# ANNEXURE-2.1

# to

# CONTRACT

# for

# SUPPLY, INSTALLATION, COMMISSIONING AND OPERATION & MAINTENANCE OF 25MW/100MWh BESS POWER PLANT

# TECHNICAL SPECIFICATIONS

*(This section of the Tender Document covers the technical specifications of the project for the Bidder to comply. However successful Bidder shall have to prepare design documents as per the actual Site conditions and to take approval of the Owner prior to start of the works)*

## TABLE OF CONTENTS

# SECTION-1 GENERAL TECHNICAL REQUIREMENTS (GTR)

# 1. Intent of Specification

1.1.1 This specification covers the design, manufacture and assembly, inspection and testing at the Contractor's / Sub-Contractor's works, packing & forwarding, transportation to Site, insurance, erection, testing and commissioning of all the equipment/material of 25MW/100MWh (at Interconnecting Point), 132kV bay extension and Operation & Maintenance service for twelve (12) years of grid connected Battery Energy Storage System (BESS) Plant with associated warranty, etc.

1.1.2 Supplies and services shall be rendered in conformity with proven design principles, taking into account the current technology. The requirements of the Contract must be fulfilled in its entirety. The supplies and services shall be rendered inclusive of all appliances and interconnecting arrangements with other supplies, necessary for installation of all accessories, needed for proper and reliable continuous operation and for satisfactory maintenance and repair.

1.1.3 In so far as data on the execution of supplies and services as contained in drawings, but none in specification and vice versa, such data shall be deemed to be contained in both. Contradictions, if any, between drawings and specifications and within various sections of the specification shall be brought to the attention of the Owner by the Bidder and the correct requirement shall be obtained before submission of the bid.

1.1.4 All materials & equipment supplied under this Contract shall be new, unused and Minimum of one (01) year warranty from the date of Commissioning of Facility shall be provided for all the equipment, until otherwise mentioned in their respective section of this specification.

# 2. Project Information

2.1.1 Project information is furnished in Annexure-A of this Technical Specification.

# 3. System Description

3.1.1 Battery Energy Storage System (BESS) technology shall consist of electrochemical batteries (Lithium iron phosphate (LFP) only), which provide the ability to store and transmit energy in the form of electricity.

3.1.2 The Plant capacity shall be sized to achieve 25MW/100MWh at the Interconnecting Point on the Commercial Operation Date (COD), in the land provided by Owner.

3.1.3 Plant shall have pooling substation within project area, which comprises of 33/132kV power transformer and other 132kV bay equipment.

3.1.4 The existing 400/220/132kV AEGCL Kukurmara (Mirza) Grid substation, Sathikarpa, Assam is identified for power evacuation. 132kV voltage level has been recommended for power evacuation.

### 3.2 Power Evacuation and Metering

3.2.1 A single 132kV bay has been allotted at 400/220/132kV AEGCL Kukurmara (Mirza) Grid substation, Sathikarpa, Assam for evacuating the 25MW.

3.2.2 The power from 33/132kV Pooling Substation located at Plant shall be evacuated to the 400/220/132kV Kukurmara (Mirza) Grid Substation through combination of 132kV Cable and Overhead lines. The circuit distance is approximately 700m.

3.2.3 Main energy metering system (Main & check meter) shall be provided in 132kV Bay located at AEGCL grid substation as per AEGCL/CEA regulations and a standby meter at Plant.

# 4. General Requirements

**Disposal/Dumping Area Details:**

4.1.1 Disposal of waste excavated material not reusable in levelling and construction shall be disposed by the bidder in the disposal sites arranged by bidder after seeking prior permission of the concerned local authorities and in compliance to all applicable laws. Dumping area shall not be made available by the Owner.

**Contractor's infrastructural facilities:**

4.1.2 The Contractor must make it's own arrangement to develop infrastructure for all their man and materials required during the Construction Phase. Necessary residential and labour camps including other facilities like water supply, sanitation etc. is to be developed /arranged by the Contractor on it's own including its maintenance during the Construction Phase & Operational Phase of the Project. All the camps, facility areas, main works area etc. are required to be fenced and protected by the Contractor on it's own. The manpower engaged by the Contractor for the works of the Project shall be mainly from local population to the extent available. However, in case of non-availability of highly skilled/semi-skilled manpower among local population, the same shall be arranged from outside.

4.1.3 Site Facilities for Owner

a. Contractor shall provide Owner's Site office with a minimum 1 nos. of porta cabin to provide at least 4 working desks for its employees and its representatives, 2 nos. of Manager cabin, Pantry, separate toilet block for male & female (min 1 number each).

b. Contractor shall provide electricity, water, Internet, AC for sufficient cooling, A3 printer cum scanner for the Owner and its representatives as required with no charges to Owner.

4.1.4 A storage yard of sufficient space should be properly demarked and fenced for ware housing of materials. Inventory and store keeping is also in the scope of Bidder. Storage yard shall have suitable power supply arrangement for storage of Containerized Battery Storage System, if required. The arrangement of lighting, security, weather protection, store keeping shall be in the scope of bidder.

4.1.5 Appropriate housekeeping and security shall be provided by the Contractor to timely replenish the material breakage / theft/ repair including transport without extra expenses to the Owners.

4.1.6 The bidder shall provide adequate number of mobile toilets and rest sheds with drinking water facilities within the Site.

**Site Visit:**

4.1.7 The Bidder is advised to visit and examine the Site of works and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the Bid and entering into a Contract for the required job. The expenses of visiting the Site shall be borne by the Bidder.

4.1.8 The Bidder or any of its personnel or agents shall be granted permission by the Owner to enter upon its premises and land/Area for the purpose of such visits, but only upon the express conditions that the Bidder, its personnel and agents will release and indemnify the Owner and its personnel, agents from and against all liabilities in respect thereof, and will be responsible for death or injury, loss or damage to property, and any other loss, damage, and expenses incurred as a result of inspection.

4.1.9 A detailed disposal plan shall be included as part of the operations and maintenance documentation. The disposal plan shall demonstrate the ability to recycle or safe dispose all parts of the Plant. The Plant/system/ sub-system disposal has to be carried out by the bidder as per the procedure approved by the Owner during Operational Phase. Bidder shall comply the E-waste (management) rules-2016 Ministry of Environment, Forest and Climate Change for disposal of Plant equipment.

4.1.10 The Bidder shall not be entitled to hold any claim against Owner for non-compliance due to lack of any kind of pre-requisite information as it is the sole responsibility of the Bidder to obtain all the necessary information with regard to Site, surrounding, working conditions, weather etc. on its own before submission of the bid.

4.1.11 Bidder shall visit the Site and carry out required land investigation studies before participating in the bid. The bidders, in their own interest, should inspect and examine the Site and its surroundings and satisfy themselves, before submitting their tender, in respect of the Site conditions including but not restricted to the following which may influence or affect the work or value thereof under the Contract:

1. Site conditions including access to the Site, existing and required roads and other means of transport/ communication for use by them in connection with the works.
2. Requirement and availability of land and other facilities for their enabling works, colonies, stores and workshops etc.
3. Ground conditions including those bearing upon transportation, disposal, handling and storage of materials required for the work or obtained there from.
4. Source and extent of availability of suitable materials including water, etc. and labour (skilled and un-skilled), required for work and Laws and Regulations governing their use and employment.

5. Geological, meteorological, topographical, hydrology and other general features of the Site and its surroundings as are pertaining to and needed for the performance of the work.
6. The limit and extent of surface and sub-surface water to be encountered during the performance of the work and the requirement of drainage and pumping.
7. The type of equipment and facilities needed, preliminary to, for and in the performance of the work; and
8. All other information pertaining to and needed for the work including information as to the risks, contingencies and other circumstances which may influence or affect the work or the value there of under this contract.
9. Transportation & Logistic constraints etc. to the locations. The bidders should note that information, if any, in this tender document, has been given merely to assist the bidders and is not warranted to be complete. The bidders should note and bear in mind that the Owner shall bear no responsibility for the lack of acquaintance of the Site and other conditions or any information relating thereto, on their part. The consequences of the lack of any knowledge, as aforesaid, on the part of the bidders shall be at their risk and expense and no charges or claims whatsoever consequent upon the lack of any information, knowledge or understanding shall be entertained or payable by the Owner.

**The detailed technical specification of each equipment are described in other section of this technical specification.**

4.1.12 This specification covers the scope requirements of Design, Engineering, Supply, transportation, Construction, Erection, Testing and Commissioning with all allied civil works for 25MW/100MWh (at Interconnecting Point) BESS Power Plant. Bidders shall ensure that engineering and supply of equipment shall be done for efficient and trouble-free operation of Plant. The scope also includes 12 years Operation & Maintenance services for grid connected Battery Energy Storage System (BESS) Power Plant. Associated warranty, and applicable insurance is also included under Bidder's scope.

4.1.13 This specifications document is not exhaustive, and the Bidder shall be responsible not only for the requirements specified herein but for Site suitable choice of materials, for proper fabrication and for the conformity to codes, regulations and legal requirements and for supplying all the documentation of these materials. However, the equipment shall conform in all respects to high standards of design engineering and workmanship and shall be capable of performing in continuous commercial operation as per agreed generation/storage guarantee.

4.1.14 Any item(s) not included in the specification / schedule but required for completion of the work shall have to be carried out/supplied without any extra expenses to Owner. Such works, not listed in the schedule of works but elaborately described to perform or to facilitate particular operation(s)

required for completion of the Project shall be deemed to have been included in the scope of this work and the Bidder shall supply, install the same without any extra expense to Owner.

4.1.15 Supplies and services shall be rendered in conformity with proven design principles, considering the current technology. The requirements of the Contract must be fulfilled in its entirety. The supplies and services shall be rendered inclusive of all appliances and interconnecting arrangements with other supplies, necessary for installation of all accessories, needed for proper and reliable continuous operation and for satisfactory maintenance and repair. It is not the intent to completely specify all the details of design, construction and installation herein.

4.1.16 The work to be carried out shall be all in accordance with the requirements, conditions, appendices etc. given in Technical Specifications together with those stated in other Parts/Sub-Parts/tender drawings of Bid Documents which shall be considered as a part of this volume as completely as if bound herewith.

4.1.17 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 a specific time period. Bidder's offer should not carry any parts like clarifications, interpretations and/or assumptions. However, if the bidder feels that, in it's opinion, certain features brought out in it's offer are superior to what has been specified, these may be highlighted separately.

4.1.18 In case of any conflicts / contradiction among various clauses / parts / appendix / annexure/chapters / appendices / tender drawings of bid documents, the most stringent requirement shall govern; decision of the Owner shall always be final & binding on the Bidder/Successful bidder. No extra claims shall be allowed on this account.

4.1.19 Bidder shall furnish all relevant data required by the Owner, at interface points within schedule as required. Further, the scope shall also include submission, in proper shape & format, of all types of manuals, handbooks & documents in requisite numbers to the Owner at different phases of the project as per the requirement of Owner.

4.1.20 The bidder shall be responsible for providing all materials, equipment, and services, specified or otherwise which are required to fulfil the intent of ensuring operability, maintainability, and reliability of the total work covered under this specification without any financial implication. This work shall be consistent with modern practice and shall be in compliance with all applicable codes, standards, guides, statutory regulations and safety requirements in force on the date of award of this Contract.

4.1.21 The Bidder shall furnish as per data requirements, schedules and other applicable sections, full details regarding all equipment and systems including complete bill of materials, design basis & aspects, drawings, data, information, technical literature and other details required to fully establish the capability and performance of the equipment and systems offered by him. Any bid not containing sufficient details to fully describe the equipment and systems offered or sufficient details regarding

past experience for meeting the qualifying requirements may be treated as non-responsive and hence rejected.

4.1.22 The drawings enclosed with the specification are indicating the minimum requirement and all bidders shall comply with it. Any further improvement required during detailed engineering and execution shall also be implemented by bidder. Bidder shall confirm that the type, make, model of all bought out items supplied by the bidder under the specification shall be subject to the approval of the Owner during detailed engineering stage.

4.1.23 The Owner shall have the right to and may modify/clarify the Tender document prior to the submission date of the bids by issuing amendments/addendum/errata/corrigenda, as appropriate and such documents shall be construed as forming part of the Tender document.

# 5. Design Basis

## 5.1 Intent

5.1.1 This technical specification's procedures and materials are meant to serve as the barest minimums. The bidder agrees to uphold the obligation to fulfil all performance and other conditions outlined in this technical specification.

5.1.2 This chapter gives a definition of the standard drawings/documents of various equipment which along with those listed in the particular specifications, shall be delivered by the Bidder to the Owner within the agreed schedule, and in a number and quality as specified in the bidding document.

5.1.3 The Owner reserves the right to request the Bidder for additional drawings/documents as may be required for proper understanding and definition of constructional, operational, co-ordination or other matters.

5.1.4 All documents shall be submitted in accordance with the agreed programme during detail engineering so that any comment and change requested by the Owner can be taken into account before starting of the manufacture of the equipment in the workshop and/or erection or installation at the Site.

5.1.5 If the Bidder fails to submit such documents, then the later execution of changes requested by the Owner and the resulting additional expense and/or delays shall be the Bidder's responsibility. The Bidder shall not be absolved of it’s responsibility and guarantee even after drawings and computations have been approved by the Owner.

5.1.6 On drawings, catalogue sheets or pamphlets of standard works submitted to the Owner, the applicable types, paragraphs, data, etc. shall either be marked distinctively, or the non-applicable parts shall be crossed out. Documents not marked in such a manner will not be accepted and reviewed / approved by the Owner.

5.1.7 If required for proper understanding of the documents, additional descriptions/explanations shall be given on these documents or on separate sheets. All symbols, marks, abbreviations, etc., appearing on any document shall clearly be explained by a legend on the same document or on an attached sheet.

5.1.8 Each device appearing on any document (drawing, diagram, list, etc.) shall clearly be designated. The abbreviation mark used for an individual device shall be identical throughout the complete documentation so as to avoid confusion. All documents shall have a uniform title-block and agreed by the Engineer in-Charge. Beginning with the very first submittal to the Engineer in-Charge, the Bidder's drawings shall bear a serial number corresponding to a drawing classification plan to be agreed upon by the Bidder and the Engineer in-Charge.

**Drawing**

a. Foundation Drawings:
   1. If a piece of works requires its own foundation or needs a special area for installation, the Bidder shall submit drawings indicating all pertinent dimensions, static and dynamic loads, etc. They shall include all essential details required for proper design and construction of the foundations and/or buildings.
   2. In addition, these shall include openings, sleeves, slopes and the arrangement of any supporting structure, i.e. base-frames or other steel constructions for permanent fixing or erection purposes.
   3. If conduits are to be installed in the foundations, the relevant information such as diameter, length, and purpose shall be indicated on the drawings.

b. Arrangement Drawings
   1. All arrangement drawings shall be drawn to scale. The General Arrangement drawings shall show the physical arrangement of Works/ equipment/assemblies in relation to each other and to agreed co-ordinates and boundaries.
   2. The Arrangement or Layout Drawings of electrical and instrumentation and control equipment shall indicate the location of all apparatus wherever used, i.e. in or on machines, control boards, switchboards, cubicles, control desks and panels, etc. The apparatus shall be denominated with the same standardised abbreviations as used in all other documents.

c. Outline Drawings: The Outline Drawing shall show all elements and the main dimensions of individual components where necessary in plan view, cross-section, side and top views. If reasonably possible such dimensions can be shown on arrangement Drawings

d. Design Drawings: The Design Drawings shall include outline drawings, assembly manufacturing drawings of components, erection drawings, showing the dimensions, design and data of all

constructions, apparatus and works to be furnished under this Contract The drawings shall - where applicable - substantially conform to the Tender Drawings and shall show:

1. Assembly of the works in plan and elevation with main dimensions
2. Sub-assembly of the principal components of the works with overall dimensions, adjustment and clearance tolerances, and numbers of corresponding detail drawings.
3. Sub-assemblies in which the Bidder proposes to ship the works.
4. All necessary details of the parts connecting to the works supplied by others.
5. Location and size of the instruments and accessories provided.
6. Method and sequence of installation & erection

e. Installation Drawings: The construction, mechanical, electrical and I&C Drawings shall provide detailed information on the disposition of the various items of a system.

**Diagrams:**

a. Electrical drawings shall be as per IEC.

b. Not with standing reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable. Size of cables, direction of power flow, upstream device detail, all CT & PT details, relay setting, OTI & WTI setting should be displayed at Control Room as per norms.

c. Block Diagrams

1. The Block Diagrams shall be used to show in a simplified manner the main inter-relationships between the elements of a system by means of symbols, block symbols and pictures without necessarily showing all the connections. The symbols used for the individual kinds of components etc., shall clearly be explained on the diagram or on an attached legend.
2. When recommendable, a block text diagram may be prepared, consisting essentially of explanatory texts enclosed in outlines which are linked by lines showing the functional relationships that exist between the various parts of an installation, works or circuit.

d. Logic Diagrams

1. The Logic or Functional Diagrams shall be used for representation of logic and sequence controls and interlocking by showing only binary logic elements and their effect on the various process equipment disregarding their electrical realisation. Logic function elements (AND, OR, NOR, NAND, STORAGE, etc.) shall be used for processing and combining binary signals.

e. Schematic/Single-Line Diagrams

1. This is a simplified diagram of the essential works and their interconnections. Each circuit shall be represented by a single line only. It shall contain all required technical information of the works represented.

2. Single-line diagrams of individual main components and switchboards shall additionally show the control, indicating, measuring, metering, protection, automatic and other auxiliary devices separated for each individual installation Site and location as applicable:
3. Furthermore, the applied recommended setting of adjustable devices (protection and control elements, time relays, etc.) shall be indicated.

f. Electrical Circuit Diagrams

1. The Circuit Diagrams shall show the power circuits in all the phases with the main apparatus as well as the pilot circuits (measuring and control circuits). It shall show in full the functioning of part or all installations, works or circuits with all required technical information.
2. The control part shall be subdivided into separately drawn "current paths", each showing all its components regardless of their actual physical location. The individual circuits are to be drawn in a straight-line sequence, avoiding line crossings. The current paths (to be designated by numbers) shall be drawn starting from two horizontal lines, which represent the control voltage source. All devices belonging to the works or forming part of the works or control devices shall appear between these two lines.
3. Contact developments of the installed switches, contactors, relays, and other apparatus which appear in the diagram shall be shown below the respective contactor coil, indicating by means of numbers and, if not on the same, also the page No., the current path in which the corresponding contact has been used.
4. Interconnections to other circuit diagrams shall be clearly marked by means of dotted line separations and the corresponding functional designation. The power circuit portion of the installation shall be drawn at the left side of the drawing.
5. Circuit diagrams shall also contain all terminals and their correct designations. Terminals grouped together to terminal blocks of switchboards, distributors, etc. shall be shown on the circuit diagrams in one fictitious horizontal line surrounded by demarcation lines. If, for any reason, the current paths of circuit diagrams must be separated, the corresponding counter terminal has to be indicated by all means.
6. The representation of electrical works and control circuits shall not be terminated at the limits of the scope of supply but has to be extended beyond this limit by all switchgear, protective, measuring and monitoring equipment required for full comprehension of the whole circuit.
7. Standard Circuit Diagrams are patterns of circuit diagrams which have been standardised with regard to scope, arrangement, representation and allocation of works with the aim of simplification and easy surveillance of electrical circuitry.

g. Terminal Diagrams

1. Such diagrams shall be prepared for any type of terminal box, marshalling rack, control cubicle, switchboard, etc., and shall show the terminals (properly numbered) and the internal and/or external conductors (wires or cables) connected to them.
2. The terminal diagram of each individual switchboard, terminal box, panel, etc. shall contain, but not be limited to the following information:
3. Terminal number of terminal board with targets (terminal number and current path) of incoming and outgoing cables and wires
    - Cable designation
    - Type of cable
    - Number and cross-section of conductors
    - Assignment of conductors
    - Number of spare conductors
    - Approximate length of cable and its destination

h. Emergency Shutdown Diagram

1. This diagram shall show the sequential steps and interdependencies during emergency shutdown of the Plant.

## 5.2 Design Requirements

5.2.1 In addition to the drawings or whenever the contractual documents do so require, the Bidder shall submit to the Owner for verification, the appropriate calculations for determining the main sizes, stress levels, dimensions and operational characteristics, safety factors, clearly indicating the principles on which the calculations were based. The calculations shall include the formulae, standards, test results, basic assumptions, etc. Submission of computer calculations without baseline information such as derivation of the calculation method, applied formulas, definition of variables and constants, explanation of abbreviations etc., will not be accepted.

5.2.2 The Bidder shall submit the detailed design basis report (civil, communication, electrical, etc.) within 15 days from date of issue of LOA. The design basis report shall include the complete all aspects in the scope of the project.

5.2.3 Plant Capacity : 25MW/100MWh at interconnecting point

5.2.4 Minimum Storage hour requirement : 4 hours

Minimum Round-Trip Efficiency : ≥ 86%

5.2.5 At the Interconnecting Point, PCS shall be sized in line with the CEA regulation requirements considering Plant active power rating shall be minimum 25MW @0.95 PF at 50°C and PSSE (Power System Simulator for Engineering) modelling shall be submitted.

5.2.6 At Interconnecting Point, both active and reactive power requirements with accounting Site temperature as per CEA connectivity to Grid regulation shall be ensured by bidder.

5.2.7 As the Site location have tendency of receiving sudden rain showers randomly throughout the year, the opening of Containerized Battery Storage System shall be in such way that rain showers cannot reach the cell/battery unit/any other equipment during maintenance.

5.2.8 The design and selection of number of Containerized Battery Storage System, configuration, series and parallel connections, orientation, inverter, and inverter duty transformer designs, etc., shall be such that it ensures maximum electric power generation/storage and minimum loss to the generated/stored power results.

5.2.9 The design of the system shall aim for a fully automated power Plant requiring minimum operator intervention, with optimized power storage features, self-monitoring and intelligence, grid monitored safety functions, data management and remote function capabilities.

5.2.10 Workmanship and finish shall be in accordance with the best and latest engineering practices. All materials used for the manufacture of equipment by the Bidder, or his sub-suppliers or sub-vendors and the workmanship shall be of good quality and acceptable, as per Indian Standards or other applicable / approved standards.

5.2.11 Bidder to design and size the rating of the PCS/Containerized Battery Storage System/IDT according to the charging and discharging cycle of the battery as specified in the technical specification. However, the continuous rating of all Inverter shall not be lesser than 30MVA at ambient temperature of 50°C.

5.2.12 PCS of same make and same rated capacity is recommended for the whole Plant.

5.2.13 Minimum three (03) number of IDT shall be considered in bidder design.

5.2.14 The inverter duty transformer shall not be overloaded for continuous operation.

5.2.15 The HT switchgear shall have one Outgoing spare feeder.

5.2.16 Sizing of cable shall be such that the maximum voltage drop at full power from the first Containerized Battery Storage System up to interconnecting point shall be optimized.

5.2.17 For Containerized Battery Storage System cables, the conductor resistance corresponds to 90°C. Short circuit current for the cable sizing shall be as per requirement and fault clearing time shall be considered for actual system fault clearing time.

5.2.18 The minimum size for cable shall be as per fault level and protection time grading requirement subject to minimum of 0.5 Sec.

5.2.19 For all HT cables, full load current and number of runs shall be calculated with consideration of 0.95 PF.

5.2.20 At MCR location, 2 X 100% auxiliary transformer shall be considered, and Inverter station, 1 X 100% auxiliary transformer shall be considered (if applicable). And for sizing, 20% future load margin shall be considered.

5.2.21 Suitable Hume Pipes of Grade NP2/NP3 shall be provided for cable (Power and Communication) crossings of road / drain / other cables. For cables crossing roads, only NP3 shall be provided.

5.2.22 For all other LT cables (Auxiliary system), Maximum voltage drop shall be limited to 3% of rated voltage and 10% of rated voltage during motor starting.

5.2.23 The Plant instrumentation and control system should be designed to ensure high availability and reliability of the Plant to assist the operators in the safe and efficient operation of the Plant with minimum effort. It should also provide the analysis of the historical data and help in the Plant maintenance people to take up the Plant and equipment on predictive maintenance.

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

5.2.25 All PCS stations (RTU) shall be ring topology up to main SCADA.

5.2.26 The Bidder is required to fulfil the functional requirements according to the above mentioned, based on their own design.

### 5.3 Grid Substation Configuration

5.3.1 The existing 400/220/132kV AEGCL Kukurmara (Mirza) Grid substation, Sathikarpa, Assam shall be the evacuation substation. 132kV level has been selected as evacuation voltage.

5.3.2 Bidder has to extend the bay at 132kV for interconnecting Plant to grid.

5.3.3 The scope of supply for the extension, interconnection of power and communication between Plant and grid substation is also in the scope of bidder.

5.3.4 The existing Bus bar scheme at 132kV level is main and transfer bus, the substation SLD shall be referred in tender drawings

5.3.5 Bidder shall follow the existing substation scheme/philosophy/Equipment clearance. Any deviation shall be promptly discussed/approved with NGEAL on beforehand.

5.3.6 The auxiliary supply(415V) is available in the substation auxiliary transformer. Bidder shall tap at auxiliary transformer secondary side, all suitable arrangements including termination shall be borne by bidder.

