
9	Security room GA, layout and foundation
10	CMCS architecture layout
11	CMCS Plinth Beam, Lintel/Tie Beam and Roof General Arrangement and Reinforcement Details
12	CMCS - Plumbing Network and Sanitary Details
13	CMCS cable trench details
14	CMCS Design with STAAD
15	CMCS foundation
16	Inverter station Platform Drawing
17	Inverter station foundation
18	Inverter transformer foundation-design and drawing
19	Design Basis -Civil & Structural Works
20	CCTV foundation drawing and design
21	WMS foundation drawing and design
22	LA foundation drawing and design
23	Floating System-CFD Analysis & Structural Design
24	Anchoring & Mooring Analysis & design
25	HDPE Floater Data Sheet
26	Floating System Layout Drawing
27	Anchoring & Mooring Layout Drawing
28	Module Cleaning system- GA and Data sheet, Design, P&ID
29	SLD- Single line diagram DC
30	SLD- Single line diagram AC
31	SLD -Auxiliary Power supply system
32	CMCS Equipment layout
33	Inverter station Platform Equipment layout
34	AC cable routing and section details
35	DC cable routing and section details
36	OFC cable routing and section details
37	DC and AC earthing calculation & layout
38	Lightning protection -layout, GA
39	Plant Lighting layout and illumination - calculations
40	CCTV Layout and GA
41	CMCS and Inverter station Light layout
42	PV Syst report
43	PG Test Procedure
44	DC cable schedule
45	AC Cable Schedule
46	Control /Comm/ Aux Cable Schedule
47	Auxiliary transformer, UPS, Battery and Battery Charger-Sizing calcula-tion
48	DC, HT and LT Cable Sizing
49	PV Module Data Sheet and Type Test Reports
50	Inverter data sheet and Inverter Type Test Report
51	Inverter transformer GA, data sheet and type test report
52	AUX Transformer GA, data sheet, Type test report and foundation
53	HT switchgear GA and data sheet & Scheme (ICOG and Pooling panel)
54	LT switchgear (ACCB) GA and data sheet and Type test reports
55	LT switchgear (ACDB) GA and data sheet and Type test reports
56	SCB GA, Data sheet and type test report
57	String Cable data sheet and Type test
58	DC Cable data sheet and Type test

59	AC Cable data sheet and Type test (Inverter to IDT)
60	HT Cable data sheet and type test report
61	LT /Aux Cable data sheet and type test report
62	Control cables data sheet
63	33 kV cable jointing & termination kit- GA & Data sheet
64	UPS, -GA & Data sheet & Type Test Report
65	Battery and Battery Charger-GA & Data sheet & Type Test
66	Weather Monitoring Station- GA & Datasheet
67	Fire Detection and protection system- GA & Datasheet
68	Lightning protection data sheet, GA and type test
69	CCTV data sheet, GA
70	SCADA Architecture including BoM
71	SCADA FAT report
72	SCADA input & output list
73	SCADA- Mimics and HMI screen
74	Communication cable data sheet - OFC/RS 485/CAT 6
75	FQAP for Civil Works
76	MQAP for PV Module
77	MQAP for Power Conditioning Unit (PCU)
78	MQAP for Inverter Transformer
79	FQAP for PV Module
80	MQAP for HT Switchgear Panel
81	MQAP for HT Power Cables
82	MQAP for SCADA System
83	MQAP for Control & Relay Panels
84	MQAP for AB Tariff Meters
85	MQAP for Auxiliary Transformers
86	MQAP for LT Power Cables
87	MQAP for Floating System
88	FQAP for Floater Assembly Works
89	FQAP for Anchoring & Mooring Works
90	MQAP for LT Panels
91	MQAP for Solar DC Cables
92	MQAP for Switchyard System (As applicable)
93	MQAP for String Combiner Box
94	MQAP for DC Cable Connector
95	MQAP for Weather Monitoring System
96	FQAP for Electro-Mechanical Erection works
97	FQAP for Cabling
Note: 1. The above Master Drawing & Document List (MDL) is indicative only and it will be finalized mutually with successful bidder after award of works. 2. Any other items mentioned in Technical Specification and not specified above shall also be made part of the Master Document List and the above list shall be updated accordingly.	

PC-II Reservoir Water test Report		
Water Parameters	**UOM**	**Average Values**
P^H		8.014
Conductivity	µS/cm	183.524
Turbidity	NTU	18.381
m-Alkalinity as CaCO3	mg/l	84.333
Iron as Fe	mg/l	0.068
Total Dissolved Solids	mg/l	121.167
Total Suspended Solids	mg/l	15.167
Total Solids	mg/l	136.333
Ca Hardness	mg/l	74.500
Mg Hardness	mg/l	27.500
Total Hardness	mg/l	102.000
Chloride	mg/l	10.667
Colloidal Silica as SiO2	mg/l	2.813
Reactive Silica as SiO2	mg/l	4.927