5.3.7 A separate ACDB with required protection and exiting scheme shall be provided after auxiliary transformer. This shall be mounted next to the existing main ACDB of substation. Further, the supply can be extended for proposed CRP/Bay/illumination/others.

5.3.8 Bidder have to construct a new pre-fabricated/RCC building within the existing substation adjacent to proposed bay (Location shall be decided during detail engineering). All required panels and auxiliary system for the bay shall be housed inside this building.

5.3.9 For UPS/DC backup supply, bidder shall have their own system. only 415V raw power will be provided by NGEAL.

5.3.10 Bidder is advised to visit the substation also to examine the works as per requirement and to independently gather any information that may be required for a successful completion of the Project. The expense of visiting the Site shall be borne by the Bidder.

# 6. Scope of Work, Supply and Services

## 6.1 Scope of Work

6.1.1 All equipment, materials and services whether explicitly stated or otherwise and that are necessary for the satisfactory operation of the Plant and its integration with respective 132kV Substation as described in the specification shall be deemed to be included in the scope of work of the Contractor and shall not be limited to the following descriptions,

a. Construction of new 132kV bay at existing grid substation (400/220/132kV AEGCL Kukurmara (Mirza) Grid substation, Sathikarpa, Assam) for line feeder.
b. Construction of complete Plant and associated civil/ electrical/ communication/ instrumentation/mechanical works of 25MW/100MWh with pooling substation.
c. Construction of interconnection between Plant and grid substation with overhead lines and UG cables.
d. Twelve (12) years of Operation & Maintenance services for grid connected Battery Energy Storage System (BESS) Plant up to interconnecting point, Associated warranty, and applicable insurances.
e. Acquiring Grid connectivity approval of dedicated 132KV bay extension works with all required clearance from grid authority including O&M expenditure of bay initially for the period of 12 years and subjected to further extension as per mutual agreement of the parties.

Executing everything necessary to complete the work in all respects stipulated, regardless of omissions in the specifications or drawings.

## 6.2 Scope of Supply

6.2.1 The scope of supply shall include overall project management, coordination, design, engineering, manufacture and assembly, inspection and testing at the Contractor's and/or sub-Contractor's works, painting, packing & forwarding, transportation to Site, receipt at Site, Site storage, erection, testing, commissioning and performance testing at Site of following:

a. Containerized Battery Storage System with BMS, thermal management system, firefighting and protection system, containers and with necessary auxiliary and protection systems.

b. Power Conditioning System (Bi-directional)
c. LT cables
d. Inverter Duty transformer with NIFPS
e. HT cables
f. HT switchgear
g. 33/132kV Power transformer with NIFPS
h. 132kV circuit breakers, Isolator, instrument transformers, Surge arrestor, Lightning arrestor, required hardware and accessories for 33/132kV pooling substation.
i. Control and Relay panels for Pooling substation and Grid substation
j. ACSR/AI59 conductor with accessories, aluminium tubes, bus bar materials, clamps & connectors, shield wires etc.
k. 132kV UG (E), Armoured, Water protected cable with suitable termination kit.
l. 132kV bay extension at Kukurmara (Mirza) grid substation with all required equipment
m. EMS, SCADA and Time synchronization equipment
n. Instrumentation and communication cable
o. Earthing system
p. Lightning Protection system
q. Plant illumination system
r. Peripheral road illumination
s. Auxiliary transformer
t. Distribution boards
u. Auxiliary System with UPS for AC and DC aux supplies
v. Weather Monitoring system
w. Fire, Heat, Smoke detection and protection system.
x. CCTV surveillance system
y. Devices, switches, converters, cables etc. for interface with existing system (Relay panel interfacing with existing evaluation PC, Multifunction metering interfacing with existing Substation SCADA, Energy meter interfacing with existing evaluation PC).
z. FOTE panel with all its accessories at both ends (Grid substation & Pooling substation).
aa. OPGW/ADSS/FO cable with distribution panel and all required accessories
bb. Tariff metering panels
cc. Power, control and signal cables between various equipment.
dd. Cable trays, supports, clamps & accessories for cabling between Plant Substation and Grid substation control room.

ee. Cable trays, supports, conduits, clamps, ties & accessories for cabling in Grid substation control room.

ff. Buried earth mat and risers for Substation.

gg. Earth mats below operating handle of individual Substation equipment.

hh. Equipment earthing for Substation and equipment in Substation Control Building

ii. Interconnection of Substation earth mat with existing underground earth mat.

jj. Lightning protection for Substation.

kk. 132k insulator strings and hardware

ll. CT & CVT junction boxes

mm. Bay marshalling kiosks

nn. Illumination system for grid substation

oo. Cable glands, lugs etc. for all the cables in scope

pp. Fire hydrant line for fire protection around proposed Substation.

qq. Other Miscellaneous works

6.2.2 The scope of work covers design, engineering, supply of all materials, construction, fabrication / assembly, and testing at works, packing / dispatch / loading / unloading and transportation (including internal transportation and material handling at Site) to Site (including transit insurance) and erection of the following Civil, Structural and Architectural works of Plant and Grid substation.

a. Site investigation - Topographic survey, Hydrology Survey, Geotechnical investigation and electrical soil resistivity measurements

b. Site preparation works - Site grading including slope protection and stabilization, filling/levelling (If required) of the allotted plot.

c. Site preparation works including cutting, clearing, transporting and disposal of bushes and other vegetation, roots.

d. Containerized Battery Storage System foundations

e. Internal/Approach roads

f. Extension of road up to existing approach road

g. Storm water drainage

h. Rainwater harvesting ponds (*if applicable*)

i. Plant fencing and gates

j. 132kV conductor with Gantry structure (for nallah crossing)

k. Vehicle Parking area

l. Cable trenches / Cable trays

m. Main Control Room

n. Grid Substation Control Room

o. Inverter control station
p. Inverter Duty Transformer foundations
q. Power Transformer foundations
r. Labour colonies, fabrication, storage, etc.
s. All Misc. foundations / civil & structural works.
t. Any other Miscellaneous civil works as required for completion of the Plant. The scope of work covers design, engineering, supply of all materials, fabrication / assembly and testing at works, packing / dispatch and transportation to Site with transit insurance for all Substation structures covering the following:
a. Towers and gantry girders in the Substation
b. Equipment supporting structures for all Substation equipment
c. Chain link fencing around the Substation and access gates
d. Foundation bolts

6.2.3 The scope of work shall also cover design, engineering and construction of the following:
a. All foundations for towers/structures
b. All foundations equipment foundations
c. Minor modification if any in Substation control building
d. Roads & drains
e. Cable trenches
f. Hume pipes / ducts for road crossing
g. Crushed stone paving within the Substation area

6.2.4 Preparation of drawings and design calculations, single line diagram, electrical layout, etc. for detailed engineering.

6.2.5 Necessary test and survey required for design of Plant is also in the scope of the bidder.

6.2.6 Any other equipment / items / civil and structural works, which is not specifically mentioned in the specification, but which are required for successful erection, testing, commissioning and satisfactory operation and maintenance of the Plant in all respects consistent with the best engineering practices are deemed to be included in the scope.

6.2.7 The items and respective quantities indicated in the BOQ therein are only indicative. Bidder shall include other items not specially indicated in the BOQ but are required for the successful execution of the contract. Detailed Bill of Quantities is listed in Annexure B.

6.2.8 Contractor shall make necessary arrangements for storing of equipment within the allocated plot only and security arrangement of storage yard/Shed shall be Contractor responsibility. Owner shall not be responsible for any theft/stolen property.

### 6.3 Scope of Service

6.3.1 Preservation, transportation, Unloading and storage of all equipment and materials at Site.

6.3.2 Erection, testing and commissioning of the complete Plant, 132kV pooling substation, 132kV bay extension including civil & structural works.

6.3.3 Bidder shall submit detailed Master Deliverable List (MDL) for approval of Owner with ten (10) days from Letter of Award. The MDL shall list all the Drawings & Documents envisaged for submission/ approval from the Owner and shall also have all the required information like drawing number (both vendor and Owner's drawing number), title, scheduled date of submission, actual date of submission and approval. The category of approval shall be decided mutually between Bidder and the Owner at the time of finalization of the MDL which shall be the basis for drawing & document approval process during project execution.

6.3.4 Preparation and submission of drawings / documents in soft (including editable and native source file) and hard form as per drawing / documentation submission schedule for getting approval from Owner.

6.3.5 As per MDL all the drawing / documents which is approved / issued for construction / manufacturing in soft forms shall be submitted in Four (04) set of hardcopies.

6.3.6 Battery sizing calculation including year on year energy dispatch.

6.3.7 Submission of Quality Plans / installation manuals / maintenance manuals / recommendation of OEM for various works and getting them approved by Owner.

6.3.8 Submission of progress report and timely adherence to the project timeline (which includes all coordination with various vendor for technical details/data interfacing and external agency/regulatory office coordination)

6.3.9 Participation in project review / technical co-ordination meetings.

6.3.10 All necessary and overall co-ordination with other vendors / Vendors on Site for erection, testing and commissioning of equipment and accessories/ internal & external agencies.

6.3.11 Pre-assembly, (if any), testing, pre-commissioning and commissioning and putting into satisfactory operation all the equipment including successful completion of initial operation.

6.3.12 Arrangement of all necessary clearances and approval by CEIG.

6.3.13 Preparation and submission of all as-built drawings in soft and hard copies (04) four set.

6.3.14 Obtaining Owner's approval and written acceptance of satisfactory performance.

6.3.15 Collection of all Site related data.

6.3.16 Soil investigation including electrical soil resistivity measurements.

6.3.17 The scope of supply shall also include the following:

a. First fill of consumables and Spare parts required for successful commissioning. Bidder shall submit the list of the spare parts required for successful commissioning of the Plant.
b. One time supply of Mandatory Spares as mentioned in Annexure-D.
c. Consumables, Spares, and Special tools & tackles for operation & maintenance (O&M) as required for successful operations and maintenance as listed in other volume/Clauses of this specification.
d. All required AMC support as described in Technical Specification for Operation and Maintenance Services shall be referred.

# 7. Terminal Points

7.1.1 132kV kV bay extension feeder to 132kV bus of existing grid substation with suitable hardware and accessories.

7.1.2 Fiber optic cable or OPGW laying from Plant to 132 kV pooling substation and termination up to fibre optic distribution frame including patch cord, use of conduits, lugging, glanding, splicing, ferrule, tags, etc. as required for complete installation for SCADA communication with control and monitoring system. Complete EMS & SCADA at Plant end is in the scope of the bidder.

7.1.3 Connection of Plant Road to the existing approach road.

7.1.4 Complete Plant is in the scope of the bidder.

7.1.5 Auxiliary supply for 132kV Substation from existing auxiliary system

7.1.6 Cable trays of existing Substation for control room interface.

7.1.7 Plant SCADA interfacing with existing SCADA

7.1.8 132kV extended Bay Control Relay panel interfacing with existing SCADA / evaluation PC. Also,

7.1.9 Multifunction metering interfacing with existing SCADA

7.1.10 Energy meter interfacing with existing SCADA/evaluation PC

# 8. Exclusions

8.1.1 The following items of work are specifically excluded from the scope of the specifications:

a. Auxiliary power source(415V) for 132kV Bay equipment at Kukurmara (Mirza) substation shall be provided by Owner. Owner shall only allow tapping at secondary side of station transformer. However, supply/installation/erection of ACDB, UPS/DC charger and battery & laying of cables with all required works shall be in bidder's scope only.

b. Land for BESS power Plant

# 9. Spares

## 9.1 Mandatory Spares

9.1.1 Bidder shall provide one time supply of the mandatory spares after commissioning of the system as listed in Annexure D.

## 9.2 Erection and Commissioning Spares

9.2.1 The Bidder shall also supply erection & commissioning spares along with equipment as per bidder's experience, for replacement of damaged or unserviceable ones during the execution of the Project at Site, to avoid delay in the project schedule. This shall form part of the main equipment supply and a separate list for the same shall be furnished along with bid. The Owner reserves the right to retain the unutilized commissioning spares. The left-over spare parts under this category if any, after successful commissioning shall be handed over to the Owner at no extra expense. The Owner reserves the right to retain the unutilized commissioning spares.

9.2.2 O&M spares, Mandatory Spares and special tools & tackles offered by the bidder shall not be used during the commissioning of the equipment. Any spares, special tools and tackles required for commissioning purpose shall be in the scope of the bidder. The bidder shall submit the list of commissioning spares based on his experience.

9.2.3 The Erection and Commissioning spares list shall be submitted by the bidder in similar format as mentioned in Annexure D.

## 9.3 Recommended Spare Parts

9.3.1 Bidder shall furnish the list of recommended spare parts for three years trouble free operation in its Price Bid. The price shall remain firm up to Twenty-four (24) months from the date of bid submission or as mentioned in the Tender enquiry.

9.3.2 All the spares supplied shall be strictly interchangeable with the parts for which they are intended to replace and are to be tested and packed for long storage under the climatic conditions prevailing at the project location.

9.3.3 The Recommended spares list shall be submitted by the bidder in the format as provided in Annexure G.

## 9.4 Consumables

9.4.1 Supply of all consumables required for erection & commissioning and performance test is included in the scope and same shall be supplied by Bidder. Bidder to provide the list for the same in line with the format attached at Annexure D.

9.4.2 In case of imported oils lubricants and other consumables the Contractor shall identify the indigenous equivalents to arrange subsequent fills. Preference should be given to indigenous oil and lubricants during first filling itself.

9.4.3 Consumables during the Operational Phase shall also be under Bidder's scope.

# 10. Special Maintenance Tools and Tackles

10.1.1 Special tools and tackle required for Operation, Maintenance, Inspection and Repair shall be supplied, neatly packed complete with operating instructions. These shall not be used for erection/ commissioning purposes by the Bidder and shall be in unused and new condition, when they are handed over to the Owner.

10.1.2 Bidder shall supply the Special tools and tackles required for this system as listed in Annexure E.

10.1.3 Bidder shall include Special tools and tackle not specified in the Annexure E but required for the successful operation and maintenance of the Plant.

# 11. Approved Vendors

11.1.1 Approved Vendor list is furnished in Annexure-F of this technical specification.

# 12. Painting and Corrosion Protection

12.1.1 Painting all structures and equipment in accordance with the Owner's standard color-coding scheme is part of the bidder's scope of work. The painting must incorporate the finish paint application that is specified elsewhere in the Technical Specification.

12.1.2 Necessary finish paints including touch-up paints, if not applied at shop, should be supplied by the Bidder, in sealed containers for Site application.

12.1.3 Paint quality and finish must meet BIS standards or an authorized equivalent, and they must be appropriate for the Site's corrosive conditions. The color-coding scheme of the Owner must be provided during the detailed engineering stage.

12.1.4 Necessary finish paints including touch up paints, should be supplied by Bidder in sealed containers for Site application.

12.1.5 All support structures shall be hot dip galvanized. Thickness of galvanizing shall not be less than 610gm/sq.m. The galvanized surfaces shall consist of a continuous and uniformly thick coating firmly adhering to the steel surface. The finished surface shall be clean and smooth and free from defects.

12.1.6 For outdoor equipment, all enclosures shall be painted with epoxy based paint. Shade of paint shall be 631 (light grey) of IS 5. Final thickness of paint shall not be less than 80 microns. Painting shall be

carried out by approved process. Sufficient quantity of touch-up paint shall be furnished for application at Site.

12.1.7 All indoor equipment, panels and cabinets shall be pre-treated as per IS 6005 before being painted with epoxy based paint shade of paint shall be RAL 7032. Final thickness of paint shall not be less than 80 microns. Painting shall be carried out by approved process. Sufficient quantity of touch-up paint shall be furnished for application at Site

# 13. General Condition for Testing

13.1.1 The Bidder will provide the Owner with the reports from every type test specified elsewhere in this specification during detailed engineering. The type test should have been carried out within the last ten (10) years of the bid opening date, unless stated otherwise. 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.

13.1.2 Though, in the event that the Bidder is unable to submit the type test report(s) within the allotted time frame or if the type test report(s) are determined not to meet the specifications, the Bidder will conduct all tests required by this Contract at no additional expense to the Owner, either at a third-party lab or in the presence of the client or Owner's representative, and submit the reports for approval. According to the specification and applicable standards, all routine and acceptance testing must be completed at no additional expenses to the Owner.

13.1.3 The Bidder shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the plant and equipment and any part of the Facilities as are specified in the Contract.

13.1.4 No part of the Facilities or foundations shall be covered up on the Site without the Bidder carrying out any test and/or inspection required under the Contract. The Bidder shall give a reasonable notice to the Engineer In-Charge whenever any such parts of the Facilities or foundations are ready or about to be ready for test and/or inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.

13.1.5 Tests shall only be conducted with the aid and in accordance with test specification(s) and standards clearly identified as approved for use by the Owner, and, where applicable, employ test instruments of suitable quality calibrated to manufacturer's recommendations by a reputable agency within the previous six (6) months.

13.1.6 In addition to the specifications already provided for the Plant, the test specification shall be supplied with the test results, and it shall include at least:

13.1.7 Indicate the model

13.1.8 Indicate the time of the tests

13.1.9 Indicate the standards followed

13.1.10 Cover a substantial percentage of the supported features of the equipment

13.1.11 Indicate who carried it out

13.1.12 The factory acceptance tests shall be carried out by the manufacturer in accordance with the requirements of IEC & UL.

# 14. Quality Assurance & Inspection

14.1.1 Equipment offered shall be of type tested and proven type. In case type test reports are not found to be meeting the specification requirements, Bidder shall conduct, free of charge to the Owner, all such type tests according to the relevant standards.

14.1.2 The Bidder shall adopt suitable quality assurance program to ensure that the equipment and services under the scope of contract whether manufactured or performed within the vendor's works or at it's sub-vendor's premises or at the Owner's Site or at any other place of work are in accordance with the specification. Such program shall be outlined by the vendor and shall be finally accepted by the Owner / authorized representative after discussion. The quality assurance (QA) program shall be generally in line with ISO 9001: 2015.

14.1.3 All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all stages, as per a comprehensive QA program. It is the Bidder's responsibility to draw up and implement such program duly approved by the Owner.

14.1.4 Manufacturing quality plan (MQP) shall detail out for all the components and equipment, various tests / inspections to be carried out as per the requirements of this specification and standards mentioned therein, quality practices and procedures followed by vendor's / sub-vendor's quality control organization, the relevant reference documents, acceptance norms etc. during all stages of manufacturing including raw material procurement, in-process manufacturing, assembly and final testing / performance testing. The quality plans shall be submitted to Owner in soft form for review and comment. Hard copies of final quality plans shall be submitted for stamping and approval in addition to soft copies.

14.1.5 Field quality plan (FQP) shall detail out for all the equipment, the quality practices, procedures etc. to be followed by the vendor's 'Site quality control organization', during various stages of Site activities starting from receipt of materials / equipment at Site.

14.1.6 FQP shall be submitted within 45 days after receiving of LOA.

14.1.7 The Bidder shall carry out inspection and testing of components and equipment during manufacture at it's works, at his sub-vendor's works and at Site to ensure compliance with the specification, quality and conformance to functional and performance requirements.

14.1.8 The Bidder shall carry out all tests / inspections required to establish that the items / equipment conform to the requirements of the specification and relevant codes / standards specified in the specification, in addition to carrying out tests as per the approved quality plans. Quality audit / surveillance / approval of the test results and inspection and acceptance of material will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service. Also, they shall not limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the materials / equipment supplied to relevant specification, standards, data sheet, drawing etc.

14.1.9 The sub-vendor whose equipment are offered shall have designed, manufactured, tested and supplied the same for the specified system voltage and which are in satisfactory operation for at least five (5) years as on date of bid opening.

14.1.10 For all spares and replacement items, the quality requirements for the supply of main equipment shall be applicable.

14.1.11 Repair / rectification procedures required, if any, shall be subject to the approval of the Owner / authorized inspection agency.

14.1.12 Before dispatching structures from fabrication shop, prototype of each structure shall be shop assembled and checked for fabrication tolerance. Also, if desired by the Owner, the same shall be presented for inspection and testing at an approved testing facility.

14.1.13 Whenever the Bidder is ready to carry out any such test and/or inspection, the Bidder shall give a seven (7) days advance notice of such test and/or inspection and of the place and time thereof to the Engineer In-Charge. The Bidder shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Engineer In-Charge (or their designated representatives) to attend the test and/or inspection.

14.1.14 The Bidder shall provide the Owner/Engineer In-Charge with a certified report of the results of any such test and/or inspection. If the Owner or Engineer In-Charge (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Bidder may proceed with the test and/or inspection in the absence of such persons and may provide the Engineer In-Charge with a certified report of the results thereof.

14.1.15 The Bidder shall provide the Owner with the technical details of the equipment/works to be inspected, however such inspection shall in no way exonerate the Bidder from any of his obligations. The Bidder, if requested by the Owner, shall arrange inspections before installation of any equipment which has been delivered to the Construction Site partly assembled.

# 15. Completion of Facility and Performance Guarantee Parameters

## 15.1 Pre-commissioning and Commissioning Test

15.1.1 As soon as the Facility or any part thereof has, in the opinion of the Bidder, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facility, the Bidder shall so notify the Owner in writing.

15.1.2 As soon as reasonably practicable the Bidder shall commence Pre-commissioning of the Facility or the relevant part thereof in preparation for Commissioning of facility.

15.1.3 After successfully running the pre-commissioning tests. Bidder shall submit the commissioning test procedure and schedule for Owner approval.

15.1.4 Upon successful Completion of the commissioning tests and acceptance of the same by the Owner, the Bidder shall initiate the trial run of the Plant on prior information to Owner in writing.

## 15.2 Trial Operation

15.2.1 The Bidder shall successfully complete the visual inspection, mechanical / electrical / functional testing, pre-commissioning and commissioning tests of the entire 25MW/100MWh BESS Power Plant. After successful completion of Commissioning Tests of the Facility, Bidder shall notify the same to Owner and seek approval of Owner for proceeding with integrated operation of the Facility i.e. the Trial Operation, which shall be conducted at Site by the Bidder in presence of Owner.

15.2.2 Before the Trial Operation, the Bidder is responsible for cleaning all the equipment and the project Site. Together with the power evacuation system, the Bidder will start up and commission the Plant in a planned, coordinated order.

15.2.3 Trial Operation shall commence within one month from the date of completion of commissioning tests as per scope of work and services. Trial operation shall run for seven (07) consecutive days in which functionality of all Plant components, as integrated unit, shall be demonstrated.

15.2.4 On prior information and approval by Owner, bidder shall schedule the trial run.

15.2.5 During trial run, Plant shall perform trouble free operation.

15.2.6 After successful completion of Trial Operation of the Facility and signing of test protocols, Bidder shall notify the Owner about completion of Facility. After satisfactory completion of Facility, the Owner shall issue acceptance certificate to the Contractor (the "Completion of Facility" or the "Commissioning of Facility").

### 15.3 Commercial Operation Date (COD)

Commercial Operation Date (COD) of the project shall be after the successful completion of the trial run as declared by the Owner.

### 15.4 Performance Guarantee (PG) parameters

15.4.1 All the equipment shall be guaranteed to meet performance requirements required under this specification and rectification shall be carried out until satisfactory results are obtained. The Owner reserves the right to reject the equipment if the performance values fall short of those indicated in the schedule of technical data sheets.

15.4.2 The guaranteed performance figures of the equipment/system shall be proved by the Contractor during the performance guarantee tests. Should the results of these tests show any decrease from the guaranteed values the Contractor shall modify the equipment as required to enable it to meet the guarantees. In such case, Performance and Guarantee Tests shall be repeated within one month, from the date the equipment is ready for retest and all expense for modifications including labour, materials and expense of additional testing to prove that the equipment meets the guarantees shall be borne by the Bidder.

15.4.3 In case of such option of rejection being exercised by the Bidder, Bidder shall replace the equipment which shall meet the guaranteed values. The Contractor shall furnish a detailed performance test procedure and a Programme well in advance for approval by the Owner.

15.4.4 The bidder shall meet the Plant Performance Guarantee parameters as specified below:

a) Bidder shall guarantee a minimum AC to AC RTE of ≥86% with auxiliary consumption.

b) Bidder shall guarantee a minimum Plant availability of 95%.

c) During Operational Phase, Taking into consideration capacity degradation, the minimum dispatchable energy for each cycle to be made available at the Interconnecting Point (IP) by the Contractor at the given year shall be as follows:

| **Years** | **Minimum Dispatchable Energy for each cycle at the start of Year @ IP** | **Minimum Dispatchable Energy for each cycle at the end of Year @ IP** |
|---|---|---|
| | **as % of the Guaranteed energy of each cycle (GEEC) @ IP i.e. 100MWh** | |
| 1. | 100.0% | 97.5% |
| 2. | 97.5% | 95.0% |
| 3. | 95.0% | 92.5% |

| Years | Minimum Dispatchable Energy for each cycle at the start of Year @ IP | Minimum Dispatchable Energy for each cycle at the end of Year @ IP |
|---|---|---|
| | as % of the Guaranteed energy of each cycle (GEEC) @ IP i.e. 100MWh | |
| 4. | 92.5% | 90.0% |
| 5. | 90.0% | 87.5% |
| 6. | 87.5% | 85.0% |
| 7. | 85.0% | 82.5% |
| 8. | 82.5% | 80.0% |
| 9. | 80.0% | 77.5% |
| 10. | 77.5% | 75.0% |
| 11. | 75.0% | 72.5% |
| 12. | 72.5.% | 70.0% |

15.4.5 During PG Test Period, MWh Capacity Installed Testing - Bidders shall demonstrate the MWh capacity at the point of interaction / Grid Point as per mutually agreed procedure during detailed engineering. Bidders shall augment the battery capacity of Containerized Battery Storage System at its own risk and expense in case MWh capacity installed is less than required value, within 15 days of demonstration made, failing which value estimated by Owner or OEM for such augmentation of Containerized Battery Storage System shall be recovered from the Performance Bank Guarantee.

**15.5 PG test procedure**

15.5.1 Consecutive one month/30 days period for conducting performance guarantee test shall be chosen on the discretion of Owner. PG test may be concluded as early as possible after trial run.

15.5.2 It is to be noted that at the end of Project life (12 years from COD), the above PG test procedure is to be repeated as Performance Test at end of project life.

15.5.3 Bidder shall submit the Type Test report to Owner for approval as mentioned in this specification.

15.5.4 Type Test carried out by Bidder / OEM on equipment similar to proposed to be supplied under this proposal / Contract, within last ten (10) years from the date of bid opening at an independent laboratory are accepted.

15.5.5 However, cases where Type Test on equipment is not carried out within applicable period or not meeting the specification requirements, bidder shall conduct all such tests at no additional expense

to Owner at third party lab and in presence of Owner representative and submit the reports for approval.

15.5.6 Bidder shall carry out all acceptance and routine tests as per specification and relevant standards wherein charges for these shall be deemed to be included in the bidder's proposal / offer.

15.5.7 Bidder shall submit the FAT and SAT Test Plan for Owner review and approval during detailed engineering.

15.5.8 After successfully erected and commissioned, PG test (30 days) shall be initiated on prior information to Owner.

15.5.9 All Plant equipment shall also demonstrate the name plate power continuously for one hour as per Owner requirement on daily basis.

15.5.10 Performance Guarantee (PG) test shall be carried out as mentioned below.

a) AC to AC Round Trip Efficiency (RtE) including Auxiliary Power Consumption
b) Procedure shall be approved during detailed engineering
c) Test Period – One (01) Month
d) Incoming & Outgoing (Import & Export energy) energy at interconnecting point will be measured using Energy Meters having accuracy class of 0.2s.

15.5.11 Bidder shall guarantee a minimum AC to AC RtE of ≥86% including auxiliary consumptions on monthly basis upto 132kV metering point over the project life is to be guaranteed by Bidder which includes auxiliary power requirement for Plant.

15.5.12 A Penalty on additional losses incurred in Plant above 14% shall be recovered from bidder. For penalty rate/ calculation shall be referred in other clauses/ sections of this tender document.

15.5.13 All equipment, tools & Tackles, instruments measuring devices required for successful conductance of PG test shall be provided by bidder.

15.5.14 The Bidder shall furnish all necessary special equipment, instrumentation tools, tackles, and labour at no expense in order for the Performance Guarantee Test (PG Test) to be successfully completed. The instrumentation's accuracy class must match the applicable document clause. This test shall be binding on all the parties of the Contract to determine compliance of the equipment with the functional guarantee.

15.5.15 PG test as follows:

a. PG Test Procedure shall be submitted during the bid.
b. Any consecutive 30 days period for conducting performance guarantee test shall be chosen on the discretion of the Owner.
c. The Bidder shall provide the data in requisite formats (specified elsewhere in the document/shall be confirmed during detail engineering) to Owner. Owner/ Owner's Representative shall vet the data for any discrepancies and systemic errors. If and once the 7-

day trial run is passed, the 30-day PG test will commence after communication from Owner in this regard.

d. The test shall be repeated in case of outage of following equipment for more than 7 days:
   1. Inverter transformer
   2. PCS
   3. HT switchgear of anyone incoming feeder

e. In the event that the bidder is unable to successfully complete the PG test within these thirty (30) days, Bidder will be granted another opportunity. In that scenario, after making the required adjustments or replacements, the PG test procedures must be performed once more in the same manner. In case the Bidder fails to achieve even trial run, the further action shall be taken as per the provisions of contract.

f. On successful completion of trial run, PG test and acceptance from Owner, the project will be accepted by the Owner.

g. Energy Input and Output and RtE shall be calculated as the average of valid 15-minute time blocks for the 30-day duration. If the Bidder is not able to demonstrate PG test during these this period, they will be given one more chance to demonstrate the PG test after incorporation of suitable corrective measures. In that case the steps for PG test shall be repeated as above.

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

1. Battery energy storage system
2. Power transformer
3. HT Switchgear of outgoing feeder
4. BMS, EMS and data logger combined.

**Raw Data Formats and Reports**

Bidder shall submit to Owner raw data from the Plant EMS on a daily basis. The Report shall be containing the signature of both representatives (Owner & Bidder).

# 16. Delivery Schedule

16.1.1 The following shall be the schedule for completion of work for this package:

| WORK | SCHEDULE |
|---|---|

| | |
|---|---|
| Design, engineering, manufacture, testing, transport and delivery at Site, loading, unloading, handling at Site, storage, construction, erection, testing, commissioning and trial run of overall system for 25MW/100MWh BESS Power Plant | **12 Months** from the date of LOI / LOA. |
| O&M of the Plant including the power evacuation system up to including 132kV Bay at 132kV grid Substation from the date of Taking-Over of Facility by Owner. | **12 Years** from the date of Taking-Over of Facility by Owner **.** |

### 16.2 Program of Performance

16.2.1 Within Fifteen (15) days after the date of notification of award, the Bidder shall prepare and submit to the Owner a detailed program of performance of the Contract, made in the form of the critical path method (CPM), the PERT network, MS-Project or other internationally used programme and showing the sequence in which it proposes to design, manufacture, transport, assemble, install and pre-commission the Facilities, as well as the date by which the Bidder reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Bidder to execute the Contract in accordance with the program and to achieve Completion, Commissioning and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Bidder shall accord with the Time Schedule included in the Contract and any other dates and periods specified in the Contract. The Bidder shall update and revise the program as and when appropriate or when required by the Owner, but without modification in the Times for Completion given and any extension granted and shall submit all such revisions to the Owner.

### 16.3 Progress Report

16.3.1 The Bidder shall monitor progress of all the activities and supply a progress report to the Owner every month. The progress report shall be in a form acceptable to the Owner and shall indicate:

a. percentage completion achieved compared with the planned percentage completion for each activity; and

b. where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

## 17. Statutory Compliance

17.1.1 The Bidder shall obtain and pay for all permits, licenses and statutory approvals from local authorities for completion of work. Original copies of these approvals shall be delivered to the Owner or his authorized representative and will become property of the Owner. It must be understood and agreed

that such factors have properly been understood and considered while submitting the bid. No claim whatsoever will be entertained by the Owner. Neither any change in the time schedule of the Contract nor any financial adjustments arising thereof shall be permitted by the Owner.

17.1.2 Bidder shall be responsible for facilitating statutory compliance for the entire scope of work while applying for overall compliance up to and including 132kV bay extension (POI).

17.1.3 Bidder shall comply all provisions and amendments thereafter of

a) Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022 *(If applicable)*

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 *(If applicable)*

c) CEA (Technical Standards for Connectivity to Grid) Regulation,2007

d) CEA (Technical Standards for construction of Electrical Plants and Electrical Lines) Regulation,2022

e) CEA (Grid Standard) Regulation,2010

f) CEA (safety requirements for construction, operation and maintenance of Electrical Plants and Electrical Lines) Regulations,2011

g) CEA (Measures relating to Safety and Electrical Supply) Regulations,2010

h) CEA (Installation and Operation of Meters) Regulations 2006

i) Indian Electricity Grid Code Regulation,2010

j) CEA (Technical standards for communication system in Power system operations) Regulation 2020

k) CERC (Communication System for Inter State transmission of Electricity) Regulations 2017 *(If applicable)*

l) 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.

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

n) MNRE guidelines/OM/Advisory/Clarifications

o) AERC, Procurement and dispatch of battery energy storage system guidelines, 2024

And any other applicable standard/regulations

17.1.4 Bidder must comply with all the statutory requirements including BESS Power Plant, and equipment safety standards. The Plant should fully meet the Grid Connectivity Regulation as per Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 with all latest amendments

17.1.5 The following clearances shall be arranged by Bidder. However, necessary documentations/applications shall be in the name of Owner.

1. Water Requirement during construction

2. Power Requirement during construction
3. SPCB clearance
4. MNRE clearance
5. Chief Electrical Inspector clearance

# 18. Grid Compliance

18.1.1 Bidder shall also submit detailed grid compliance study with Power Plant Controller as per CEA technical standards to grid connectivity standard to grid connectivity and latest guideline of NERLDC first charging clearance. In this regard, Bidder to submit Generic model data of Inverters and PPC suitable for use in PSS/E software available at NERLDC and Encrypted user-defined model (UDM) of Inverter and PPC in PSS/E software (*.dll files) as applicable. In case any Site testing required for grid compliance as per NERLDC, it shall also be conducted.

18.1.2 Bidder shall carry out detailed consolidated Grid compliance study at least 12 months before the scheduled First Charging date of the Plant and ensure availability of PSSE and PSCAD model of Inverter/PCS and PPC during selection of respective Manufacturer. Bidder shall follow the "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". Owner shall provide the data regarding BoS items/Grid for completion of Grid compliance study by Bidder.

18.1.3 Bidder shall provide all data and applicable study/simulation reports as per 'Procedure for Integration of Plant those are regional entities" for submission to NERLDC for first time charging clearances (as required by regulatory/statutory body). It may be emphasized for clarity that the following information and simulation report are included in the above procedure.

18.1.4 Dynamic Model

a) Copy of dynamic model as per the connectivity

b) Updated dynamic model 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) and Short circuit study/Load flow study/harmonics analysis results.

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

18.1.6 Power Quality Simulation report of the complete Plant including Harmonics, DC currents and Flicker at POI.

18.1.7 Final Updated dynamic model after COD of the entire station (within one month of COD declaration) after Site verification and Site testing if required.

18.1.8 Bidder shall update themselves latest requirement for technical data requirement/PSSE/PSCAD Model as per NERLDC/CTU. The minimum data required for IBR (Inverter Based Resources) to be submitted to for Grid study. Bidder shall submit above documents within 3 months from LoA. However, the final requirement or any other requirement shall be intimated during detail engineering in due course of interaction with NERLDC.

18.1.9 During Grid compliance study by Bidder, shall provide all data and parameters related to BoS components (not under Bidder's scope) for carryout the steady state/Dynamic/Power quality study upto point of respective Substation. In case of non-compliance of Power Quality, Bidder to install necessary power quality mitigation equipment to limit these values at POI. Bidder shall also carry out Power Quality Measurement yearly once during Operational Phase and install Power quality mitigation equipment if required.

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

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

# 19. Operation and Maintenance (O&M)

## 19.1 General Requirements

19.1.1 The Operation and Maintenance (O&M) Services for Plant shall begin from Taking-Over of Facility by Owner, and shall be comprising of two parts:

a. Comprehensive O&M Services for the Containerized Battery Storage System.

b. Non-Comprehensive O&M Services for the complete Plant (except Containerized Battery Storage System), (BOS).

## 19.2 Comprehensive O&M for the Containerized Battery Storage System

19.2.1 The Contractor shall be responsible for the complete i.e. Comprehensive Operation and Maintenance of Containerized Battery Storage System, including but not limited to, Corrective Maintenance, Preventive Maintenance, spares, Consumables, Warranties, OEM/Vendor Co-ordination, etc. for Term of the Contract.

**Note:** *In case of the PCS being integrated within the Containerized Battery Storage System, the same shall be included in the comprehensive O&M scope.*

## 19.3 Non-Comprehensive O&M for the Balance of System

19.3.1 The Contractor shall be responsible for, inter-alia, Corrective Maintenance, Preventive Maintenance, Consumables, Warranties, Vendor Coordination, etc. of all Balance of System (i.e. except containerized Battery Storage System) for Term of the Contract.

19.3.2 In case of standalone PCS, the PCS shall be included in Non-Comprehensive O&M scope of work.

19.3.3 All spares (indicated in the recommended spare list submitted by the Contractor) for the Corrective maintenances shall be in the scope of the Owner.

19.3.4 Contractor shall provide the annual forecast of recommended spares consumption and annual budgetary plan for the same on time-to-time basis to the Owner. The Inventory optimization of the spares shall also be in the scope of the Contractor. Any and all spares not listed in the scope of the Owner as per the contract, shall be borne by the Contractor.

**For detailed scope of O&M service, please refer the Detailed Technical Specifications for Operation and Maintenance Services attached as Annexure-2.2 to Contract for Supply, Installation, Commissioning and Operation & Maintenance of 25MW/100MWh BESS Power Plant.**

# 20. Handing Over and Taking Over (HOTO)

20.1.1 On successful completion of Operation and Maintenance period, the Operational Plant(s) and equipment's will be handed over to the Owner in completely healthy and safe condition without any pending defect. During the handing over of the Plant(s), the Bidder shall submit the following to consider final closer of contract.

a. All as-built Drawings
b. Technical document with detailed specification, test results for all deliverable items, Operation & Maintenance and Safety Instruction Manual and other information about the project.
c. Plant performance approved report by Owner for the entire contractual Operational Phase along with complete maintenance record
d. Bill of Material (BOM)
e. Handover the tools and tackles at the end of the contract period to the Owner in good condition.
f. Handover unused consumables of good quality to the Owner at the end of the contract period or as advised by the Owner.

20.1.2 After Operational Phase, Owner may at its discretion decide to extend the existing O&M contract on mutually acceptable terms & conditions or undertake the O&M of the Plant on its own.

# 21. Training

21.1.1 Bidder shall be responsible for providing training to Owner's personnel on offered systems at Bidder's Works/Bidder's Associate's Work/Site. It shall include training operators in the use of system, in operation and maintenance of the equipment and usage of software to the extent that the Owner's personnel can make maintenance of the systems.

21.1.2 The bidder shall provide training to the personnel of Owner for minimum of 45 man-days at its works and at Site for erection, testing, commissioning and O&M at free of charge. If additional man-days are required at the time of training, bidder shall fulfil the requirement without any financial implication.

21.1.3 The bidder shall provide a training of suitable duration on all supplied materials especially Containerized Battery Storage System, BMS, Transformer, EMS, SCADA, Battery Chargers, UPS, Inverters, ICOG equipment, converters, servers, special tools, testing kits etc. for Owner's personnel to provide working knowledge of the equipment, operation and diagnostic tools, supervision and monitoring using local craft terminal. The training may be provided by the Bidder or its sub-vendor at the Site itself, preferably during installation, and will include training materials and presentation equipment. No separate charges for training shall be payable to the Bidder.

21.1.4 Specialized training shall be provided to the persons operating the EMS and to the field support staff to ensure quick fault detection and restoration of the communication system. Training shall be provided to the maintenance persons on all communication equipment for its operation and maintenance.

# 22. Transportation

22.1.1 The Bidder shall at its own risk and expense transport all the Plant equipment and materials including Containerized Battery Storage System to the Site by the mode of transport that the Bidder judges most suitable under all the circumstances.

22.1.2 The Bidder shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Containerized Battery Storage System and Plant equipment to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Bidder in obtaining such approvals, if requested by the Bidder. The Bidder shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant equipment to the Site.

22.1.3 The Bidder has to comply with the provisions of carriage by Road Act 2007 Govt. of India and its rules and its further amendments (if any).

# ANNEXURE-A: Project Information

## 1. Background

1.1 The proposed project aims at providing 25MW/100MWh at interconnecting point, Containerized Battery Storage System and associated systems for the 400/220/132/33kV Kukurmara (Mirza) Grid Substation, Kamrup District, Assam. The major stakeholders in the project are as listed below,

1. APDCL- Assam Power Distribution Company Limited
2. OTPC- ONGC Tripura Power Company Limited
3. AEGCL- Assam Electricity Grid Corporation Limited
4. ADB- Asian Development Bank

1.2 New and Green Energy of Assam Limited (**"Owner")** intends to implement a 25MW/100MWh BESS Power Plant in Kukurmara (Mirza) Grid Substation, Sathikarpa, Assam ("**Plant**").

## 2. Project Details:

| | | |
|---|---|---|
| a) | Owner | New and Green Energy of Assam Limited (NGEAL) |
| b) | Owner's Engineer | Fichtner Consulting Engineers (India) Pvt. Ltd |
| c) | Project | 25MW/100MWh BESS Power Plant |
| d) | Site location | Kukurmara (Mirza) Grid Substation, Kamrup district, Sathikarpa Assam |
| e) | Site coordinates | 26.064° N, 91.551° E |
| f) | Available land area (Free issue) | 7000 Sq.m. |
| g) | Nearest airport | Guwahati |
| h) | Nearest railway station | Changsari |
| i) | Approach road | NH17 |
| j) | Distance to NH | 1km (approx.) |
| k) | Design ambient temperature for electrical equipment (except BESS and Inverter) | 50 degree C |
| l) | Relative humidity for design | 90% |
| m) | Basic design wind speed | 50 m/s |
| n) | Seismic Zone | Zone V |
| o) | Corrosion Category | C2 as per ISO14713 |

| | | |
|---|---|---|
| p) | Average Annual rainfall | 145.83 mm |
| q) | AC Low voltage system | 415 V (±) 10%, 3 phase, 4 wire solidly grounded system |
| r) | AC High Voltage System | 132 kV (±)10%, 3 phase, 3 wire system, solidly grounded system. |
| s) | AC control voltage | 240 V (±) 10%, 1 phase |
| t) | DC control voltage | 220V +10% to –15% |
| u) | Power frequency | 50 Hz (+) 3% to (-) 5% |
| v) | Short Circuit Levels | 33kV, 25kA for 1 sec<br>132kV, 40kA for 3 sec |
| w) | Creepage | 31 mm/kV |

# ANNEXURE-B: Bill of Quantities (BOQ)

| S.No. | Item Description | Unit | Quantity |
|---|---|---|---|
| **1** | **BESS** | | |
| 1.1 | Containerized battery storage System with BMS, Fire firefighting and protection system, with necessary auxiliary system | Nos | *DDE |
| **2** | **Balance of System** | | |
| 2.1 | Bi-directional PCS, with necessary auxiliary features | Nos | *DDE |
| 2.2 | BESS DC Cable, 1.5kV, Armoured, FRLS (from Battery to PCS) | Meter | *DDE |
| 2.3 | LT Power cable, 1.9/3.3kV, Armoured, FRLS (from PCS to IDT) | Meter | *DDE |
| 2.4 | 33kV, Inverter Duty Transformer, OCTC | Nos | *DDE |
| 2.6 | 33kV UG Cable, Al, Armoured, FRLS, XLPE Cable | Meter | *DDE |
| 2.7 | 33kV HT Switchgear, 25kA for 1sec | Set | 1 |
| 2.9 | Fire protection system and accessories | Lot | 1 |
| **3** | **Power evacuation & Bay extension** | | |
| 3.1 | 33/132kV Power Transformer, 24/30MVA (Minimum, shall be decided during detail engineering) ONAN/ONAF, YNyn02, OLTC+10% TO -10% in steps of 1.25% | Nos | 1 |
| 3.4 | Surge arrestor, 120kV, 10kA, CL III | Nos | 9 |
| 3.5 | 145kV Isolator 2E/S, 1600A, 40kA, 3sec | Set | 5 |
| 3.6 | 145kV, 1600A, 40kA, 3sec, SF6 Gas Insulated, circuit breaker with supporting structure & other accessories | Set | 2 |
| 3.7 | CT, 145kV, Five core, 300/1-1-1-1-1A - To CRP BAY<br>Core: 1 - Line Protection, Core: 2 - Protection, Core:3 - Metering, Core:4 - Spare, Core:5 - Transformer Protection | Set | 1 |
| 3.8 | CVT, Three Core, Core:1 To MFM, Core:2 Protection, Core:3 Spare | Set | 2 |
| 3.9 | Tariff and Metering Arrangement including CT & PT Specification shall be as per AEGCL<br>145kV, 250/1A, CL-0.2S, 15VA<br>WDG MET., 132kV/√3/110V/√3, CL-0.2, 50VA | Set | 1 |
| 3.10 | 132kV UG cable, Al, Armoured, XLPE cable (Gantry to 132kV Bay @GSS) | Meter | *DDE |
| 3.11 | 132kV conductor, Moose Conductor | Meter | *DDE |
| 3.12 | Gantry Steel structure (Galvanized) | Ton | *DDE |

| S.No. | Item Description | Unit | Quantity |
|---|---|---|---|
| 3.13 | 132kV Outdoor type Cable Termination Kit, XLPE Insulated Power Cable | Lot | 1 |
| 3.14 | Auxiliary power systems | Lot | 1 |
| 3.15 | Control and Relay panel with numerical relay with BCU- IEC 61850 compliant | Nos | 2 |
| 3.16 | Power Quality Meter (PQM) | Nos | 1 |
| 3.17 | Phasor Monitoring Unit (PMU) | Nos | 1 |
| 3.18 | Bus post insulators | Lot | 1 |
| 3.19 | Bay Marshalling Kiosk | Lot | 1 |
| 3.20 | CT Junction Box | Lot | 1 |
| 3.21 | CVT Junction Box | Lot | 1 |
| 3.22 | Conductors & Long rod Insulators | Lot | 1 |
| 3.23 | FOTE panel and accessories | Lot | 1 |
| 3.24 | Substation Auxiliaries | Lot | 1 |
| **4** | **Control and Instrumentation** | | |
| 4.1 | SCADA with EMS | Lot | 1 |
| 4.2 | Fire protection system | Lot | 1 |
| 4.3 | CCTV system | lot | 1 |
| 4.5 | Telephone cables | Lot | 1 |
| **5** | **Auxiliary system (transformer, lighting, UPS etc.)** | | |
| 5.1 | 33/0.415 kV Auxiliary Transformer at Plant | Nos | 1 |
| 5.2 | 415V AC distribution boards - Control room | Lot | 1 |
| 5.3 | 415V lighting distribution boards - Control room | Lot | 1 |
| 5.4 | 220V Valve regulated Lead Acid (VRLA) Batteries (Cell voltage of 2.0V),(2*100%) | Lot | 1 |
| 5.5 | 220V Float Cum Boost Chargers (FCBC),(2*100%) | Lot | 1 |
| 5.6 | 220V DCDB, (2*100%) | Lot | 1 |
| 5.7 | Clamps and Connectors | Lot | *DDE |
| 5.8 | Illumination System | Lot | *DDE |
| **6** | **Civil and Auxiliary** | | |
| 6.1 | Control Building @BESS Power Plant | Sq.m. | 220 |
| 6.2 | Control Building @GSS | Sq.m. | 18 |
| 6.3 | Inverter control station | Sq.m. | *DDE |

| S.No. | Item Description | Unit | Quantity |
|---|---|---|---|
| 6.4 | HVAC for Control Buildings | Lot | *DDE |
| 6.5 | Spare and Consumables | Lot | 1 |
| 6.6 | Roads and drains | Meter | *DDE |
| 6.7 | Land refilling (Land development) | Cu.m. | 15328.34 |
| 7 | Miscellaneous items including Clamps & connectors, Danger plates, tower earthing accessories, Cabling accessories such as cable glands, lug, clamps, pipes, conduits, trefoil clamps, and other accessories etc. | Lot | 1 |

Note:

*DDE: During Detail Engineering (To be finalised during detail engineering) by the bidder and approved by Owner.

# ANNEXURE-C: Benchmarking Report

1. 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.
    a) Fault current characteristics (voltage -current) of Inverter during fault condition. The Reactive power response of the Inverter in case of fault condition, should be faster to support Grid or as per Grid operator.
    b) Current and voltage Waveform capture facility during LVRT/HVRT at Inverter output terminal during event and accessible to PPC. Availability of high-resolution data with pre fault/post fault time and automatic extraction of the above data into PPC subsequent to fault avoiding manual/OEM intervention.
    c) During LVRT and HVRT, the Inverter shall distribute its active and reactive capacity in such a way that first priority will be reactive power support as per voltage dip. The active current and overall current shall be limited as per the transient rated current limit of inverter. Inverters should be capable to support reactive current in case of asymmetrical (1 ph/2 ph) fault condition. Active and reactive power response shall be oscillation free.
    d) Inverter controller Setting facility from local as per CEA Regulation. The Inverter and its PSS/e and PSCAD model should have the tuneable parameters: FRT Voltage threshold, K factor, Proportional Gain, Integral Gain and Active and reactive power recovery gain during fault recovery duration etc. as recommended by grid Operator.
    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.
    h) A separate benchmarking report /simulation comparison is required for SCR=5 and 3 for PSS/E and PSCAD software and furnishing the Parameters for the same. Provision to change setting in inverter according to various operating condition at Site is to be provided.
    i) Following shall be part of submission-
        - Comparison of field test measurement with simulation results numerical values & as well as graphical values for following points.

            1. Power Quality (only in EMT).

2. Active power set change (RMS & EMT)
3. Reactive power control- V control, pf & Q control (RMS & EMT)
4. IBR capability demonstration (RMS & EMT)
5. LVRT (RMS & EMT)
6. HVRT (RMS & EMT)
7. Frequency response (RMS & EMT)

- Final simulation model parameters like Generator model, Electrical control model, drive train model etc. shall be included in benchmarking report. (RMS & EMT)
- Firmware version of IBR unit controller for which IBR unit got certified shall also be included in this report.
- Field test report documents shall be referenced in the benchmarking report.
- 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.
- 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).
- EMT model of IBR unit- flat run results for 100 seconds with simulation time step of 10us or greater shall be included for electrical parameters (P, Q, V, f) and speed. Further, model shall get initialised within 3 seconds & shall have snapshot capability.
- 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.
- Include a table having IBR controller setting, RMS & EMT model parameter for different control parameters as specified. (RMS & EMT).
- IBR unit model for PSS/E shall include .sav, .dyr, .py, .idv, .sld, .out files and PSCAD .pscx and other supporting files.
- Conclusion part include table for which models are benchmarked & whether the model replicates the actual. Error in simulation vs. actual shall be minimum to the extent possible, however it shall not be more than 5%.

# ANNEXURE-D: List of Mandatory Spares

1. Bidder shall provide one time supply of the mandatory spares required for this system as listed.
2. Bidder shall include other spares not specified in the Mandatory spares but required for the successful operation and maintenance of the Plant.

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| | | | |
| **1** | **Containerized Battery Storage System** | | |
| **1.1** | **Battery Module** | | |
| 1.1.1 | Connector (Each Positive and Negative) | 0.3% * | Nos |
| 1.1.2 | Fuse | 0.2% * | Nos |
| 1.1.3 | Socket | 0.2% * | Nos |
| 1.1.4 | Plug | 0.3% * | Nos |
| 1.1.5 | Fan (module) | 0.3% * | Nos |
| **1.2** | **Control Panel / Control Unit** | | |
| 1.2.1 | MCB | 0.3% * | Nos |
| 1.2.2 | MCCB | 0.3% * | Nos |
| 1.2.3 | Switching supply | 0.1% * | Nos |
| 1.2.4 | Flood Sensor | 0.1% * | Nos |
| 1.2.5 | Intermediate relay | 0.1% * | Nos |
| 1.2.6 | Fan (control box) | 0.1% * | Nos |
| 1.2.7 | Surge Protection Device (SPD) | 0.3% * | Nos |
| 1.2.8 | Electricity meter | 0.1% * | Nos |
| 1.2.9 | Current Transformer | 0.1% * | Nos |
| 1.2.10 | Emergency stop button | 0.1% * | Nos |
| 1.2.11 | UPS | 0.1% * | Nos |
| 1.2.12 | UPS battery | 0.1% * | Nos |
| 1.2.13 | Indicator | 0.1% * | Nos |
| 1.2.14 | Fuse | 0.2% * | Nos |
| 1.2.15 | Internal Communication Cable of the Rack | 0.2% * | Nos |
| 1.2.16 | DC cable for internal rack | 0.3% * | Nos |
| 1.2.17 | AC/DC Power Source | 0.2% * | Nos |
| 1.2.18 | Main Control box | 1 | Nos |
| 1.2.19 | E_CAN Driver | 1 | Nos |
| 1.2.20 | Debug wiring harness including the connector (2 sets of cable from BMS to CAN box and CAN Box to Laptop.) | 1 | Nos |
| **1.3** | **High Voltage (HV) Box** | | |
| 1.3.1 | Connector (Each Positive and Negative socket) | 0.3% * | Nos |
| 1.3.2 | High Voltage relay | 0.3% * | Nos |
| 1.3.3 | Pre-charge resistor | 0.2% * | Nos |
| 1.3.4 | Fuse | 0.2% * | Nos |
| 1.3.5 | DC disconnector | 0.3% * | Nos |

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| 1.3.6 | Indicator | 0.1% * | Nos |
| 1.3.7 | Hall Sensor | 0.1% * | Nos |
| 1.3.8 | Pre-charge contactor | 2 | Nos |
| 1.3.9 | Current Transducer | 2 | Nos |
| **1.4** | **Fire Protection System** | | |
| 1.4.1 | Fire alarm control panel | 0.3% * | Nos |
| 1.4.2 | Battery | 0.1% * | Nos |
| 1.4.3 | Manual release button | 0.1% * | Nos |
| 1.4.4 | Emergency stop button | 0.1% * | Nos |
| 1.4.5 | Horn/Strobe/Annunciator | 0.1% * | Nos |
| 1.4.6 | Alarm bell | 0.1% * | Nos |
| 1.4.7 | Smoke detector | 0.2% * | Nos |
| 1.4.8 | Thermal detector | 0.2% * | Nos |
| 1.4.9 | Aerosol | 0.3% * | Nos |
| 1.4.10 | Aerosol Bracket | 0.3% * | Nos |
| 1.4.11 | Hydrogen detector (H2) | 0.2% * | Nos |
| 1.4.12 | Electric ventilation louver | 0.1% * | Nos |
| 1.4.13 | Exhaust fan | 0.1% * | Nos |
| 1.4.14 | Ventilation system emergency start/stop button | 0.1% * | Nos |
| 1.4.15 | Sprinkler | 0.1% * | Nos |
| 1.4.16 | Quick connector | 0.1% * | Nos |
| **1.5** | **Liquid cooling system** | | |
| 1.5.1 | Antifreeze coolant | 0.3% * | Litre |
| **1.6** | **Battery Management System** | | |
| 1.6.1 | Master Battery Management Unit | 0.3% * | Nos |
| 1.6.2 | Slave Battery Management Unit | 0.3% * | Nos |
| 1.6.3 | Central Battery Management Unit | 0.3% * | Nos |
| **2** | **Cables** | | |
| 2.1 | HT Cable (All kV level) | 2% * | km |
| 2.2 | LT Cable | 2% * | km |
| 2.3 | Power, control, signal cables and communication cables /FO | 5% * | km |
| **3** | **Power Conditioning System (PCS)** | | |
| 3.1 | MFC PCB | 2% * | Nos |
| 3.2 | Status Monitoring PCB | 2% * | Nos |
| 3.3 | Core PCB | 2% * | Nos |
| 3.4 | Adaptor PCB | 2% * | Nos |
| 3.5 | Voltage sampling PCB | 2% * | Nos |
| 3.6 | Insulation resistance measuring PCB | 2% * | Nos |
| 3.7 | Low voltage across capacitor PCB | 2% * | Nos |
| 3.8 | Soft start circuit board | 2% * | Nos |
| 3.9 | Cooling Fan | 5% * | Nos |
| 3.10 | IGBT Unit for PCU | 2% * | Nos |

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| 3.11 | Semiconductor Fuse | 5% * | Nos |
| 3.12 | DC switch | 2% * | Nos |
| 3.13 | AC breaker | 5% * | Nos |
| 3.14 | Temperature sensors | 2% * | Nos |
| 3.15 | Voltage and current sensor | 2% * | Nos |
| 3.16 | Human-Machine Interface (HMI) Panels | 2% * | Nos |
| **4** | **33kV HT Switchgear** | | |
| 4.1 | 33 kV Indoor Current Transformer | 1 | Nos |
| 4.2 | 33 kV Indoor Potential Transformer | 1 | Nos |
| 4.3 | 33 kV Surge Arrestor | 1 | Nos |
| 4.4 | 33kV Circuit Breakers | 1 | Nos |
| 4.5 | Load Break Switches | 1 | Nos |
| 4.6 | Numerical Relay | 1 | Nos |
| 4.7 | Earth Switches | 1 | Nos |
| 4.8 | Fuses and Fuse holders | 1 | Nos |
| 4.9 | Surge Arresters | 1 | Nos |
| 4.10 | Pistol handle | 1 | Nos |
| 4.11 | LED of each colour | 1 | Nos |
| **5** | **SCADA** | | |
| 5.1 | SCADA Ethernet switch - Each type | 5% * | Nos |
| 5.2 | PLC - Each type | 1 | Nos |
| 5.3 | Converters - Each type | 1 | Nos |
| 5.4 | I/O Modules - Each type | 1 | Nos |
| 5.5 | Kuman-Machine Interface (HMI) panels | 1 | Nos |
| 5.6 | IP telephone - Each type | 1 | Nos |
| 5.7 | Network Switches | 1 | Nos |
| 5.8 | Routers | 1 | Nos |
| 5.9 | Fiber Optic Transceivers | 1 | Nos |
| **6** | **Inverter Duty Transformer (IDT)** | | |
| 6.1 | Set of Gaskets (Each set shall represent complete quantity of different types of gaskets used in one transformer. Total list of gaskets shall be indicated by bidder during detailed Engineering) | 1 | Set |
| 6.2 | Set of valves (Each set shall represent complete qty of different types of gaskets used in one transformer. Total list of gaskets shall be indicated by bidder during detailed Engg.) | 1 | Set |
| 6.3 | Winding temperature indicator with alarm & trip contacts along with 4-20mA transmitter | 1 | Nos |
| 6.4 | Oil temperature indicator with alarm & trip contacts along with 4-20mA transmitter | 1 | Nos |
| 6.5 | Buchholz relay complete unit of Inverter transformer | 1 | Nos |
| 6.6 | Pressure Relief Device of Inverter Transformer | 1 | Nos |

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| 6.7 | Magnetic Oil Gauge (MOG) of Inverter Transformer | 1 | Nos |
| 6.8 | LV Bushing with metal parts and gaskets of Inverter Transformer | 1 | Set |
| 6.9 | HV Bushing with metal parts and gaskets of Inverter Transformer | 1 | Set |
| 6.10 | HV neutral bushing (If applicable) | 1 | Set |
| 6.11 | Transformer Oil | 10% * | Litre |
| **7** | **Weather Monitoring System** | | |
| 7.1 | Pyranometer | 1 | Nos |
| 7.2 | Each type of sensor (Ambient/Rain/Wind, etc.) | 1 | Nos |
| 7.3 | Module temperature sensor | 5 | Nos |
| **8** | **Distribution Boards (415V)** | | |
| 8.1 | MCB | 2% * | Nos |
| **9** | **132kV Surge Arrestor** | | |
| 9.1 | Complete Surge Arrester with insulating base and Terminal connector & structure | 1 | Nos |
| 9.2 | Surge counter/monitor | 5 | Nos |
| **10** | **132kV Circuit Breakers** | | |
| 10.1 | Grading Capacitor | 3 | Nos |
| 10.2 | Rubber gaskets 'O' rings ans seals | 1 | Set |
| 10.3 | Trip coils with resistor | 2 | Set |
| 10.4 | closing coil with resistor | 2 | Set |
| 10.5 | terminal pads and connectors | 2 | Set |
| 10.6 | molecular filter | 2 | Nos |
| 10.7 | density/ pressure monitoring system | 1 | Nos |
| 10.8 | Corona rings | 1 | Nos |
| 10.9 | Pressure switches | 1 | Set |
| 10.10 | Pressure Gauge and coupling | 1 | Set |
| 10.11 | SF6 Gas | 15% of total used quantity in substation | Set |
| 10.12 | Auxiliary switch assembly | 1 | Set |
| 10.13 | Operation Counter | 1 | No. |
| 10.14 | Magnetic ventile, if required | 3 | Nos. |
| 10.15 | Actuator rings, if required | 6 | Nos. |
| 10.16 | Control valves, if required | 1 | No. |
| **11** | **Control and Relay Panel** | | |
| 11.1 | Numerical Relay (IED) of each make and type along with software | 1 | Nos |
| 11.2 | Push Buttons | 1 | Nos |
| 11.3 | Indicator and Pilot Lights | 1 | Nos |
| 11.4 | Timer Relays | 1 | Nos |

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| 11.5 | Emergency Stop Buttons | 1 | Nos |
| **12** | **Isolator** | | |
| 12.1 | One complete pole including support Insulator, motor operating mechanism and terminal connector but excluding structure (For cyclone/whirlwind/tornado prone areas- /10% poles of each make and model installed at the substation) | 1 | Nos |
| 12.2 | Isolator Arms with finger contacts and current carrying assembly | 1 | set |
| 12.3 | Support Insulators | 1 | set |
| 12.4 | Copper contact fingers for male & female contacts | 2 | set |
| 12.5 | Open / Close contactor assembly, timers, key interlock push button switch & auxiliary switches | 1 | set |
| 12.6 | Limit switch | 2 | sets |
| 12.7 | Hinge pins | 3 | Nos. |
| 12.8 | Bearings | 1 | set |
| 12.9 | Motor housing bearing assembly | 1 | No. |
| 12.10 | Terminal Pads and connectors | 2 | sets |
| 12.11 | Motor with gear assembly and bevel gear assembly | 1 | No. |
| 12.12 | Corona shield rings | 3 | Nos. |
| 12.13 | Interlocking coil with resistor | 5 | Nos. |
| 12.14 | Fuses of each rating | 5 | Nos. |
| **13** | Fibre Optic cable | 1% * | km |
| **14** | **33/132kV Power Transformer** | | |
| 14.1 | Transformer Oil | 10% * | Litre |
| 14.2 | Breather (Silica Gel) | 1 | Nos |
| 14.3 | Gaskets for erection (for all type) | 1 | Nos |
| 14.4 | HV Bushing with fittings | 1 | Nos |
| 14.5 | Bush Assembly | 1 | Nos |
| 14.6 | Bushing mounted CTs | 1 | Nos |
| 14.7 | Axial flow fan assembly | 1 | Nos |
| 14.8 | Gate Valve (for all type) | 1 | Nos |
| 14.9 | Butt fly valve (for all type) | 1 | Nos |
| 14.10 | OTI & WTI with sensing device (as applicable) | 1 | Nos |
| 14.11 | Mag.Oil level Indicator | 1 | Nos |
| 14.12 | Mag.Oil level Indicator | 1 | Nos |
| 14.13 | OLTC Motor | 1 | Nos |
| 14.14 | Oil Surge relay for OLTC | 1 | Nos |
| 14.15 | Voltage and current sensors | 1 | Nos |
| 14.16 | Buchholz relay | 1 | Nos |
| 14.17 | PRV for OLTC | 1 | Nos |
| **15** | **Auxiliary Transformer** | | |

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| 15.1 | Transformer Oil | 10% * | Litre |
| 15.2 | Breather (Silica Gel) | 1 | Nos |
| 15.3 | Gaskets and Seals | 2% * | Nos |
| 15.4 | Cooling Fans (if applicable) | 1 | Nos |
| 15.5 | Cooling Radiators (if applicable) | 1 | Nos |
| 15.6 | Circuit Breakers | 1 | Nos |
| 15.7 | OTI & WTI with sensing device (as applicable) | 1 | Nos |
| 15.8 | Buchholz relay | 1 | Nos |
| 15.9 | Explosion vent diaphragm | 1 | Nos |
| 15.10 | Terminal Connectors | 1 | Nos |
| **16** | **Insulator** | | |
| 16.1 | Disc Insulators | 5% * | Nos |
| 16.2 | Insulator caps | 5% * | Nos |
| 16.3 | Insulation sleeves | 5% * | Nos |
| 16.4 | Long Rod | 5% * | Nos |
| **18** | **220V/110V/48V Battery and Battery Charger** | | |
| 18.1 | Spare battery cell without electrolyte | 1. 10 Nos. for population ≥ 100 Nos.<br>2. 5 Nos. for population < 100 Nos. | |
| 18.2 | Terminal connectors with Bolts & Nuts | 10 * | Nos. |
| 18.3 | Float level indicators | 10 * | |
| 18.4 | Vent Plugs | 10 * | |
| 18.5 | Set of Control Cards | 1 Complete set for each type of charger | Set |
| 18.6 | Set of relays | 1 | Set |
| 18.7 | Series inductor | 1 | Nos |
| 18.8 | Set of contactors | 1 | Set |
| 18.9 | Micro switches | 1 | Set |
| 18.10 | Filter Capacitors | 1 | Set |
| 18.11 | Thyristor/ Diode | 1 | Set |
| 18.12 | Set of switches | 1 | Set |
| 18.13 | Set of wound resistors | 1 | Set |
| 18.14 | Potentiometers | 1 | Nos |
| 18.15 | Fuses of Thyristor with indicators | 6 | Set |
| **19** | **Fire, Heat, Smoke detection and protection system** | | |
| 19.1 | Fire detection sensor | 1 | Nos |
| 19.2 | Heat detection sensor | 1 | Nos |
| 19.3 | Smoke detection sensor | 1 | Nos |
| **20** | **Miscellaneous Item** | | |
| 20.1 | Earthing strip | 0.5% * | km |
| 20.2 | Earth pit | 0.5% * | Nos |

| S.No | Description | Quantity | UoM |
|---|---|---|---|
| 20.3 | Route marker | 0.25% * | Nos |
| 20.4 | Clamps | 0.5% * | Nos |
| 20.5 | Glands | 0.5% * | Nos |
| Note: *(% of total population for each type and each make) | | | |

# ANNEXURE-E: List of Special Tools & Tackles

1. Bidder shall provide all the special tools and tackles (permanently) for successful operation and maintenance of the Plant, but not limited to the following.

| S. No | Item | Unit | Quantity |
|---|---|---|---|
| 1. | Gas Leakage Detector | No. | 1 |
| 2. | Leakage current analyser for Surge Arrester | No. | 1 |
| 3. | CT / PT Test kit | No. | 1 |
| 4. | CB analyser | No. | 1 |
| 5. | Dew point meter for checking moisture of SF6 gas | No. | 1 |
| 6. | Portable Leak Testing Equipment<br>Airtight tooling is required. | No. | 1 |
| 7. | Tooling kit<br>One round and one square explosion-proof valve interface respectively. | No. | 1 |
| 8. | Battery Discharge & Charge Tester | No. | 1 |
| 9. | Lithium Battery Equalizing Maintenance System<br>ACTM-5201. Module overall balance. | No. | 1 |
| 10. | Balanced Transfer Harness. | No. | 1 |

# ANNEXURE-F: List of Approved Vendors

Vendor list is furnished with Contract Document.

# ANNEXURE-G: Format for Recommended Spare List

1. Bidder shall provide supply of the recommended spares required for successful operation of the Plant.

| Recommended Spare list | | | |
|---|---|---|---|
| **S.no.** | **Category / System** | **Quantity** | **UOM** |
| **1** | **Containerized Battery Storage System Components** | | |
| 1.1 | | | |
| 1.2 | | | |
| **2** | **Electrical Components** | | |
| 2.1 | | | |
| 2.2 | | | |
| **3** | **Control Systems** | | |
| 3.1 | | | |
| 3.2 | | | |
| **4** | **Cooling and HVAC Systems** | | |
| 4.1 | | | |
| 4.2 | | | |
| **5** | **Protection Systems** | | |
| 5.1 | | | |
| 5.2 | | | |
| **6** | **Mechanical Components** | | |
| 6.1 | | | |
| 6.2 | | | |
| **7** | **Instrumentation** | | |
| 7.1 | | | |
| 7.2 | | | |
| **8** | **Miscellaneous** | | |
| 8.1 | | | |
| 8.2 | | | |
| **9** | **Documentation** | | |
| 9.1 | | | |
| 9.2 | | | |
| Note: | | | |

# SECTION - 2 DETAILED TECHNICAL SPECIFICATIONS (DTS) - ELECTRICAL

# 1. Containerized Battery Storage System (BESS)

## 1.1 Introduction

1.1.1 The Containerized Battery Storage System of capacity 25MW/100MWh (Usable energy capacity at Interconnecting Point) as per the project requirement.

1.1.2 The Containerized Battery Storage System shall consist of only one type of battery.

1.1.3 The DC voltage of Containerized Battery Storage System shall be selected by the Bidder to suit the PCS and battery for efficient and safe operational requirement.

## 1.2 Codes and standards

1.2.1 The Containerized Battery Storage System to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC/ IEEE standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below.

| Standards | Description |
|---|---|
| IEC 62935 | Planning & Installation of Electrical Energy Storage System |
| IEC 61850 / DNP3 | Communications networks and management systems. (BESS control system communication) |
| IEC 62619 or UL1642 or UL1973 (For Cell) | Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications / Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications |
| IEC 63056 or UL1642 or UL1973 (For Battery Level) | Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications |
| IEC 62620 | Marking, tests and requirements for lithium secondary cells and batteries used in industrial applications including stationary applications |
| IEC 62897 or NFPA 72.A or NFPA 855. | Stationary Energy Storage Systems with Lithium Batteries –Safety Requirements |
| IEC 62281 or UN38.3 (For battery & Cell) | Safety of primary and secondary lithium cells and batteries during transport: Applicable for storage systems using Lithium-Ion chemistries |
| IEC 62933-5-1 + IEC | Electrical energy storage (EES) systems - Part 5-1 & 2: Safety |

| Standards | Description |
|---|---|
| 62933-5- 2 or UL9540 and UL9540A (BESS Level) IS 17092 | considerations for grid-integrated EES systems – General specification / Standard for Energy Storage Systems and Equipment Electrical energy storage (EES) systems - Part 2- 1: Unit Parameters and testing methods - General Specification. Tests for Class B applications (Duty Cycle Round Trip Efficiency Test, Equipment and Basic Function Test, Available energy Test, Insulation test)- 5-1 + IEC 62933-5-2 IS 17092: Electrical Energy Storage System Safety Requirements |
| IEC 62933-5-4 | Safety test methods and Procedure for grid integrated ESS system-LI Ion based system |
| IEC 62933-2-1 | Electrical energy storage (EES) systems - Part 21: Unit Parameters and testing methods - General Specification Tests - Duty Cycle Round Trip Efficiency Test, Equipment and Basic Function test, Available Energy test, Insulation test |
| IEC 62933-3 | Planning and performance assessment of electrical energy storage systems - Additional requirements for power intensive and renewable energy sources integration related applications |
| IEC/TS 62933-4 | EES Systems - Electrical energy storage (EES) systems - Part 4-1: Guidance on environmental issues - General specification |
| IEC/TS 62933-5 | Electrical energy storage (EES) systems - Part 5-2: Safety requirements for grid-integrated EES systems - Electrochemical-based systems |
| UL 9540A | Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy |
| IEEE 1491 | Guide for selection and use of BMS in stationary applications |
| IEEE 2030.2.1-2019 | IEEE Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems |

### 1.3 Technical Requirements

1.3.1 The bidder shall be able to provide the components of the Containerized Battery Storage System as per following technical specifications described below in this section.

| Description | Requirement |
|---|---|
| Battery Technology | Lithium Iron Phosphate (LFP), Lithium-ion |

<table>
<tr><td>Rated No of Cycles (Minimum)</td><td colspan="3">2 cycles per day</td></tr>
<tr><td>Min. Dispatchable Energy</td><td colspan="3"><table>
<tr><th rowspan="2">Years</th><th>Minimum Dispatchable Energy for each cycle at the start of Year @ IP</th><th>Minimum Dispatchable Energy for each cycle at the end of Year @ IP</th></tr>
<tr><th colspan="2">as a % capacity at the beginning of life / COD at Interconnecting Point (i.e. 100MWh)</th></tr>
<tr><td>1.</td><td>100.0%</td><td>97.5%</td></tr>
<tr><td>2.</td><td>97.5%</td><td>95.0%</td></tr>
<tr><td>3.</td><td>95.0%</td><td>92.5%</td></tr>
<tr><td>4.</td><td>92.5%</td><td>90.0%</td></tr>
<tr><td>5.</td><td>90.0%</td><td>87.5%</td></tr>
<tr><td>6.</td><td>87.5%</td><td>85.0%</td></tr>
<tr><td>7.</td><td>85.0%</td><td>82.5%</td></tr>
<tr><td>8.</td><td>82.5%</td><td>80.0%</td></tr>
<tr><td>9.</td><td>80.0%</td><td>77.5%</td></tr>
<tr><td>10.</td><td>77.5%</td><td>75.0%</td></tr>
<tr><td>11.</td><td>75.0%</td><td>72.5%</td></tr>
<tr><td>12.</td><td>72.5.%</td><td>70.0%</td></tr>
</table></td></tr>
<tr><td>Cycle Life</td><td colspan="3">Minimum 12 Years from Date of successful Commissioning. BESS shall be designed to perform maximum 02 complete charge-discharge cycle per day-based application/operation requirement. Bidder shall indicate the minimum BESS Battery DoD level beyond which the Battery cannot be operated. Battery DoD Vs Life Cycle graph also shall be provided. BESS control system shall be designed in such a way that during operation the above minimum DoD level shall not violated under any operating condition. Bidder shall provide suitable calculation/document in this regard during detail engineering. DoD shall be defined at 0.25C Rate of Discharge.</td></tr>
<tr><td>Response time</td><td colspan="3">1 second</td></tr>
<tr><td>BESS operating ambient temperature</td><td colspan="3">-30° to 50° C ambient</td></tr>
</table>

| | |
|---|---|
| Watt-hour rating (dispatchable capacity) | The quantum of energy (MWh) discharged from the BESS year on year shall be equivalent to the energy discharge rating of the BESS with normative annual degradation and the discharge duration shall be equivalent to the BESS Energy Discharge Duration (C rate). Bidder shall inform the Owner about its BESS discharge rating capacity (after nominal degradation), for the purpose of planning the schedule. |
| BESS Degradation above Nominal Value | In case of degradation above nominal value, the Bidder shall compensate such degradation with augmentation of BESS at bidder's own expense. |
| Round trip efficiency with auxiliary consumption | ≥86% |
| Battery cell discharge efficiency | >96% |
| Battery cooling type | Liquid |
| Minimum permissible depth of discharge (DoD) | ≥90% |
| Container size | 20 or 40 feet |
| Protection Class-(Container) | > IP54 |
| Self-Discharge per month | < 3% |
| Communication protocol | CAN, Modbus RTU, TCP/IP, IEC61850 |
| Recommended storage temperature | -20°C to 35°C |

| | |
|---|---|
| (°C) | |
| Compliance | IEC62619, UL9540A, UL1973 |
| Protection & features | Over and Under Discharge<br>Over and Under Temperature<br>Over and Under Current<br>Over and Under Voltage<br>Ground Fault<br>Internal battery Fault<br>Cell Balancing<br>Battery Fuse for each cell & Module<br>Module reverse polarity<br>DC Contactor for each Battery Rack<br>Grounding Over Current<br>Failure of temperature controller<br>failure of electrolytic system |
| Peak Management | In the Peak Management Use Case scenario, excess power from grid during the early and/or mid-day periods shall be stored in the BESS and discharged and utilizing the stored energy during Evening Peak Hours or as per the requirement. |
| Charge – Discharge Cycles | Two (02) cycle per day |
| Ventilation System inside the Container | Should be such as to maintain minimum and maximum Temperature as recommended by the manufacturer for optimum performance of the batteries on continuous basis. |
| Grid Charging | Yes |
| Power Factor range at POI/metering point (minimum VAR support to Grid facility) | As per CEA connectivity regulation when it is charging/discharging condition. In addition to reactive power support to grid as per CEA regulation, BESS shall have facility to provide VAR support to the extent possible to Grid even when there is no active power flow during charging /discharging. |
| Project Life | 25 years except for Containerized Battery Storage System |

1.3.2 Ambient temperature as mentioned above shall be applicable in case of conflict between ambient temperature mentioned above and those specified elsewhere in the specification.

1.3.3 Response time: The design of Containerized Battery Storage System should be such that its response time shall not be more than 1 (one) sec. Response time is the time interval between need for response (a command or grid event or Plant power generation event, etc.) is detected by the BESS and the time when power as measured at the grid has attained that level. This shall include all intermediate response time of system components.

## 1.4 Nameplate Ratings

1.4.1 Overall System Real Power and Energy Ratings

During discharge, the Containerized Battery Storage System shall be rated to supply at the PCC the continuous net AC real power and AC energy output specified above. These ratings shall be referred to in all project documentation, including this specification, as the nameplate watt rating and the nameplate watt-hour rating. All nameplate ratings shall be achievable over the End of Battery life. The nameplate watt rating and nameplate watt-hour rating shall be achievable during discharge for the full range of stated environmental conditions, provided that the battery is fully charged and the HVAC system (if incorporated in the Containerized Battery Storage System) has stabilized. In any case, the Containerized Battery Storage System shall be capable of being discharged at reduced power levels from that specified above. However, in no case will the energy discharged from the battery be greater than the nameplate watt-hour rating. The Bidder shall clearly state in its O&M manual as well as during design review the expected efficiencies of the major subsystems (battery, PCS) as well as the expected losses from auxiliaries.

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

1.4.2 Overall System Reactive Power Rating

In accordance with the VAR-related control modes identified in this specification, the Containerized Battery Storage System shall be capable of dispatching both leading and lagging reactive power at the PCC, up to the rated VAR capacity, regardless of whether the battery is being simultaneously discharged or charged. This rating shall be referred to in all project documentation, including this specification, as the nameplate VAR rating. The Containerized Battery Storage System shall be capable of simultaneously producing real and reactive power as long as no nameplate rating is exceeded. That is, the combination of operation at full nameplate watt rating and full nameplate VAR rating shall not exceed the nameplate VA rating

## 1.5 Design Requirements

1.5.1 Containerized Battery Storage System shall be transportable, based on commercially available electrochemical storage solutions, capable of receiving, storing and delivering electrical energy at specified rate(s) suitable for the application laid out in the specifications herein. It comprises of unit batteries, battery management system (BMS), auxiliaries, such as HVAC and fire suppression and protection systems, ac switchgear, Control Systems etc.

1.5.2 In order to lower life-cycle expenses and make it easier to replenish storage capacity, the Containerized Battery Storage System's design must take modularity into account. This will also make maintenance, space needs, and dependability easier to manage. Additionally, the design should make it simple and quick to replace the unit's batteries, minimizing downtime. The overarching design concept will aim to minimize and optimize all expenses to the Owner—not only low upfront expenditures or ongoing maintenance expenses.

1.5.3 Life-cycle expenses include the following: initial system expense, unit battery replacement expense, battery disposal (if any) periodic equipment upgrades, operation & maintenance expenses, auxiliary system energy consumption, charging energy expenses (that is, expenses due to overall battery and PCS losses), and any other contributors to life-cycle energy expense.

1.5.4 Electrochemical cells must be replaceable (in small orders) with a maximum six-week lead time under normal business conditions. Designs using components that are experimental or undocumented in any way are prohibited.

1.5.5 The design shall ensure that any malfunctioning or underperforming component must be able to be completely removed, fixed, and replaced on the job Site by the maintenance personnel. This capability shall be demonstrated in the factory acceptance test (FAT) for unit batteries and other key components.

1.5.6 Battery shall be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements.

1.5.7 The battery cells may be supplied as separate, individual units or as group of cells combined into modules. The design, materials, and method of cell construction shall conform to the applicable code and/or standard.

1.5.8 Bidder shall submit battery particulars such as C Rate, SoC, DoD, terminal voltage, nominal voltage, nominal capacity (Ah), nominal energy (Wh). Cycle life, Open-circuit voltage (V), Internal Resistance, Cut-off Voltage, Specific Energy (Wh/kg), Specific Power (W/kg), Energy Density (Wh/L), Power Density (W/L), Maximum Continuous Discharge Current, Maximum 30-sec Discharge Pulse Current, Charge Voltage, Float Voltage, (Recommended) Charge Current and (Maximum) Internal Resistance along with bid proposal.

1.5.9 Battery system shall have suitable positive and negative ramp rate to support BESS Operation in Grid Connected mode. Bidders shall consider highest ramp up/down load profile of power transformers while designing the Containerized Battery Storage System.

**1.6 Battery subsystem Design requirements**

1.6.1 Electrochemical cell - Only cells that are commercially available or for which suitable, replacement cells can be supplied on short notice will be allowed. The cell material shall have good electrical conductivity, stability, and chemical compatibility. For both premature cell failures and end-of-battery-life replacement, the Contractor shall guarantee cell availability, and the length of down time (hours or days) required to replace cells. The cells may be supplied as separate, individual units or as group of cells combined into modules. The cells shall meet the seismic requirements for the planned location of the BESS. Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the Containerized Battery Storage System and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the Owner and approved prior to dispatch.

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

1.6.2 Cell Covers - The cell covers shall be capable to withstand internal pressure without bulging / cracking. It shall also be fire retardant. Fixing of pressure regulation valve (if provided) & terminal posts in the cover shall be such that seepage of electrolyte, gas escape, and entry of electrostatic spark are prevented.

1.6.3 Separator - The separators used in manufacturing of battery cells, shall be of suitable material with large porosity, low acid / alkaline solubility and good insulating properties depending on the type of technology used for battery. The design of separators shall ensure that there is no misalignment during normal operation and handling.

1.6.4 Terminals - Both the positive and negative terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid / alkaline resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of a proven material that does not have any harmful effect on cell performance. Both positive and negative posts shall be clearly and unambiguously identifiable. Terminal post seals shall not transmit stresses between the cover or container and posts. All battery modules shall be supplied with terminal covers to avoid unintentional contact.

1.6.5 The storage system may consist of one or more unit batteries. If the storage system consists of more than one unit battery, these may be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements. The DC voltage of battery system shall be selected by the Bidder to suit the PCS and battery efficient and safe operational requirement.

1.6.6 Each electrically series-connected string of unit batteries shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). This protection shall be coordinated with the PCS capabilities and battery string protection and shall take into account switching or other transients and the inductance/resistance (L/R) ratio at the relevant areas of the dc system. The means of disconnect shall provide for a physical interruption of the string electrical circuit, which shall be visible to anyone servicing the individual unit batteries in the string and shall be capable of being locked or secured in an open position.

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

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

1.6.9 Where appropriate, DC wiring shall be braced for available fault currents. Protection shall include a dc breaker, fuse, or other current-limiting device on the battery bus. This protection shall be coordinated with the PCS capabilities and battery string protection. The Contractor shall produce a fault analysis and protection coordination study for the battery dc subsystem during final design. The Owner reserves the right to withhold permission to ship the BESS until the fault analysis has been satisfactorily completed.

1.6.10 Cells, wiring, switch gear, and all dc electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety as per standard/subject to approval during detail engineering. Cell and module terminals and interconnects shall have adequate current-carrying capacity. The polarities of cell and module terminal posts shall be embossed on the cover at the terminal.

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

adjustable. The Contractor shall have overall responsibility for the safety of the electrical design and installation of the battery, as well as all aspects of the BESS.

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

1.6.13 Abnormal conditions shall include but not be limited to (1) weak unit batteries that could reasonably be expected to fail to provide rated capacity upon full discharge, (2) high-resistance or open-unit batteries, (3) high-resistance or open external unit battery connections, (4) unit batteries with temperatures exceeding operating thresholds, and (5) internally shorted unit batteries. Unit battery monitoring, whether automatic or manual, should be specified to alert the proper personnel in a timely manner that an abnormal unit battery condition exists or may exist. All alarms shall be part of the control system and shall include remote display or annunciation capability.

1.6.14 The unit batteries shall be racked or shall be housed in stackable modules. The unit batteries or cells shall be arranged and installed to permit easy access for equipment and personnel. The moveable units shall be arranged and installed to permit easy access for equipment and personnel to carry out unit removal and replacement activities. For all systems, it shall be possible to remove and replace a prematurely failed unit battery or cell (as appropriate), when system performance specifications cannot be met. The lengths and widths of all aisles and spaces into which personnel may enter in the field for operations and/or routine or unscheduled maintenance purposes, as well as egress routes from these aisles and spaces, shall conform to applicable codes and standards. All racks and metallic conductive members of stackable modules shall be grounded to earth. Racks shall meet the seismic load and road vibration requirements and shall include means to restrain cell movement during seismic events and transport. The Contractor shall furnish analyses and/or other data that show that the rack and cell designs are designed to meet all potential seismic and transport vibration requirements.

1.6.15 Provision shall be made for future Augmentation/Replacement by keeping Spare Racks for accommodating Battery Stack Modules capacity.

1.6.16 The design of all modules and racks shall specifically account for the anticipated vibrations and shocks associated with the transportation of the Containerized Battery Storage System.

1.6.17 Connectors, Nuts and bolts, Heat Shrinkable sleeves - Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably coated to withstand corrosion due to acid / base at a very high rate of charge or discharge. Nuts and bolts for connecting the cells shall be made of copper, brass, or stainless steel, which shall be effectively coated to prevent corrosion. All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing the environmental impact including a corrosive environment.

1.6.18 Mounting - All the batteries shall be mounted in a metallic stand/frame. The suitable isolation should be provided between base of frame and ground to avoid the grounding of frame. The frame shall be properly painted with the acid / base resistant paint. The battery stands shall be designed to withstand the environmental consideration such as seismic design consideration.

1.6.19 External connection to the cells, including inter-cells or inter-module connections (such as cables/ straps etc.) shall also be designed to prevent failure during transportation.

1.6.20 The Cell/module terminals and interconnects shall have adequate current carrying capacity. The Cells/modules, wiring, switch gear, and all DC electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety. The DC bus work and load-carrying cables within the storage subsystem shall have an enough margin for the actual load current. Also, all other components shall have enough margin for the actual load current according to applicable code and/or standard.

1.6.21 Each electrically series-connected battery string shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). This protection shall be coordinated with the PCS capabilities and battery string protection and shall take into account switching or other transients and the inductance/resistance (L/R) ratio at the relevant areas of the dc system. These disconnecting devices should be capable of operating with normal load current and provide physical interruption. Reverse coordination of fuses shall be done to prevent unnecessary blowing of fuses.

1.6.22 The battery system may be ungrounded or grounded. Grounded configurations may be centre, or one-pole-grounded and/or solid or high resistance grounded. Bidder to deploy ground leakage current levels detection and alarm system with field adjustable detection / trip level for each container / bank or, if more than one electrical series string is installed in the container / bank, for each series string.

1.6.23 The DC voltage of battery system shall be selected by the Bidder to suit the PCS for efficient and safe operational requirement of Containerized Battery Storage System.

1.6.24 Material, equipment, safety requirements and methods used in the manufacturing of Lithium-Ion Battery (Cell, Module, Racks, Enclosure) of Containerized Battery Storage System shall conform to the relevant IEC / UL / IS latest edition of standards and Codes.

1.6.25 All cells/modules shall be traceable to the point of origin for purpose of addressing safety issues.

1.6.26 Each Cell shall be integrated with BMS, and each module shall be provided with Battery Management Unit,

1.6.27 Each rack comprising Battery Modules shall be supplied with Battery Control Box. Battery Control Box shall provide Manual switch to isolate rack from electrical network, lifting / withdrawing arrangement, LED Indications for status (Running, Alarm), Debugging port, Communication ports, Auxiliary Power

Supply connection arrangement, Contactor with position status and Pre-charge status and Battery Control Unit.

1.6.28 Battery Cell, Modules and Rack system shall be compatible to conduct BMS Functions as mentioned in separate section in this specification.

1.6.29 Suitable ventilation / Air or liquid controlled cooling in battery room/container must be maintained to minimize negative effects of the battery which may lead to higher degradation or thermal runaway.

1.6.30 Containerized Battery Storage System shall have minimum protection class IP54.

1.6.31 Bidder shall deploy safety measures such as Rubber mats, convex mirrors, Fire extinguisher, Emergency Trip provisions, manual call points, Safety PPE etc.

1.6.32 Automatic fire fighting system should be provided as per NFPA.

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

**1.7 Constructional Requirements**

1.7.1 The methods and materials specified in this technical specification are intended to represent minimum requirements. Reliance thereon shall not diminish the responsibility for meeting performance and other requirements stated in this technical specification.

1.7.2 The design of the Containerized Battery Storage System shall incorporate the principle of modularity, with a view to reducing life-cycle expenses and ease of replenishment of storage capacity while facilitating ease of maintenance, space requirements, and reliability. The design should also facilitate rapid and easy replacement of the unit batteries without significant downtime. Overall, the design philosophy shall be to minimize and optimize all expenses to the Owner, not simply initial capital expenses or low maintenance expenses.

1.7.3 Life-cycle expenses include the following: initial system expense, unit battery replacement expense, battery disposal (if any) periodic equipment upgrades, operation & maintenance expenses, auxiliary system energy consumption, charging energy expenses (that is, expenses due to overall battery and PCS losses), and any other contributors to life-cycle energy expense.

1.7.4 The major equipment items shall include a battery, battery management system (BMS), PCS, and EMS/SCADA which is to be integrated with BOS system/PCS Transformers/ Switchgear and grid. Additional equipment shall include HVAC, wiring, connectors, protective devices, grounding, junction boxes and enclosures, instrumentation, enclosures, and all other items needed for a fully functional, grid- interactive BESS to meet the requirements set forth in this specification. All systems and components of systems including electrical storage unit, switching devices in the PCS, components of monitoring and control systems, and components of auxiliary systems must use proven and previously

demonstrated technology. Electrochemical cells, PCS switching devices, and control system hardware and software must be commercially available and in use for other markets. Electrochemical cells must be replaceable (in small orders) with a maximum six-week lead time under normal business conditions. Designs using experimental or otherwise undocumented components are not permitted.

1.7.5 It shall be possible to fully remove, repair, and replace in the field any failed or poorly performing component, assuming that spare parts, test equipment, and maintenance personnel are on the Site. This capability shall be demonstrated in the factory acceptance test (FAT) for unit batteries and other key components.

1.7.6 The Containerized Battery Storage System shall be capable of unattended operation, with provision of remote monitoring and control.

1.7.7 In addition to above, the Contractor shall also submit Available energy Test Report as per IEC 62933-2-1 on Annual basis.

**Operational Window**

1.7.8 Operational Window shall mean the expected hours/duration of system (capacity) availability on each day during the term of the Contract, excluding:

a) Maximum BESS recovery time: - The Contractor shall clearly specify the maximum recovery times required to restore the BESS for functional availability between duty cycles. However, in no case, the same shall be more than 1 hour.

b) It shall be the responsibility of the Contractor to make periodic replacements/replenishments of system capacities (to ensure annual guaranteed system ratings), if and when required, up to the Term of the Contract. Outage time as a result of replacement will also be counted as an "Accountable BESS Outage" for the purpose of computing Containerized Battery Storage System Availability.

1.7.9 The BESS shall be containerized, using either standard International Organization for Standardization (ISO 668) shipping containers or custom-designed power equipment centres. The container or containers shall be designed to be drop- shipped onto a properly prepared pad or foundation (such as compacted soil, concrete pad or platform, and so on). When fully installed, all Containerized Battery Storage System components including battery racks all auxiliaries, such as HVAC and fire suppression systems, back up supply and so on and tools shall be enclosed in (or on) the containers, even if certain components must be separately shipped and installed at the Site.

1.7.10 Containers shall be designed and constructed to meet IP54 requirements. The design and installation of Containers shall meet relevant regulatory requirements for occupational safety and health under national and state legislations.

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

1.7.12 The containers and their contents shall be designed to be easily prepared for transport, shipped, connected and operated at Site. The Contractor shall ensure that all required bracing and shipping stabilization equipment to enable transport is either kept at hand or brought to the Site in a timely manner before transport.

1.7.13 In designing for transportability of the lithium-ion batteries, the Contractor shall follow the relevant guidelines (Sub-section 38.3) set forth in the United Nations document" Recommendation on Transport of dangerous Goods—Manual of tests and Criteria" (ST/SG/AC.10/11/Rev.5), with specific reference to obtaining UN38.3 and UN3480 certification at Battery module and/or container level.

1.7.14 The Containerized Battery Storage System or BESS containers shall be of a size and weight to be capable of being transported to project Sites with due consideration for the load bearing restrictions imposed by bridges, if any, and rarefied atmospheric conditions in the region.

1.7.15 Containers shall incorporate standard lugs or other means for lifting by crane or shall be properly palletized for movement with forklift trucks, or both.

**Supply Distribution system within container**

1.7.16 The Containerized Battery Storage System shall include an internal auxiliary supply distribution system for which can fed from BoS infrastructure with metering. The auxiliary power system and/or control system design with suitable back up power shall provide for whatever emergency power is necessary for an orderly system shutdown during abnormal conditions such as a loss of grid power. The auxiliary power system and/or control system design shall also provide for the capability to restart automatically after BESS shutdowns of several days.

1.7.17 The backup of auxiliary power system shall not affect the main battery capacity under normal conditions.

**Control and Communication**

1.7.18 The control system shall be designed to provide for automatic, unattended operation. The control system design shall provide for local manual operation and remote operation or dispatch from a remotely located computer. The control system shall be programmable for establishing or adjusting all parameters, set points, algorithms, limits, and so on that are required for effective operation as described in this specification. The control system shall be designed to prevent externally supplied, control panel or local signals from causing the BESS to operate in an unsafe manner or in a manner that may damage the BESS.

**Control Functions and Protocols**

1.7.19 To the extent possible, all BESS control functions, and operating modes shall be in accordance with standard functionalities for smart distributed resources, as documented in the IEC 61850-90-7.

1.7.20 The communication protocol for the BESS shall be according to IEEE 1815-2010, Standard for Electric Power Communications Distributed Network Protocol (DNP3) or IEC 61850.

1.7.21 If data points and/or control functions outside the standard point definitions in DNP3 AN2011-001/IEC 61850 are created by the Contractor, the Contractor shall maintain a systematic log of the same for the purpose of maintaining/facilitating interoperability with future standards/protocols for distributed energy resources.

**Additional Control System Functions**

1.7.22 Shutdown/Startup/Standby: - The start and stop controls shall be as per DNP3 AN2011-001 standard specifications or IEC 61850. The control system shall use these controls for an orderly and safe shutdown, even in the absence of grid power. The control system shall also use these controls for an orderly startup sequence, which shall provide for a safe system reset from any standby or operating condition so that the unit goes through a normal startup sequence in the same way it would when being powered up after loss of power or being in a shutdown state. The control system shall include provisions for a standby state (that is, BESS but not charging or discharging), which shall be the end result of a normal startup sequence. It shall also be possible to enter the standby state from any of the other operating states except connect/disconnect.

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

a) Emergency trip switch
b) Loss of the low-voltage AC or utility grid voltage.
c) An AC circuit breaker trip (either side of transformer).
d) Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
e) Smoke/fire alarm
f) Control logic trouble
g) A DC ground fault (field-adjustable setting)
h) Remote disable (no reset required)
i) Grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase)
j) Abnormal frequency
k) Abnormal voltage
l) Islanding condition
m) Protection or control scheme failures, including the following:

1. Failure of local interconnection protection system
2. Failure of critical breaker trip coil or interrupting device
3. Loss of DC supply

1.7.24 Change Operational Mode: The control system shall support activating/deactivating control functions. The control functions are expected to be executed by command from a remote host but may also be scheduled.

1.7.25 Control System Hardware Requirements: All local control and monitoring system components shall be housed in appropriate controlled environment enclosures either as separate arrangement or in conjunction with EMS and SCADA system.

1.7.26 Control System Self-Protection and Self-Diagnostic Features: The Containerized Battery Storage System shall include appropriate self-protective and self-diagnostic features to protect itself and the battery from damage in the event of Containerized Battery Storage System component failure or causes. The self-protective features shall not allow local or remote signals cause the BESS to be operated in a manner that may be unsafe or damaging to the BESS. All protective operations resulting in a shutdown shall be carried out in an orderly and safe manner, even in the absence of utility power.

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

1.7.28 The BESS shall alarm upon detection of a DC ground fault. The alarm trip level shall be field adjustable.

1.7.29 Door interlock switches shall be provided for all Containerized Battery Storage System doors. The BESS shall alarm and go to shutdown mode when a BESS door is opened. Doors shall be fitted with provisions for external locks The BESS shall alarm and go to shutdown mode upon detection of smoke.

1.7.30 Surge-protection devices shall be provided at the input and output terminals of the BESS.

## 1.8 Battery Management System

1.8.1 The BMS shall be designed to provide automatic, unattended operation of the Containerized Battery Storage System.

1.8.2 Battery storage shall discharge based on battery capacity and real-time load. The reference value shall be updated periodically depending upon the electrical parameter measurement. The charging shall be performed in constant current constant voltage (CCCV) mode. However, change of operating mode from CC to CV during charging shall be determined on the basis of Supplier recommendations and the battery type and technology offered.

1.8.3 The battery storage shall discharge on real time basis as per functional requirement. Battery SoC shall be monitored periodically to evaluate the remaining capacity at start of discharge operation and

accordingly a constant rate of discharge will be defined. Further, an additional feature shall be provided to change/edit the discharge duration and rate of discharge whenever required.

1.8.4 BMS shall monitor battery system parameters such as string voltage & current, cumulative number of cycles and throughput along with DoD. It shall automatically determine the State of Charge (SOC) and State of Health (SOH) of the battery individual cell/module.

1.8.5 It shall also monitor utility side parameters such as voltage, charge/discharge current and protection system readings/status.

1.8.6 BMS shall automatically control the charging state of each module based on monitoring of parameters and power/energy requirements. It should charge the module in float/boost mode and/or Constant Current Constant Voltage (CC-CV) mode as per requirements of battery sub system. It shall also be designed to protect the battery cells/module/string from out of tolerance and unsafe operating conditions under any eventuality and mitigate fire risk. Further, it should regulate the voltage to limit the temperature rise in the cell.

1.8.7 The BMS shall automatically control the charge and discharge of the individual cells/module, balancing between cells/module to optimize energy consumption and range, monitor cell/module heath and provide critical safeguards to protect the batteries from damage.

1.8.8 Monitoring and storing the battery's parameters and communicating the same to SCADA/EMS.

1.8.9 Alarm and fault generation and communicating the same to SCADA/EMS.

1.8.10 Isolating the battery in cases of any emergency.

1.8.11 BMS, EMS and PCS shall be operated in coordinated manner in order to achieve the above requirement.

1.8.12 Bidder to supply the BMS system as per battery OEM recommendation & requirement and shall be in line with the application requirements. Type test report of the BMS shall also need to submit during detail engineering.

1.8.13 Bidders to deploy BMS at Battery bank/string level using HMI, Controllers, Battery Administration Unit, network & Communication Cables etc. where Battery Modules & Battery Control Boxes will communicate with Battery Administration Unit (BAU). BMS of each battery bank / string shall be integrated with EMS over MODBUS TCP/IP connection.

1.8.14 BMS should provide the necessary monitoring and control to protect the battery cells/module/string from out of tolerance ambient or unsafe operating conditions.

1.8.15 The BMS should automatically control the charge and discharge of the individual cells/module, balancing between cells/module to optimize energy consumption and range, monitor cell/module heath and provide critical safeguards to protect the batteries from damage.

1.8.16 Bidder to supply the BMS system as per battery OEM recommendation & requirement and shall be in line with the application requirements.

1.8.17 BMS shall perform high level functionalities

a. Cell/module Monitoring: Each cell voltage, Module voltage, Rack Voltage, each cell, Module & Rack current, Rack Power, Cell /Module level Temperature.
b. Cell/module Protection: Protecting the battery from out of tolerance operating conditions such as voltage, Temperature, Current etc. and BMS must provide full cell/module protection to cover almost any eventuality. The protection shall be inbuilt to avoid thermal runaway of Battery system at any condition. Isolate battery cell, Module, Rack in case of emergency.
c. Charge control: BMS shall automatically control the charge and discharge of the individual cell/module along with PCS.
d. SOC Determination: BMS shall automatically determine the State of Charge (SOC) of the individual cell/module.
e. SOH Determination: BMS shall automatically determine the State of Health (SOH) of the individual cell/module.
f. Cell Balancing: BMS shall automatically balance between cells/modules to optimize energy consumption, range and protect the battery.
g. History - (Logbook Function): Monitoring and storing the battery's parameters and communicating the same EMS.
h. Alarm and fault generation and communicating the same to SCADA.
i. Isolating the battery in cases of emergency.

1.8.18 Bidder shall deploy multi-tiered framework that allows real time monitoring and protection of the battery within the BESS not just at the cell level but at module, string, and system level. The BMS shall constantly monitor the status of battery and use applications specific algorithms to analyze the data, control the battery environment and balance it.

1.8.19 BMS at Battery bank / Container level shall provide following features / information. Bidder shall include in it's proposal all the BMS features needed for the completeness and trouble-free operation even if the same are not specifically appearing in these specifications and unless otherwise specifically excluded.

| **Features** | **Remark** |
|---|---|
| User Configuration, Login /Logout | |
| Language | English |
| Date Time | Display Date Time. Synchronization with GPS Clock |

| Features | Remark |
|---|---|
| Runtime | Display D:H:M:S from last outage |
| Day | Display Day |
| Firmware Version | Display Firmware Version |
| Battery Bank Rack Wise Status | • Charging / Discharging – Status<br>• Voltage – Value<br>• Current – value<br>• SoC – Value<br>• SoH - Value |
| Battery Control Unit | • Contactor Position Status<br>• Contactor Pre-charge Status |
| Battery Bank Summary | • Voltage-Value<br>• Current – Value<br>• SoC – Value<br>• SoH Value<br>• Charging / Discharging - Statue<br>• Bank overall Status - Normal / Abnormal Average Cell Voltage – value<br>• Average Temperature – Deg C<br>• Charging Current Limit – value<br>• Discharging Current Limit – Value<br>• Max Temp & Its Location - Value >> Rack >> Module >> Cell No.<br>• Min Temp & Its Location - Value >> Rack >> Module >> Cell No.<br>• Max Cell Voltage & Its Location - Value >> Rack>> Module >> Cell No.<br>• Min Cell Voltage & Its Location - Value >> Rack>> Module >> Cell No. |
| Rack wise Status | • Max Cell Voltage & Its Location - Value >> Module >> Cell No.<br>• Min Cell Voltage & Its Location - Value >> Module >> Cell No.<br>• Max Temp & Its Location - Value >> Module >> Cell No.<br>• Min Temp & Its Location - Value >> Module >> Cell No.<br>• Charging / Discharging – Status Voltage – Value |

| Features | Remark |
|---|---|
| | • Current – Value Insulation – Value<br>• Positive Insulation – Value<br>• Negative Insulation – Value<br>• System Status - Normal / Abnormal<br>• Pre-charge Voltage – Value<br>• Average Temperature – Value<br>• Average Voltage – Value<br>• SoC – Value<br>• SoH – Value<br>• Positive Status<br>• Pre-charge Status<br>• Negative Status<br>• Disconnector<br>• Charging Current Limit – Value<br>• Discharging Current Limit – Value |
| Rack Wise Alarms (Normal/ Warning / Alarm / Critical) | • Cell Voltage High<br>• Cell Voltage Low<br>• Total Voltage High<br>• Total Voltage Low<br>• Charging Overcurrent<br>• Discharging Overcurrent<br>• BMU Communication Fail<br>• BMU Fault<br>• Charging Temp High<br>• Charging Temp Low<br>• Discharging Temp High<br>• Discharging Temp Low<br>• Insulation Low<br>• Terminal Temp High<br>• Contactor Faulty |
| Rack wise/Battery wise Cell Voltage | • Module 1 to n >> Cell No 1 to n >> Voltage Value for each cell |

| Features | Remark |
|---|---|
| Rack wise/Battery wise Temperature | • Module 1 to n >> Cell No 1 to n >> Temp Value for each cell |
| Module Positive Point Temperature | • Module 1 to n >> temp Value |
| Rackwise Warning Limit / Alarm Limit and Critical Limit Setup | • Total Voltage High<br>• Total Voltage Low<br>• Charging Overcurrent<br>• Discharging Overcurrent<br>• Insulation Low<br>• Cell Voltage High<br>• Cell Voltage Low<br>• Charging Temp High<br>• Charging Temp Low<br>• Discharging Temp High<br>• Discharging Temp Low |
| Rack wise Alarm Info | • Date>>Time>>Alarm Values>>Alarm Description |
| Battery Control Unit Operation | • Rack Connection Status - Connected / Disconnected<br>• Rack Status - Enable / Disable Operate Command - Disable / Enable<br>• Error Code - High Voltage Difference, Type 1 Fault, type 2 Fault, High Cell Voltage, Low Cell Voltage, System Status Stop<br>• Connection Operate - Command with Status Minimum Parallel Numbers of Rack - Value with Status<br>• Emergency Stop Electrical Status - Normal / Abnormal |
| Configure Type 1 Fault | • High Cell Voltage Alarm<br>• Low Cell Voltage Alarm<br>• Cell High Temp Discharge Alarm<br>• Cell Low Temp Discharge Alarm<br>• Cell High Temp Charge Alarm<br>• Cell Low Temp Charge Alarm<br>• Module terminal Over temperature Alarm<br>• High Temp of Battery Control Unit Power Connection |
| Configure Type 2 Fault | • High Rack Voltage Alarm or Critical Alarm |

| Features | Remark |
|---|---|
| | • High Cell Voltage Critical Alarm<br>• Low Rack Voltage Alarm or Critical Alarm Low<br>• Cell Voltage Critical Alarm<br>• Cell High Temp Discharge Critical Alarm<br>• Cell low Temp Discharge Critical Alarm<br>• Cell High Temp Charge Critical Alarm<br>• Cell Low Temp charge critical Alarm<br>• Charge Over current alarm or critical alarm Discharge Over current alarm or critical alarm Low insulation resistance alarm or critical alarm.<br>• Module terminal Over temperature Critical Alarm<br>• High Temp of Battery Control Unit, Power Connection Critical BAU & EMS Communication failure<br>• Battery Control Unit & BAU Communication failure Battery Control Unit & BMU Communication failure BMU Hardware failure<br>• Contactor failure Battery Control Unit Hardware failure BAU Hardware failure<br>• Current Sensor Failure Insulation sampling failure Isolation switch Off |

### 1.9 DC Combiner Panel

1.9.1 Bidder shall deploy DC combiner panel for combining the multiple Battery Racks and reduce DC connection channels on PCS.

1.9.2 DCP shall be supplied with necessary DC Protection through DC Breaker / Fuses.

1.9.3 Bidder shall deploy sensors, controllers to measure input and output parameters like voltage, Current etc. of DC combiner panel and integrate the same to EMS.

1.9.4 The DC combiner panel shall be such that input & output termination can be made through suitable cable glands of appropriate sizes for both incoming and outgoing cables.

1.9.5 Suitable markings shall be provided on the busbars for easy identification and cable tagging shall be done at the cable termination points for identification.

1.9.6 The rating of the Copper bus bars/terminal blocks housed in DC combiner panel shall be suitable with adequate safety factor to interconnect the battery rack system.

1.9.7 Bidder shall provide the necessary fittings and structure for DC combiner panel installation.

1.9.8 Bidder shall submit the DC Combiner panel details for Owner review and approval during detailed engineering. Minimum Technical particular but not limited to are as below.

| **Particular** | **Remark** |
|---|---|
| Material | FRP / GRP with full dust, water & vermin proof arrangement |
| IP level | IP 66 |
| Temperature range (Continuous) | -50 to +150 Deg Celsius |
| Impact Resistance | IK10 |
| Gasket | Silicon / neoprene |
| Flammability rating | Fire retardant & self-extinguishing UL 94 V-0 |
| Toxicity | Halogen free |
| UV Stabilize | Yes |

## 1.10 Testing

1.10.1 The Contractor shall develop and submit to the Owner for its review and approval a comprehensive MQP that shall demonstrate that the BESS will meet the requirements of the specification. The Owner shall have the right to request reasonable changes to the test plan.

1.10.2 Where full-scale testing of larger systems at the factory may be difficult or impossible due to the large system, the MQP shall be carried out at a subsystem or module level and shall consist of tests of 100% of the subsystems or modules that comprise the complete BESS, to the extent possible. In the MQP plan, the Contractor shall clearly state what is being tested and shall fully explain any features or functions of the fully assembled BESS that would not be fully tested in the reduced-scale testing proposed. In such a case, the SAT plan shall further describe how the tests that could not be carried out in the factory will instead be carried out at the Site.

1.10.3 During factory test, bidder shall demonstrate to the Owner/Owner's representative the complete operational, functional, protectional, Local/remote and chemical test by simulating situations.

1.10.4 The BESS will not be accepted for shipment until all FATs have been successfully completed. In addition, the Owner will verify that all provisions of the contract have been met, including verification of all required submittals, any spare parts delivery, and any required system modifications.

## 1.11 Other Design Requirements

**Fire Protection and fighting system**

1.11.1 The Contractor shall design and install a fire protection system that conforms to national and local codes, good engineering practice and CEA guidelines. The fire protection system design and associated alarms shall take into account that the BESS will be unattended. If required by the type of fire protection system provided, the Contractor shall calculate and take into account the heat content of the battery cell materials in designing an appropriate fire protection system. Separate fire protection systems may be used in the battery, PCS, and control areas. For high energy density technologies, the Contractor shall also obtain thermal runaway characterization of the Containerized Battery Storage Systems.

1.11.2 In case of fire inside the container, each container shall have its own automated fire extinguishing system to suppress the fire completely.

**Disposal**

1.11.3 If any toxic substance can be emitted from the equipment during a failure, fire, or emergency or protective operation, description of the toxic nature of the substances as well as treatment for exposure to it shall be included in the O&M manual. Their treatment and disposal shall be in accordance with the New Hazardous Waste Management Rules 2022 notified by the Government of India.

## 1.12 Warranty

1.12.1 The Contractor shall provide a warranty for the entire BESS and its constituent equipment. Contractor shall procure performance guarantees from the OEM to ensure minimum performance levels for predefined application(s) as per the terms of the specification. The Warranty shall clearly indicate life expectancy given discharge profiles provided for the application.

1.12.2 The warranty period of the Containerized Battery Storage System (unit or racks) shall be not less than 12 years from the date of Commissioning of Facility.

1.12.3 For the Containerized Battery Storage System (unit or racks), the warranty shall cover parts warranty including battery nominal capacity ratings in order to meet the complete project Life condition described in this specification.

1.12.4 Warranty replacement shall be required for individual unit batteries that degrade in performance to the point at which the BESS cannot meet the requirements specified in this specification up to the End of Project Life and/or for unit batteries that materially degrade the availability, reliability, safety, or functionality of the BESS.

1.12.5 The warranty shall guarantee the availability of battery replacements delivered to the Site within 2 weeks of notification during the battery warranty period. This period, shall, however, not be considered part of the Plant maintenance outage period.

1.12.6 Additional Warranty requirements:

a) The warranty shall specify the terms and conditions of the warranty, including operating conditions requirements, procedures that must be followed, and all maintenance requirements. The warranty terms shall be easy to understand and shall be clearly stated.

b) The warranty shall provide an explicit statement as to the warranted cycle life and the warranted calendar life of the battery.

c) The warranty shall include a simple and easy to understand proration formula, if any, to be used in crediting the Owner for unused life or capacity of equipment replaced or repaired.

d) The warranty shall specify the scope of service associated with software updates. The warranty shall specify the scope of service included in replacement or repair of the equipment.

e) The warranty shall specify all labour, materials, shipping charges, and other expenses not included in the warranty.

f) The append shall specify the estimated time to complete the repairs/replacement required to restore the BESS to the warranted performance level. The time shall be given as the number of working days from the time of notice to the Contractor that the BESS has failed to meet the performance requirements.

# 2. Power Conditioning System (PCS)

## 2.1 Introduction

2.1.1 The Power Conditioning System (PCS) shall be bi-directional Inverter and shall act as an interface between the DC battery system and the AC grid. PCS shall be designed to charge & discharge the Containerized Battery Storage System in coordination with Energy Management System (EMS) and Battery Management System (BMS).

2.1.2 The PCS shall consist of solid-state electronic switch along with all associated control and protection, filtering, measuring instruments and data logging devices.

2.1.3 The PCS shall be bi-directional inverter with four quadrant operation. The PCS output shall always follow the electrical network voltage and frequency by sensing the electrical network voltage and phase, and the PCS shall always remain synchronized with the electrical network. The PCS shall use only self-commutated device which shall be adequately rated.

## 2.2 Codes and Standards

2.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC/ IEEE standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IEC 61000 | Emission/ Immunity requirement Harmonics |
| IEEE 519 | Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems |
| IEC 62116 / IEEE 1547 | Protection against Islanding of Grid |
| IEC 60529 | Ingress protection test |
| IEC 62109-1 Ed.1 | Safety of Power converters for use in Power Systems |
| IEC 62909-1 | Bi-directional grid connected power converters - Part 1: General requirements |
| IEC 62909-2 (if applicable) | Bi-directional grid-connected power converters - Part 2: Interface of GCPC and distributed energy resources |
| IEC 61000-6-2 Ed.2 | Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments |
| IEC 61000-6-4 Ed.2.1 | Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - |

| Standard | Description |
|---|---|
| | Emission standard for industrial environments |
| IEC 62116 Ed.2 | Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures |
| IEC 60068-2-1:2007 | Environmental testing - Part 2-1: Tests - Test A: Cold |
| IEC 60068-2-2:2007 | Environmental testing - Part 2-2: Tests - Test B: Dry heat |
| IEC 60068-2-14:2009 | Environmental testing - Part 2-14: Tests - Test N: Change of temperature |
| IEC 60068-2-30:2005 | Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle) |
| IEC 60068-2-52:2017 | Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution) Severity level 1 |
| Grid Connectivity | Relevant latest CEA Regulations (including LVRT/HVRT compliance) and latest Grid Code as amended and revised from time to time Indian Electricity Grid Code |
| IEC 62040-1 or IEC 62477-1 or Equivalent | General and safety requirements |
| IEEE 1547, IEC 61850(communication standard) UL 1741 (testing) | Interconnecting distributed resources with electrical power system |
| IEC 62477 part 1 & 2 | Safety requirements for power electronic converter systems and requirement: Part 1: General, Part 2: Power electronic converters from 1000 V AC or 1500 V DC up to 36 kV AC or 54 kV DC |
| IEC 61683 or, equivalent | Power conditioners - Procedure for measuring efficiency |
| IEC 60947 (1, 2, 3) | Switches / Breakers / Connectors |
| IEC 61557-12 | Power metering & monitoring devices |
| IEEE 519 | Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems |
| UL 1741 | Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources |

## 2.3 General Requirement

2.3.1 PCS shall be made of new, suitable, quality, and non-defective material. The specifications and grades of materials shall comply with the applicable Indian and International Standards.

2.3.2 The PCS shall be suitable for the Site conditions provided in project information.

2.3.3 Total capacity of inverter shall be inline with CEA regulation requirements considering Plant active power rating 25MW at interconnecting point at 132kV at 50˚ C.

2.3.4 PCS power factor shall be adjustable to range 0.8lag and 0.8lead. Operating temperature range of the PCS shall be -25˚ C to 60˚ C and Relative humidity ranges from 0 to 100%.

2.3.5 The PCS shall be immune to any kind of electromagnetic interference and shall comply with the standard IEC 61000.

2.3.6 PCS shall consist of associated control & protection and data logging devices. The PCS shall be suitable to supply three phase AC power to the Inverter duty transformer. The PCS shall be capable of continuous operation at rated output and the following variation range to suit the network condition:

a) Voltage variation: +10% to -10%

b) Frequency variation: -5% Hz to +3% Hz

## 2.4 Design Requirements

2.4.1 Bidders shall propose PCS capacity and Type (Indoor / Outdoor as well as Air or liquid cooled) after Site survey and considering the environment at Site.

2.4.2 Bidder shall propose the PCS compatible to Battery & multi winding Transformers.

2.4.3 PCS is interface between Battery (DC System) and AC Systems carrying out power conversion function i.e. AC to DC conversion during battery charging and DC to AC conversion during battery discharging. It may be a single unit or combination of parallel units.

2.4.4 The PCS, in conjunction with the control system, shall be capable of completely automatic, unattended operation, including self-protection, synchronizing, and paralleling with the utility, and disconnect.

2.4.5 Proposed PCS shall consist of solid-state devices, charge controller, associated controls and protection systems and compatible to proposed Battery & multi winding Transformers technology.

2.4.6 PCS shall supply rated power to the grid / battery for rated duration without violating the temperature rise limits.

2.4.7 The Inverter shall have suitably rated DC Contactors/Circuit Breakers to allow safe start up and shut down of the system in the DC side of Inverter.

2.4.8 The PCS shall have suitably rated in built AC Circuit Breakers to isolate the BESS from grid during abnormal conditions. AC Breaker shall have inbuilt with CT protection for each phase and earth fault protection. The AC Breaker shall be equipped with adequate protection relays, fuses, annunciations and remote operating and controlling facility through SCADA.

2.4.9 Inverter shall have emergency stop push button for tripping of inverter with complete DC & AC electric isolation.

2.4.10 The PCS shall be transformer less design with necessary provision for connecting to an external Inverter Grade Transformer for galvanic isolation.

2.4.11 Each solid-state electronic device shall have to be protected to ensure long life of the Inverter as well as smooth functioning of the Inverter.

2.4.12 Complete inverter along with cooling system shall be of proven design.

PCS enclosure & Waste heat removal - PCS enclosure must be suitable to withstand the harsh environmental conditions for complete designed life. The cooling necessary to maintain temperature of PCS within design limit will be in the Bidders scope.

In air cooled system: Waste heat rejection shall be done to ambient air. Air handling system to have filters to stop entrance of dust inside PCS. In oil cooled system: Provision to monitor coolant leaks, alarming & protection. Weatherproof & dustproof enclosure/Container of IP-54 with provisions to prevent moisture condensation, water, airborne dust, rodents, insects etc. from air intake / exhaust ports and compliant to IEC-60529 and NFPA 855.

2.4.13 Inverter shall be suitable for installation outdoor on foundation pads with shed or indoor in container enclosures/pre-engineered building.

2.4.14 Bidder shall include in it's proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, LCD, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in these specifications. PCS PCBs shall have conformal coating, industrial grade Hardware to withstand the harsh environment.

2.4.15 PCS shall contain adequate inbuilt filter bank, harmonic filters etc. for its operation without deteriorating the quality of power in terms of power factor, harmonics, transients, flicker etc.

2.4.16 PCS shall have suitable communication port for communication with EMS.

2.4.17 PCS should conform to all applicable IEC / IS and UL standards and IEEE Guidelines

2.4.18 PCS Shall be also have adequate protection against earth leakage faults. Internal Surge Protection Device (SPD – Type 1+2 ) shall be provided in the PCS on both DC and AC side. It shall consist of MOV Type arrestor. The discharge capability of the SPD shall be at least 10kA at 8/20 microsecond wave as per IEC 61643-12. During earth fault and failure of MOV, the SPD shall safely disconnect the healthy system.

2.4.19 PCS Shall have provision to be isolated from grid (AC and DC) through Circuit Breakers (Siemens, Schnider or L&T) which shall be inbuilt within the PCS.

2.4.20 Local LCD Display - PCS shall have Local LCD display to monitor various functions and parameters locally viz. charging / discharging, voltage, current, power, alarms etc. Control and read-out should be provided on the indicating panel integral to the Inverter.

2.4.21 PCS should be suitable for parallel operation of multiple PCSs to scale energy storage installations for future expansion.

2.4.22 The bidder shall ensure by carrying out all necessary studies that the PCS will not excite any resonant conditions in the system that may result islanding / tripping of Plant.

2.4.23 PCS should communicate with EMS for its optimized operation & for reporting health parameters to EMS to monitor & control.

2.4.24 Bidders to propose Modular Type of PCS preferably. Bidder shall ensure that no abnormal interaction shall take place among the various PCS modules during any grid operating condition which may result in outages. The PCS controller offered by the Contactor shall be such as to ensure stability, reliability, and a good dynamic performance.

2.4.25 Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized.

2.4.26 The inverter shall be capable of supplying reactive power as per grid requirement (automatically or manual intervention through EMS) during normal operation. However, reactive power support, beyond 0.95 pf, might be at the behest of active power.

2.4.27 Indoor PCS Arrangement - The PCS room shall be adequately ventilated to prevent temperature in the PCS room to exceed the maximum permissible limit. The Ventilation Plant capacity and air quality of inverter room shall be as per PCS and other auxiliaries' manufacturer's recommendations. Filter at the air inlet of the PCS room shall be provided to prevent dust ingress. Ventilation shall be designed such that the temperature rise of the inverter rooms doesn't exceed 3 deg above ambient. All exhaust and fresh air fans should be provided with thermostat control. In case Liquid cooled PCS are offered, Bidder to ensure that coolant is used in closed cycle. Complete inverter along with cooling system shall be of proven design.

2.4.28 PCS shall be compatible to conduct functions as mentioned below.:

a) Monitoring: BMS and EMS shall monitor Battery side parameters such as voltage, charge/discharge current, power quality parameters, protection system readings / status or any other parameter essential for monitoring health of battery. It shall also monitor parameters like charging / discharging current, power quality parameters, voltage, and protection system, etc. on the Grid side of PCS.

b) Active/ Reactive Power Control: PCS shall have capability to provide both active and reactive power separately as per requirement limited to rated MVA capacity of system and provide power in all four quadrants complied to IEEE 1547 and IEEE 519. Change in delivery of active/reactive power towards load side should be smooth over the range of 0~100%. Similarly, the change in charging current of batteries should also be smoothly controllable. PCS output power shall remain within 1% of the set value, for AC input variation of +/- 10%. PCS shall be able to provide 0.8 lead to 0.8 lag reactive power support without curtailing the active power.

c) Charge control functions – PCS shall be able to control battery Charge based upon power/energy requirements, Charge battery in float/boost /cc-cv mode as per requirement and regulate float/boost voltage in case of prescribed temperature rise of battery (OEM Recommendation) to avoid thermal runaway through EMS System (Without any manual intervention).

d) Operation Mode – PCS shall be connected with the distribution grid and operate in grid connected mode. The grid connected mode shall be the default mode and shall be capable for standalone mode as well. Beyond the voltage limits, PCS shall disconnect itself from grid automatically. After normalization of voltage condition, it shall be able to restart / reconnect automatically.

e) Ramp up and Ramp Down – PCS Shall have suitable positive and negative ramp rate to support BESS Operation in Grid Connected and islanded mode. Bidder shall study the load profile of EHV Power transformers (Grid connected Scenario) and DSS power Transformers (islanded Scenario) and propose the BESS equipment accordingly. Bidders shall consider highest ramp up/down load profile of power transformers while designing the BESS Solution.

2.4.29 PCS upon detecting a grid disturbance, transition from Grid Tied (current source) mode of operation to Micro-grid (voltage source) and back to Grid Tied (current source) mode of operation seamlessly (less than 15ms/instantly after restoration of grid). PCS shall be capable of fault ride through functionalities.

2.4.30 PCS shall be capable of supplying reactive power as per grid requirement (automatically or manual input through EMS) during normal operation. However, it should supply required active and reactive power based on load during off grid mode of operation.

2.4.31 PCS should have operational capability for grid- connected mode.

2.4.32 PCS include appropriate self-protective and self-diagnostic feature to protect itself and the Battery from damage in the event of PCS component failure or from parameters beyond the PCS's safe operating range due to internal or external causes. Faults due to malfunctioning within the PCS, including commutation failure, shall be cleared by the PCS protective devices.

2.4.33 PCS Shall be capable of starting and operating as black start (Automatically or with external command from EMS). Exercise of the black start capability shall under no circumstance result in an accidental energizing of the Host Utility's bus. PCS black start shall be possible from EMS without any setting modification at PCS panel locally.

2.4.34 Bidder shall submit the recommended Inverter Duty Transformer (IDT) vector group and inverter grounding details during Bid submission. Bidder shall also provide DC side grounding and ground fault detection details during bid submission.

2.4.35 The efficiency of the Inverter shall be equal to or more than 98 % at 75% load as per IEC 61683. Bidder shall submit the conversion efficiency curves on partial output powers for the Inverter. The bidder shall

specify the conversion efficiency at following load conditions i.e. 25%, 50%, 75% and 100% during Bid submission, which shall be confirmed by type test reports.

2.4.36 The Inverter enclosure and internals including nuts, bolts etc. shall have to be adequately protected, taking into consideration the atmosphere and weather prevailing in the area.

2.4.37 PCS Micro grid controller logic shall be customizable at any stage of its life.

2.4.38 The PCS shall have protection against any sustained fault in the feeder line /Grid.

2.4.39 PCS should be designed for volt VAR function i.e., immediate, and automatic voltage support to the grid.

2.4.40 PCS should be designed for Hz-Watt function i.e., immediate, and automatic frequency support to the grid.

2.4.41 PCS should be designed for four-quadrant energy storage applications in both grid-tied and micro-grid applications.

2.4.42 Type test certification of similar enclosure from NABL accredited lab is preferred. However, test report for IP test in accordance with IS 60529 from private lab along with calculations is also sufficient. However, if the Bidder is not able to submit report of the type test(s) conducted within last ten (10) years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional expense to the Owner either at third party lab or in presence of client/Owners representative and submit the reports for approval.

**2.5 Control and Protective Requirements**

2.5.1 The Inverter shall be complying to Statutory norms, CEA regulation and SLDC requirements. The Inverter shall be capable of supplying reactive power as per grid requirement, during BESS generation hours. The Inverter shall support load PF from 0.9 Lag to 0.9 Lead. Inverter shall have Active Power limit control, Reactive Power and Power Factor control feature. Plant operator shall be able to start and stop the inverter and shall have the control to set Active power, Reactive power and Power factor limit set points through SCADA HMI and Local Control Display Unit.

2.5.2 The Inverter shall have internal protection arrangement against any sustained fault in the feeder line and against lightning in the feeder line. Protection against short circuit, Internal Surge, loss of synchronization, over temperature, DC bus over voltage, DC reverse voltage, cooling fan failure and, earth leakage faults and any sustained fault in the feeder line.

2.5.3 Inverter system shall also include negative sequence protection such that if the balancing of 3 Phase system is failed, the protection shall envisage isolation of the Inverter from the circuit.

2.5.4 The Inverter shall have self-protective and self-diagnostic feature to protect itself and from damage in the event of Inverter component failure or from parameters beyond the Inverter's safe operating range due to internal or external causes.

2.5.5 The Inverter shall have special safety features like active Anti Islanding Detection and Isolation facility.

2.5.6 In case of grid failure, the Inverter shall be re-synchronized automatically with grid, on revival of power supply after ensuring the stability of the Grid.

2.5.7 The design and operation of Inverter shall be such as to limit the individual and total harmonic distortions (THD) within the limits as per IEEE 519.

**2.6 Constructional Requirement**

2.6.1 PCS shall be suitable for outdoor application with electronic degree of protection IP65.

2.6.2 Mounting accessories along with tools and tackles for mounting the inverter shall be supplied along with the inverter.

**2.7 Tests**

2.7.1 During Bid Submission, the Bidder shall submit all the type test reports including temperature rise test and surge withstand test carried out within last five (05) years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

2.7.2 However, if the Bidder is not able to submit report of the type test(s) conducted within last five (05) years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional expense to the Owner either at third party lab or in presence of client/Owners representative and submit the reports for approval.

**2.8 Routine Test**

2.8.1 During manufacture and on Completion, all equipment shall be subjected to the Acceptance and Routine tests as laid down in IEC/IS standard.

**2.9 Type Test**

2.9.1 Standard Operating Condition for Inverter as per CEA standards

**2.10 Test Certificates**

2.10.1 Certified reports of all the tests carried out at the works shall be furnished in requisite no. of copies as stated in the conditions of contract document for approval of the test reports.

2.10.2 The equipment shall be dispatched from works only after receipt of Owner/ Owner's representative written approval of the test reports.

2.10.3 All the type test certificates on any equipment shall be furnished for Owner/ Owner's representative approval / acceptance. Otherwise, the equipment shall have to be type tested, free of charge to prove the design.

2.10.4 Type test certificates of similar capacity of equipment furnished by the Bidder shall be dated not more than five (05) years from the date of testing.

### 2.11 Drawings, Data and Manuals

2.11.1 Documents to be submitted after award of contract.

a. Guaranteed Technical parameters (GTP)
b. GA, Cross Section Drawings
c. Schematic and Wiring diagrams.
d. Detailed Bill of materials (BOM) of each component with make & specification (as applicable) like dimension, material composition, electrical and mechanical properties, etc.
e. MPPT algorithms & control schemes
f. Visual inspection criteria
g. Harmonic Spectrum
h. Type test certificates and Reports.
i. Installation
j. O & M Manual.
k. Manufacturing Quality Plan (MQP)
l. Standard Operating Procedure (SOP)
m. PQ Capability Curve

### 2.12 Spares, Fittings and Accessories

2.12.1 All the applicable fittings and accessories shall be provided to mount and operate PCS safely without any energy loss.

2.12.2 20% or, minimum Two (02) nos. spares whichever is maximum shall be provided for each rating of Fuses, MCBs, SPDs, etc.

### 2.13 Quality Control

2.13.1 Bidder shall submit the MQAP, FAT and FQP for the PCS.

## 2.14 Warranty

2.14.1 The warranty period of the PCS shall be minimum five (05) years from the date of Commissioning of Facility.

2.14.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

2.14.3 During the warranty period, whenever a technical problem is encountered with PCS, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the inverter shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the Bidder. Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 3. Inverter Duty Transformer (IDT)

## 3.1 Introduction

3.1.1 The Inverter Duty Transformer (IDT) is used to transform the low voltage to desired medium voltage. The IDT shall be rated for 0.69/33kV. The IDT shall be supplied as per design requirement and shall be suitable for outdoor installation.

## 3.2 Codes and Standards

3.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

| Standard | Description |
|---|---|
| IS 2026 (Part I to IV),<br>IEC 60076 | Power Transformers |
| IEC 354, IS 6600 | Guide for loading of oil immersed transformers |
| IEC 60542 | Tap Changer |
| IS 5120, IS 3639 | Fittings and accessories for power transformers |
| IS 12463 | Insulating oil for transformer |
| IS 2099, IEC 60137<br>IS 12676 | Transformer Bushings |
| IS 3347 | Dimensions for Porcelain Transformer Bushings |
| IS 2629 | Recommended Practice for hot dip galvanizing of iron and steel |
| IS 2705 | Current Transformers |
| IS 2633 | Methods of testing of coating of zinc coated items |
| IEC 60296 | Transformer Oil |
| IS 3637 | Gas and Oil Operated Relay |
| IS 2026 | Power Transformers |
| IS 335 | New insulating oils – Specification |
| CBIP No. 295 | CBIP Manual on Transformers Publication |

## 3.3 General Requirements

3.3.1 Inverter Duty Transformer shall have electrolytic grade copper/aluminium windings.

3.3.2 Inverter Duty Transformer shall have 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 connections 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.

3.3.3 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.

3.3.4 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.

3.3.5 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.

3.3.6 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.

3.3.7 Inverter transformer shall be proven and of successfully type tested design.

3.3.8 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.

3.3.9 Power rating of inverter transformer shall not be less than total rated capacity of respective Inverters at any temperature within the operating temperature limits.

## 3.4 Constructional Features

3.4.1 **Tank**

a. The transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and cover shall be of welded construction and there should be provision for lifting by crane.

b. At least two adequately sized inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided, one at each end of the tank. The inspection hole(s) shall be sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

c. The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil

and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of with 2 coats of glossy, oil and weather resistant non-fading epoxy-based paint of colour shade RAL 7032.

d. The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant and oil insoluble insulating varnish of white shade.

e. All bolts and nuts exposed to atmosphere shall be galvanized. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets that shall give satisfactory service under the operating conditions for complete life of the transformer, if not opened for maintenance at Site.

f. Transformer tank shall be mounted on bi-directional rollers for rail gauge suitable as per IS / CBIP. Suitable locking arrangement shall be provided to prevent accidental movement of transformer. Tank shall also be provided with lifting lugs and minimum four jacking pad.

g. The tank together with radiators, conservator, bushings and other fittings shall be designed to withstand the following conditions without permanent distortion:

h. Full vacuum (mm of Hg – value as per latest CBIP Manual), for filling with oil by vacuum. Internal gas pressure of 0.35 Kg/cm2 (5 lbs/sq.in) with oil as at operating level.

i. The transformer shall have conservator tank of adequate capacity to accommodate oil preservation system and volumetric expansion of total transformer oil. The conservator shall be bolted into position so that it can be removed for cleaning purposes.

j. The conservator shall be of single compartment type. 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.

k. The tank cover shall be suitably sloped so that it does not retain rainwater. The material used for gaskets shall be cork, neoprene or approved equivalent.

3.4.2 **Core**

a. The magnetic circuit shall be of core type. The core shall be constructed from high grade, non-ageing, cold rolled, super grain-oriented silicon steel laminations (CRGOS) equivalent to M4 grade steels or better.

b. The insulation structure of the core to clamp plates shall be such that it withstands a voltage of 2kV (rms) for one minute in air.

c. Adequate lifting lugs will be provided to enable the core & windings to be lifted.

d. The core design shall be such as to limit the flux density to 1.7 Tesla at principle tap.

e. Transformer shall also withstand following over-fluxing conditions due to combined voltage and frequency fluctuations:

1. 110% for continuous rating

2. 125% for at least one minute
3. 140% for at least five seconds

f. Bidder shall furnish over-fluxing characteristics up to 150% during detailed engineering.

g. The transformer shall also be capable of withstanding without damage during the time, for a duration of at least two seconds the stresses caused by short circuit limited only by the transformer impedance with 110% rated voltage maintained at source end.

3.4.3 **Windings**

a. Windings shall be of Aluminium/Copper material.

b. Windings shall have uniform insulation.

c. Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.

d. The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.

e. Windings shall be made in dust proof and conditioned atmosphere.

3.4.4 **Internal Earthing**

a. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by copper strip connection to the tank.

3.4.5 **Bushings**:

a. Bushings shall be designed and tested to comply with the applicable standards. If type test certificates are not available, these tests shall also be carried out in addition to the routine tests. Bushings rated for 400A and above shall have non-ferrous flanges and hardware. Bushings shall be supplied with terminal connector clamp suitable for connecting the cables.

b. Bushings below 52 kV shall be of silicone composite / condenser / oil communicating type.

c. No arcing horns to be provided on the bushings.

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

3.4.6 **Cable boxes and Disconnecting chambers:**

a. Cable boxes shall be supplied with gland plates having holes to suit specified cables.

b. Cable boxes / disconnecting chambers shall be provided with body earth terminals.

c. LV cable boxes shall be provided with necessary LV bushings, bus bars, bus bar supports for making cable terminations.

d. HV cable boxes shall be provided with necessary HV bushings and terminals for making cable terminations.

e. Cable boxes shall be provided with suitable gaskets to ensure the specified protection class requirement (IP55). Cable boxes / disconnecting chambers shall be provided with necessary arrangements to prevent entry of rainwater into the same.

f. Disconnecting chambers:

1. Disconnecting chambers shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank.
2. Disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors / links and removable covers.
3. Phase-to-phase and Phase-to-ground clearances within the chamber shall be such as to enable either the transformer or cable to be subject separately to HV tests.

g. Internal surface of cable boxes shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.

h. Cable entry on LV side:

1. Three wire system, Bottom Entry of cables.
2. Cable shall be in bidder's Scope. Cable Gland Lugs and SS hardware for connecting cable on LT bus bar shall be in bidder scope. Bidder shall provide hole on the bottom side gland plate of HV cable box for cable entry. Cable Gland is nickel plated brass gland of double compression type of reputed make.
3. Cable size, number of runs, Cable OD shall be finalized during detailed engineering.

i. Cable Entry on HV Side

1. Bottom Entry of cable, *33* kV grade Aluminium Conductor armoured XLPE insulation.
2. Cable Gland Lugs and SS hardware for connecting cable on HT bus bar shall be in bidder scope. Bidder shall provide hole on the bottom side gland plate of HV Cable box for cable entry. Cable Gland is nickel plated brass gland of double compression type of reputed make. Cable size, number of runs, Cable OD shall be finalized during detailed engineering.

j. Neutral bushings

1. The neutrals of the star connected HV windings shall be brought out to separate bushing terminals.
2. The neutral bushings shall be provided on the tank at location that facilitates connecting to the earth chamber. Neutral shall solidly be earthed during normal operation.

k. Bushing CT

1. Shall be of adequate rating for protection (differential, REF and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings/bushing bottom (cable box); 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 lose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

l. Marshalling box

1. Marshalling box shall be tank mounted, outdoor and weather/vermin/dust proof (protection class IP55), sheet-steel (2mm thick minimum) enclosure, with hinged door having padlocking facility and painted.
2. Marshalling box shall have proper lighting and thermostatically controlled space heaters.
3. All doors, covers and plates shall be fitted with neoprene gaskets. Bottom shall be at least 450 mm above floor level and provided with gland plate and cable glands as required. Top surface shall be sloped to drain off water falling on the box.
4. It shall be in the bidder scope to provide the interconnection cabling between the marshalling box and all the accessory devices of transformer by either PVC insulated unarmoured cables routed through GI conduit (or) PVC insulated, armoured cables.
5. Necessary cable glands shall be provided at the marshalling box for the above-mentioned cables as well as for terminating the incoming cables from remote panels.
6. One dummy terminal block in between each trip wire terminal shall be provided. The terminal blocks shall be ELMEX 10 mm2 or approved equal. At least 20% spare terminals shall be provided on each panel.
7. The gasket used shall be of neoprene rubber.
8. 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.
9. Internal surface of marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.

m. Transformer oil

1. Transformer Oil shall conform to the requirements of IS:335 Transformers shall be supplied complete with transformer oil. No inhibitors shall be used in the oil.
2. In case transformer is supplied partially filled with oil, oil required for topping up shall be supplied in non-returnable sealed containers along with main consignment to avoid any shortage of oil at the time of topping up of oil at Site.

n. 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 with gun metal fittings. Sampling & drain valves should have zero leakage rate.

o. Gaskets

1. Gasket shall be fitted with weatherproof, hot oil resistant, rubberized cork gasket. If gasket is compressible, metallic stops shall be provided to prevent over compression.
2. 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, bidder 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.

### 3.5 Fittings and Accessories

3.5.1 The transformer shall be complete with oil for first filling and all standard fittings and accessories as per IS 2026 including the following:

a. First fill of oil as per IS2026 with 10% extra oil
b. Oil conservator with filling hole, cap, and air cell separator for the main and OLTC oil compartments.
c. Drain plug for conservator.
d. Magnetic oil level gauge with alarm contacts
e. Prismatic oil level indicator
f. Silica gel breather for conservator
g. Double float Buchholz relay with alarm and trip contact
h. Shut off valve for Buchholz relay on both sides.
i. Dial type oil temperature indicator with alarm, trip contacts and maximum temperature indicator.
j. Dial type CT operated winding temperature indicator with alarm, trip contacts and maximum temperature indicator.
k. Thermometer pockets
l. Pressure relief valve with trip and alarm contacts.
m. Air release vent, drain plug for radiators.
n. Flanged filter valve at top and bottom
o. Lifting lug and jacking pads
p. Rating and terminal marking plate
q. Bi-directional flanged wheels
r. Detachable radiators complete with top and bottom valves.

### 3.6 Tests

3.6.1 Type Tests:

a. Type Test of the transformer shall be carried out in accordance with IS: 2026

b. In case the transformer manufacturer has conducted all type tests required as per IS 2026 within last ten (10) years, as on the date of bid opening, the type test reports have to be submitted to Owner for waiver of conductance of such type test(s). These reports shall be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) shall have been either conducted at an independent laboratory or shall have been witnessed by an Owner's representative. Any other additional expense involved in this regard shall be on bidder's scope.

c. In case the type test for the transformer has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, the theoretical evaluation of the ability to withstand the dynamic effects of short circuit, based on the calculation and consideration of the design characteristics and manufacturing practices shall be carried out as per IS 2026-5/IEC 60076-5. Necessary design document and reference test reports related to theoretical comparative evaluation should be submitted by bidder. Any other additional expense involved in this regard shall be on bidder's scope.

3.6.2 Routine tests

a. All routine tests as per IS: 2026 shall be conducted on 100% transformers in the scope of supply of this tender.

b. In addition to the above, the following test as per procedure below has to be conducted on all transformers as per IS 2026/ CBIP:

- Oil Leakage Test on completely assembled transformer -
- 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 / $m^2$ measured at the base of the tank. The pressure shall be maintained for a period of not less than 24 hours during which time no sweating shall occur.

3.6.3 Special Tests

a. Temperature Rise test as per IS 2026

b. Tank Vacuum & Tank Pressure Test as per CBIP

3.6.4 Tests at Site:

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

- Insulation resistance test

- Measurement of Voltage Ratio
- Polarity test
- Magnetic Balance test
- Dielectric test on oil
- Physical check
- Breakdown voltage on transformer oil. Oil filtration (if Oil BDV is not satisfactory)

3.6.5 Inspection and testing of transformers.

a. Bidder shall provide inspection call to Owner for all routine, type and special tests are per relevant clauses. Prior to the call, bidder shall submit the detailed manufacturing quality plan (MQP) format for approval. Inspection shall be carried out jointly by Owner and Vendor.

### 3.7 NIFPS for Inverter Duty Transformer

3.7.1 Each transformer shall be provided with a dedicated Nitrogen Injection system. It shall act as a fast and effective fire fighter without employing water or carbon dioxide. Fire shall be extinguished within 3 minutes of system activation and within 30 seconds of commencement of nitrogen injection. Nitrogen Injection system shall consist of the following components.

3.7.2 Fire Extinguishing Cubicle placed on a plinth at a distance of about 5 m away from transformer. The cubicle shall be enclosed in civil structure (three sided with roof) of appropriate size considering ease of approach for manual operation in case of fire. The system shall be connected to the top of transformer oil tank for depressurization of tank and from its bottom through oil pipes to the steel oil tank (capacity 10% of total volume of oil in transformer). The cubicle should house a pressurized nitrogen cylinder, connected to the oil tank of transformer. The Transformer Conservator Isolation Valve (TCIV) shall be fitted between the conservator tank and Buchholz relay. The Cubicle shall be made of CRCA sheet of 2 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5. The degree of protection shall be IP55 (minimum). The following items shall be provided in the Cubicle.

a. Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
b. Oil drainpipe with mechanical quick drain valve.
c. Electromechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
d. Pressure monitoring switch for back-up protection for nitrogen release.
e. Limit switches for monitoring of the system.
f. Butterfly valve with flanges on the top of panel for connecting oil drainpipe and nitrogen injection pipes for transformer.
g. Oil drainpipe extension of suitable sizes for connecting pipes to oil pit.

h. Panel lighting and Space heater.

3.7.3 A pit / sump of appropriate size in a corner of the tank shall be provided by Owner with adequate slope to facilitate suction of the pump for complete emptying of the tank.

3.7.4 Specifications for cover of Soak oil / Burnt oil tank shall be as per below:

a. Size: 600 X 600 mm

b. Material: Cast Iron

c. Type: Heavy duty Airtight

3.7.5 A Control box shall be used for monitoring system operation, automatic control and remote operation. Separate control box for each transformer is to be provided. Enclosure of control box shall be of reputed Make only. Two or more transformer control box in one enclose shall not be acceptable. Potential Free contacts shall be available for alarm troubles for input to Substation automation system (SAS) / Power Management System (PMS). A separate hooter & emergency trip provision shall be provided in control room. Control box shall also to be connected to relay panel in control room for receiving system activation signals. Control supply voltage shall be of 220 V DC. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided. Only DIN mounted auxiliary contactors (of approved vendor) with or without add-on block are to be provided for signalling / contact multiplication etc. Use of miniature relays shall not be acceptable.

a. System ON

b. TCIV open

c. Oil drain valve closed

d. Gas inlet valve closed

e. TCIV closed

f. Detector trip

g. Buchholz relay trip

h. Oil drain valve open

i. Extinction in progress

j. Cylinder pressure low

k. Differential relay trip

l. PRD / RPRR trip

m. Transformer trip

n. System out of service

o. Fault in cable connecting fault detector

p. Fault in cable connecting differential relay

q. Fault in cable connecting Buchholz relay

r. Fault in cable connecting PRD

s. Fault in cable connecting transformer reactor trip
t. Fault in cable connecting TCIV
u. Auto / Manual / Off
v. Extinction release on / off
w. Lamp test
x. Visual / Audio alarm for AC supply fail
y. Visual / Audio alarm for DC supply fail

3.7.6 Transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipeline, between conservator and Buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator. The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer. Locking plates shall be provided for pad locking. A suitable platform and ladder shall be provided to approach Buchholz relay and the TCIV valve for manual reset. The ladder shall be pad lockable cover right from FGL to avoid unauthorized climbing in transformer charged condition and with top handrail.

3.7.7 The system shall be complete with adequate number of detectors (quartz bulb) fitted on the top cover of the transformer oil tank. Detectors shall be connected in parallel to the signal box by Fire survival cables. Fire survival cables (capable to withstand 750 deg C.) shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-2-1 or relevant Indian standards.

3.7.8 Signal box shall be mounted away from transformer main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & detectors and for further connection to be control box. The degree of protection shall be IP55 (minimum).

3.7.9 Fire Retardant Low Smoke (FRLS) cable shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshalling box to transformer conservator isolation valve connection on transformer. Separate cables for AC supply & DC supply shall be used.

3.7.10 Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

a. Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.
b. Flanges between Buchholz relay and conservator tank for fixing TCIV.
c. Pipe connections between transformer and FEC and between FEC and oil pit required for collecting top oil.

d. Butterfly valves / Gate valves on oil drainpipe and nitrogen injection pipe which should be able to withstand full vacuum.

3.7.11 On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

3.7.12 Besides automatic control, remote electrical push button control at Control box and local manual control in the cubicle shall also be provided. Tripping of all circuit breakers (on HV & LV side) associated transformer is the pre-requisite for activation of system.

3.7.13 The following electrical signals shall be used for activating the system under prevention mode/fire extinguishing mode.

3.7.14 For prevention:

a. Differential relay operation.

b. Buchholz relay paralleled with pressure relief Rise Relay

3.7.15 For extinguishing

a. Fire Detector

b. Buchholz relay paralleled with pressure relief Relay.

3.7.16 The system shall be designed to be operated manually in case of failure of power supply to the system. It shall be ensured that once the system gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PRD shall get closed only if all the connected breakers are open.

3.7.17 The supplier shall demonstrate the entire functional test associated with the following as Factory Acceptance Tests:

a. FEC, Control Box

b. Fire Detector

c. Transformer Conservator Isolation Valve

3.7.18 The performance test of the complete system shall be carried out after erection of the system with transformer at Site.

**3.8 Quality Control**

3.8.1 Bidder shall submit the MQAP, FAT and FQP for the Inverter Duty Transformer (IDT).

### 3.9 Installation & Commissioning Support

3.9.1 Supervision of erection/assembly of transformer fittings and accessories including marshalling box wiring. This shall include providing technical guidance to erection team wherever required.

3.9.2 Commissioning / service engineer(s) shall be available at Site at the time of commissioning of the Power Plant. All necessary guidance / support in overcoming technical problems (if any) related to the transformers.

### 3.10 Documents / Drawings Required

3.10.1 Following documents shall be submitted to Owner along with technical offer:

a. Filled in values/details wherever the same is asked for in Owner technical specifications
b. Confirmation of NIL deviation to Owner Purchase Specification. In case any deviation is taken, bidder shall indicate the clause no., Owner requirement as per the subject clause and the deviation taken.
c. Bidder shall provide their deviations from the original specification in the bidder deviation sheet.

3.10.2 Documents to be submitted after receipt of purchase order

a. Following documents shall be submitted for Owner approval within seven days from date of purchase order.
b. Overall General Arrangement (plan, elevation, end view) with overall dimensions and BOM.
c. Rating plate details
d. Valve schedule plate details with elevation & side view showing valve positions
e. HV cable box with disconnecting chamber, bushings, gland plate, cable termination details etc.
f. LV cable box with disconnecting chamber, bushings, gland plate, cable termination details etc.
g. Marshalling box GA (front view, side view, bill of items) and wiring diagram
h. Foundation plan
i. Bill of material of transformer (BOM)
j. Un-tanking details (removal of core and assembly from tank)
k. Type Test Reports
l. Guaranteed technical specification of transformer as per IEC/IS standards.
m. Manufacturing Quality Plan (routine tests, type tests, test certificates) covering Incoming materials, in-process checks during manufacturing, final inspection, finished goods, packing, and forwarding.
n. Manufacturing clearance shall be subject to approval of the above documents by Owner.

3.10.3 Documents to be submitted along with consignment.

a. Following documents shall be submitted to Owner at the time of delivery of the consignment:

- As built drawings of transformer
- Routine test reports on transformer
- Type test reports of transformer
- Test certificate for transformer oil
- Operations and maintenance manual of transformer in hard + soft copy

3.10.4 Support from bidder during document approval phase

a. During the phase of approval of design / engineering / quality documents (GA, GTP, BOM, MQP, Test report etc.), it will be required to hold in-depth discussions with Owner to provide clarifications through clear understanding of technical queries. (**Note**: All documents / drawings shall be supported by necessary computer inputs / outputs, wherever applicable)

### 3.11 Warranty

3.11.1 The warranty period of the IDT shall be minimum two (02) years from the date of Commissioning of Facility.

3.11.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

3.11.3 During the warranty period, whenever a technical problem is encountered with transformers, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the transformers shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

3.11.4 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 4. HT & LT Cables

## 4.1 Introduction

4.1.1 The AC cables in the Plant shall be equipped in the following,

a. Connection from Containerized Battery Storage System to Power conditioning system (PCS)
b. Connection from Power conditioning system (PCS) to Inverter Duty Transformers (IDT),
c. Connection from IDT to 33kV HT switchgear at Plant control room,
d. Connection from 33kV HT switchgear at Plant control room to 132/33kV Power Transformer,
e. Connection from 132kV Gantry at Plant to 132kV Switchyard at 400/220/132kV Kukurmara (Mirza) Grid Substation.
f. Auxiliary power cables used inside the Plant.

## 4.2 Codes and Standards

4.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

| Standards | Description |
|---|---|
| IS: 3975 | Mild steel wires formed wires and tapes for armouring of cables. |
| IS: 5831 | PVC insulation and sheath of electric cables. |
| IS: 7098 Part-I | Cross-linked polyethylene insulated PVC sheathed cables |
| IS: 7098 Part-II | Cross-linked polyethylene insulated PVC sheathed cables |
| IS: 8130 | Conductors for insulated electric cables and flexible cords. |
| IS: 10418 | Drums for electric cables. |
| IS: 10810 | Methods of tests for cables. |
| IS: 3961 | Recommended current ratings for cables |
| IEC: 60502-2 | Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV). |
| IS:398 | Aluminium Alloy Conductors. |
| IEC 60331, BS 6387, SS 299 | Fire Resistance Test |
| IEC 60332, BS 4066, IEEE 383 | Flame Retardant Test |
| IEC 61034, BS 7622, EN | Smoke Emission Test |

| | |
|---|---|
| 50268 | |
| IEC 60754, BS 6425 | Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content |
| ASTM D 2863 | Oxygen Index Test. |
| IEC:332 | Test on electric cables under fire conditions. |
| Indian Electricity Act and rules framed there-under. | |
| Regulations laid by CEA of India. | |
| Regulations laid by the office of the Chief Electrical Inspector to Government (CEIG). | |

**4.3 Design Requirements**

4.3.1 The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water. All cables shall be suitable for high ambient, high humid tropical climatic conditions.

4.3.2 Cables shall be capable of operating satisfactorily under the power supply and frequency variations, high ambient, high humid tropical climatic conditions as specified in project information.

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

4.3.4 Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be multi stranded. XLPE insulation shall be suitable for continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. For single-core armoured cables, the armouring may constitute the metallic part of insulation screening.

4.3.5 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.

4.3.6 In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them. For single core armoured cables, armouring shall be of aluminium conductors/strip. For multicore armoured cables, armouring shall be of galvanized steel strip as per relevant IEC/IS standard.

4.3.7 Insulation material shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.

4.3.8 Insulation shall be water tree retardant (TR) cross linked polyethylene insulation applied by extrusion.

4.3.9 Design ambient air temperature shall be considered as 50 deg C for sizing the electrical equipment and relative humidity of 95% maximum.

4.3.10 Method of curing for cables shall be —dry curing / gas curing.

4.3.11 Power cables shall be sized to satisfy the following Criteria:

a. Short circuit withstands capacity for applicable fault current and duration.

b. Full load current carrying capacity under installation conditions considering Site ambient temperature & Site installation (Grouping) conditions as per the manufacturer's recommendation.

c. Permissible voltage drop limits under steady state/transient state as mentioned elsewhere in this specification.

4.3.12 Power cables shall withstand the fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault.

4.3.13 Short Circuit withstands duration for conductors shall be decided during detailed engineering for all feeders.

4.3.14 The 33kV Power cables shall have aluminium (AL) conductor. All the conductors shall be multi-stranded.

4.3.15 Consider 20% Spare capacity is for each type of cable.

4.3.16 The eccentricity shall be calculated as

$$\frac{tmax - tmin}{tmax} \times 100$$

The Ovality shall be calculated as

$$\frac{dmax - dmin}{dmax} \times 100$$

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.

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

4.3.18 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.

**4.4 Specific Requirements**

4.4.1 All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added into the PVC compound of the outer sheath. The sheath shall be resistant to water, UV radiation, fungus, etc.

4.4.2 Repaired & damaged cables shall not be acceptable. Both ends of cables shall be sealed with heat shrink PVC/rubber caps.

4.4.3 All cables designed to withstand mechanical, electrical, and thermal stresses developed under steady state and transient operating conditions.

4.4.4 Cables for 415/240 V AC and 220/48/24 V DC shall be rated for 1.1 kV grade.

4.4.5 For power cables, copper conductor shall be used for current rating of up to 10 A. For higher current rating, conductor can be aluminium/copper. Minimum size of copper conductor shall be 2.5 sq. mm and aluminium conductor shall be 6 sq. mm.

4.4.6 Three core 33kV earthed grade cables shall constitute the following:

a. Circular stranded and compacted aluminium conductor.
b. Extruded semi conducting compound as conductor screen.
c. Extruded XLPE insulation.
d. Extruded semi conducting compound as insulation screen.
e. Copper tape as metallic screen for each core
f. Extruded PVC inner sheath.
g. Galvanized steel formed strip.
h. Extruded PVC outer sheath.

4.4.7 Single core 33kV earthed grade cables shall constitute the following:

a. Circular stranded and compacted aluminium conductor.
b. Extruded Semi conducting compound as conductor screen.
c. Extruded XLPE insulation.
d. Extruded Semi conducting compound as insulation screen.
e. Hard drawn aluminium strip armour
f. Extruded FRLS PVC outer sheath.
g. Separate metallic screen for insulation is required for single core armoured cable.

4.4.8 Single core 132kV Cables shall have the following requirements:

a. Circular stranded and compacted aluminium conductor.
b. Extruded semiconductor compound for conductor screening.
c. Extruded XLPE (Cross linked polyethylene) -Insulation Material.
d. Extruded Semi conducting compound as insulation screen
e. Moisture barrier
f. Insulation Metallic Screen: copper Tape.
g. Inner Sheath: Extruded PVC type
h. Armouring: Galvanized steel round strip.
i. Outer Sheath: Extruded PVC type

4.4.9 Multicore 1.1 kV earthed grade cables shall constitute the following:

a. Circular / shaped, stranded aluminium conductor (compacted for >10 sq.mm)
b. Extruded XLPE insulation.
c. Extruded PVC inner sheath.
d. Galvanized steel formed wire/strip.

e. Extruded FRLS PVC outer sheath.

4.4.10 Single core 1.1 kV earthed grade cables shall constitute the following:

a. Circular stranded aluminium conductor
b. Extruded XLPE insulation.
c. Hard drawn aluminium wire armour
d. Extruded FRLS PVC outer sheath.

**4.5 Cable Identification System**

4.5.1 In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed/printed on the outer sheath at an interval of one meter throughout the length of cables.

a. Manufacturer's name and or trademark.
b. Year of manufacture
c. Cable code
d. Type of cable and voltage class.
e. Nominal cross section area of conductor and no. of cores.
f. Progressive sequential length making.
g. Name of the Owner:
h. Cables shall be marked as having FRLSH outer sheath at every five (5) meters.
i. The embossing/printing shall be progressive, automatic, in line and marking shall be legible and indelible.

**4.6 Cable Drums**

4.6.1 Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with waterproof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails to eliminate ingress of water during transportation, storage, and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418. Each drum shall carry manufacturer's name, Owner's name, address and contract number, item number and type, size and length of cable and net gross weight stencilled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

4.6.2 All the cables shall be in bidder scope, which includes the additional cable requirement and the cables utilised for testing purpose. No additional payment shall be provided by the Owner for additional cable requirement. Cable joints shall be avoided.

**4.7 Tests**

4.7.1 Cables offered shall be type tested and proven type. Routine tests shall be carried out on 100% drums. Acceptance tests shall be carried out on no. of drums selected on random basis in the lot as per IS 7098 Part-I (Appendix-A) & Part-II (Annexure-D), of each type and size of cable of each lot. Cable manufacturer shall provide the Type Test & Special Test reports as per Clause. No. 12.2 of IEC-62067. Size shall mean area of cross section in sq.mm read in conjunction with the number of cores. Type shall mean type of insulation, sheath, volt grade FRLS/FR etc. Type test reports shall be latest, and validity of type test reports shall be as per CEA guidelines.

4.7.2 The tests mentioned below are indicative. The cables shall be tested for any other tests mentioned in relevant IS including the latest amendments.

4.7.3 Type Test

a. Tests on conductor (as per IS 8130)
   1. Resistance test
   2. Wrapping Test for Aluminium
   3. Tensile test (for aluminium)

b. Tests for Armour wires (as per IS 3975)

c. Tests for thickness of insulation and sheath

d. Physical tests for insulation
   1. Tensile strength and elongation at break
   2. Ageing in air oven
   3. Shrinkage test
   4. Hot test
   5. Water absorption test (gravimetric)

e. Physical test for outer sheath (as per IS: 5831)
   1. Tensile strength and elongation at break
   2. Ageing in air oven
   3. Shrinkage Test
   4. Hot deformation
   5. Heat shock test
   6. Loss of mass test in air oven
   7. Thermal heat stability test (as per IS: 5831)
   8. Bleeding and blooming test

4.7.4 Acceptance Test

a. Conductor resistance test

b. Test for thickness of insulation and sheath
c. Wrapping test
d. Hot set test for insulation
e. Tensile strength and elongation at break test for insulation and outer sheath
f. Partial discharge test (for screened cables)
g. Partial discharge test (for HT screened cables)
h. High voltage test
i. Insulation resistance (volume resistivity) test

4.7.5 Routine Test

a. Conductor resistance test
b. Partial discharge test
c. High voltage test
d. Damp Heat Test
e. High temperature test
f. Thermal endurance test

4.7.6 Special Test

a. Oxygen index test as per IS 10810 Part-58
b. Temperature index test as per IS 10810 Part-64
c. Acid gas generation test as per IS 10810 Part-59
d. Smoke generation test as per IS 10810 Part-63
e. Flammability tests as per IS 10810 Parts-53 and 62
f. Flame retardant test as per IS 10810 Part-61
g. Ultraviolet resistance test as per ASTM-G-53
h. Dielectric strength retention test
i. Water absorption test (by electrical method)
j. Test for Anti-rodent and Anti-termite property

4.7.7 Site Test: The following minimum tests/ checks shall be conducted at Site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a. Insulation resistance test
b. High voltage test
c. All cables before laying shall be tested in cable drum at Site. After laying of cables, it shall again be tested to check for any damage of cable during laying.

## 4.8 Drawings & Documents

4.8.1 The following drawings and documents shall be submitted for approval during detail engineering stage.

a. Technical data sheet.
b. Cable cross-sectional drawing.
c. Short circuit withstands calculation of metallic screen and conductor.
d. Component list & Bill of Quantities.
e. Erection and commissioning procedures along with de-rating factors.
f. Catalogues / drawings / leaflets for all items.
g. General Instruction for Operation and maintenance manual.
h. Test reports along with type test reports.
i. Sub-vendor list – Source of raw material.
j. Manufacturing quality plan.
k. Conformity Certificates to be submitted (from NABL accredited lab)

# 5. HT Switchgear

## 5.1 Introduction

5.1.1 The HT Switchgear panel is used to pool multiple IDT feeders from the Plant. The Switchgear shall consist of Vacuum circuit breaker of 33kV voltage level and associated protection relays and control circuits.

## 5.2 Codes and Standards

5.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IS: 2705 | Current transformers -Specification (Part I to IV) |
| IS: 3156 | Specification for Voltage transformers (Part I to IV) |
| IS: 3231 | Electrical relays for power system protection. |
| IS: 3427 | A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and up to Including 52 kV. |
| IS: 5578 | Guide for marking of insulated conductors |
| IS: 6005 | Code of practice for phosphate of iron and steel |
| IS: 9385 | HV fuses |
| IS: 9431 | Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 Volts up to and including 300 kV |
| IS: 11353 | Guide for uniform system of marking and identification of conductors and apparatus terminals. |
| IS: 13118 | Specification for high voltage alternating current circuit breakers |
| IS: 12729 | Switchgear & Control gear for voltages exceeding 1000 V – General requirements |
| IS: 10624 | High voltage fuse-links for motor circuit applications |

| Standard | Description |
|---|---|
| IS: 9920 | High Voltage Switches for Rated Voltages above 1 kV and less than 52 kV |
| IS: 14666 | High voltage alternating current switch fuse combinations. |
| IS: 12534 | Application guide for the selection of high voltage fuses for transformer circuit applications |
| IEC 62271-200 | High-voltage switchgear and control gear |
| IEC-62271-100 | High-voltage switchgear and control gear alternating current circuit breakers. |
| IEC-62271-106 | High-voltage switchgear and control gear - Part 106: Alternating current contactors, contactor-based controllers, and motor-starters |
| IEC-60099 | Non-linear resistor type gapped surge arrestor for AC systems |
| IEC- 62271-102 | High-voltage switchgear and control gear – Alternating current disconnectors and earthing switches |

### 5.3 Design Requirements

5.3.1 Design ambient air temperature shall be considered as 50°C for sizing the electrical equipment and relative humidity of 95% maximum.

5.3.2 Power supply shall be as per bidder's auxiliary power supply philosophy.

5.3.3 **Insulation level**

a. One (1) minute Power Frequency withstand voltage for 33 kV

b. 1.2/50 Micro sec(µs), impulse withstand voltage for 33 kV

5.3.4 **Short circuit withstand rating:**

a. Circuit Breaker (VCB) : 25 kA for 3 sec

5.3.5 **Internal arc withstand rating:**

a. 33kV switchgear Panel : *As per system fault current*

5.3.6 **Current Rating**

a) Ambient temperature prevailing inside the switchgear while carrying rated current, when the outside air ambient temperature is 50ºC shall be considered as Design ambient temperature

for sizing the equipment/device/bus rating. Temperature rise shall be as per applicable IEC/IS standards. A design margin of not less than 10% shall be considered for sizing various devices.

5.3.7 **Control supply and space heater supply.**

b) For all the feeders control supply voltage shall be 220 V DC. For each 33kV pooling switchgears, 2 Nos. 220 V DC control supply shall be provided.

c) For each switchgear, 240 V AC supply shall be provided for auxiliary supply. For each panel space heater, cubicle lamp & socket, rated for 240 V AC supply shall be provided.

d) Thermostatically controlled space heaters shall be provided separately to keep the ambient temperature under control inside the enclosure to prevent condensation. Space heater material shall be of SS. The heaters shall be located such that wiring, buses and control devices do not get overheated.

e) For each switchgear board, 1 No of 240V UPS supply shall be provided.

5.3.8 **Controls**

a) HV Switchgears shall have Vacuum circuit breakers.

b) All feeders shall be controlled from SAS / SCADA from the switchgear. All the protection and safety interlocks shall be hardwired in the Switchgear itself.

c) The incomer modules shall be interlocked with their upstream breaker such that they can be closed only when upstream breaker is closed and trip automatically when upstream breaker is tripped or manually opened.

d) All HT switchgear panels shall be provided with pad lock and key arrangement with key rack.

e) Local / Remote selection shall be provided in switchgear. Local selection is envisaged for local operation from Switchgear. Remote selection shall enable starting from SAS/SCADA.

f) All analog signals, digital signals shall be grouped at one place in each panel for cabling to SAS.

g) All hardware/software required for interfacing with the SAS system shall be supplied by the Bidder.

a. 20% of control terminals in each feeder shall be provided as spare subject to a minimum of 2 terminals.

b. Each Equipment with MODBUS protocol shall have unique identification address for communication. The Slave address shall be provided by bidder during detailed engineering.

c. MODBUS data address of all the signals shall be populated and submitted to the Owner to configure in the SCADA.

5.3.9 **Communication:**

a. The Numerical relay shall communicate on IEC 61850 Protocol for data exchange, DFR file transfer and Relay parameterization.
b. All meters shall communicate on MODBUS-RS 485 protocol. Twenty-meter devices shall be connected in one MODBUS loop.
c. MOBUS -RS 485/MODBUS-TCP/IP converters shall be provided as required. The converter shall be connected to the Ethernet switch.
d. IEC 61850/Ethernet Switch shall be provided and mounted in the Switchgear panel suitably.
e. CAT 6 cable shall be used for IEC 61850 & TCP/IP communication.
f. Twisted Pair Cables shall be used for RS 485 communication.

## 5.4 Specific Requirements

### 5.4.1 Switchgear Construction

a) The switchgear shall have a single front, single tier, fully compartmentalized, draw-out type, metal clad construction complying with clause No. 3.109.1 of IEC-62271 part 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 busbar, and auxiliary control devices. The adjacent panels shall be completely separated by steel sheets except in busbar compartments where insulated barriers shall be provided to segregate adjacent panels.
b) The circuit breakers and bus VTs shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position. Withdrawable bus VTs shall be preferably on front side of the panel board.
c) The trucks shall have distinct Service, Test / 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. While switchgear designs with doors for breaker compartments would be preferred, standard designs of reputed switchgear, provided the breaker compartment is completely sealed from all other compartments and retains the IP-4X (minimum) degree of protection in the Isolated position.
d) The switchgear assembly shall be dust, moisture, rodent and vermin proof with the truck in any position Service, Test / 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.
e) Circuit breakers, LV compartments, busbar chamber & cable termination chamber etc. shall be housed in separate compartment within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units. 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 Owner's approval during detail engineering.

f) The VT/ relay compartments shall have degree of protection not less than IP52 in accordance with IS:13947. However, remaining compartments can have a degree of protection of IP4X (minimum). No louvers/opening shall be provided on the top of the panel. All other 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.

g) Enclosure shall be constructed with rolled steel sections and cold rolled steel sheets of at least 2.0 mm thickness, Gland plates of minimum 3 mm thick, shall be made out of hot rolled or cold rolled steel sheets and for single core cables, it shall be nonmagnetic material.

h) The switchgear shall be cooled by natural air flow up to 2500 Amp rating, and forced cooling accepted above 2500 Amp rating. In case of force cooling air flow and temperature monitoring system integrated to SCADA system shall be provided.

i) Total height of the switchgear panels shall not exceed 2500 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 700 mm from bottom of the panel base. All relays, meters, indicating lamps, switches etc. shall be flush mounted on the respective cubicle front door.

j) Safety shutters complying with IEC-62271 part 200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to TEST and ISOLATE position. The shutters shall move automatically, through a linkage with the movement of the truck. Pressure relief device shall be provided for each HV compartment to vent out safely the gases produced in case of fault.

k) The switchgear shall have the facility of extension on both sides. Complete design detail of switchgear such as busbar cross sections, enclosure material, enclosure dimensions, Flange, connection arrangement, bolt spacing & dimension, Gasket detail etc. Further manufacturer supplying equipment under present scope shall furnish all the required details in addition to mentioned above necessary for design and successful implementation of an adaptor / interface module / panel during later stage while extending switchgear board by any other manufacturer, without any help of manufacturer who has supplied the equipment in present scope. The details are to be furnished during detail engineering stage.

l) Electrical Insulating mat (as per IS: 15652) shall be provided for all the panels (in front as well as back of the panel).

m) For each transmission line/Cable and spare Feeder, gland plate/holes shall be designed to accommodate 3 runs of 3 core of required cable size of aluminium cable. However, this detail may change during detail engineering and b

n) Bidder shall accommodate the same without any extra expense to the Owner.

o) Similar equipment and components shall be of same make. Equipment of same type and rating shall be interchangeable.

p) Tariff metering (CT/PT, TTB's, MCB's, 220V DC supply, Supply selection switch, UPS supply, ABT Meters and its accessories etc.) with required sealing arrangement front (Top Bottom), Rear (Top Bottom) shall be provided for each feeder. All communication ports (RS-485 and LAN Ports) of ABT Metering system shall be brought to Control cubicle of respective panel for future connections (as metering compartment of will be sealed by concerned authorities and we intend to have access of ABT meter communication ports.). If required separate panel shall be provided for metering.

q) MIMIC with Semaphore to be provided. MIMIC shall indicate symbols of transformer, bus PT, and normal power flow arrow. Details of MIMIC will be finalized during detailed engineering.

r) Breaker local / remote switch status shall be integrated to SAS/SCADA.

s) Cable trench of HT panel board shall be designed after considering adequate margin of cable bending radius.

t) Cable entry in the trench shall be at least above 1000mm to HFL (High Flood Level)

u) Spare feeder shall be suitable for universal application (Transformer / Transmission line) etc. (Functionality of various panels shall be available in this panel)

v) Annunciator with SAS/SCADA integration to be provided for each compartment. (4 Nos of Spare window is to be provided in each annunciator)

w) All Gland plates shall be supplied in pre-drilled condition at Site.

x) Seismic Zone as per IS 1893 compliance for switchgear.

y) MFM and PQM shall be provided with TTB. (3 element, 4 wire)

z) 20% Spare TB’s are to be provided for each type of TB type wise & terminal station wise e.g. breaker, CT, PT, supply, etc. (subject to minimum two TB’s). All control terminals shall be of Stud type (screw drive operated) and control wiring shall be terminated with ring type lugs.

aa) Compartment internal wiring truff fill factor shall not be more than 50%.

bb) LV compartment of the panel shall be spacious for any future requirement. (Minimum 20% additional space must be available)

cc) Common Hooter system is to be provided for each switchgear board.

dd) Drawing pockets shall be provided for each compartment.

ee) LED indicating lamps shall be true colour cluster type.

ff) Station Service Transformer feeder philosophy shall be same as HT feeder with ABT metering panel including CT & VT (if applicable).

gg) All protective relay panels shall be provided with test blocks for online testing (Secondary injection) without disturbing wiring. Adequate numbers of multi finger test plugs shall be provided.

hh) Switchgear shall have adequate space for mounting differential relay for future use on front door and shall have adequate space at the back side of the said relays (within panel/switchgear) for interconnecting arrangement within the panel. Transmission line feeder shall have space provision for installation of PS class CT for future requirement.

5.4.2 **Internal Arc withstand requirements.**

a) The HV switchgear shall be arc resistant type and it shall also be effective during the process of inserting the switching devices and/or VT's into the service position or withdrawing the switching devices and / or VTs into the test position.

b) The switchgear, as per IEC-62271-200, shall be:

- Designed to provide loss of service continuity classification LSC2B-PM
- Internally arc tested front, lateral and rear (FLR) i.e. IAC A FLR for an arc fault current as specified to meet the requirements of Annex A IEC 62271-200 (criteria 1 to 5)

c) The segregation shall be designed to prevent arcs, smoke and/or vaporized metal from going directly or indirectly from one compartment to another so as to prevent the fault or its effects spreading to other compartments.

d) Compartmenting shall be such that maintenance can be carried out safely on one (1) circuit with other adjacent circuits still in service.

e) HV switchgear shall comply with IEC 60298 with regards to mechanical strength in the event of internal arc. Viewing glass windows shall have the same strength as the enclosure against Internal Arc.

f) The arc detection system shall be of the light sensitive/current sensitive type or pressure switch based and shall detect and isolate only the faulted bus section of the switchgear so that healthy bus section continues to operate satisfactorily. The fitting of the arc detection system does not nullify any of the switchgear type tests. Preferences shall be for an arc detection system which indicates the location of the fault.

5.4.3 **Bus and Bus Taps**

a) The main buses and connections shall be of high conductivity Copper / Aluminium alloy sized for specified current ratings with maximum temperature limited to 90°C and 105°C for silver plated joints. The busbars shall be designed for specified short circuit rating.

b) All bus connections/joints shall be silver plated. Adequate contact pressure shall be ensured by means of two bolts connection with plain and spring washers and lock nuts. Bimetallic connectors shall be furnished for connections between dissimilar metals. The auxiliary contacts shall be silver plated with minimum thickness of 10 microns.

c) Busbar insulators shall be epoxy cast resin type designed to withstand stresses due to maximum short circuit current. Bus insulator shall be flame-retardant, non- hygroscopic track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded Fiberglass etc.

d) Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating heat shrink sleeves for busbars and cast-resin shrouds / silicon rubber shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchgear and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.

e) Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly. However, where busduct termination is envisaged, sequence of R,Y,B shall match with the R,Y,B sequence of equipment on the other end of busduct.

f) The busbar chamber shall be without seal off bushing between the panels, However, Bus chamber shall be totally enclosed & separated from all other chambers and shall be provided with epoxy case seal-off bushings through which the buses shall pass so as to prevent fire from bus chamber to other chambers.

g) Creepage distance for bus bar insulators shall be 31mm/kV.

5.4.4 **Circuit Breaker (CB)**

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

b) Surge arrestor shall be provided for each feeder.

c) Circuit breaker shall be restriking free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker. Spring charging motor winding shall be provided with Class -E or better insulation.

d) Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre-trip and post trip conditions.

e) Master trip relay – 86 trip circuit supervision shall be provided (in set and reset conditions).

f) Self-reset type lockout relay to be provided on Bus PT panel for under voltage tripping of all feeders.

g) Each breaker feeder shall be provided with the following as a minimum:

- Anti-pumping relay
- Motor charged spring operating mechanism with spring charged limit switches & required number of contacts.
- Manual spring charging facility
- Mechanical indication for spring charged condition
- Mechanical indication for circuit breaker ON / OFF status and circuit breaker positions (SERVICE / TEST/ ISOLATED) each with having required number of contacts for interlocks.
- Closing coil and tripping coil
- CTs for protection
- Mechanical ON / OFF provision of circuit breaker
- Circuit breaker operation counter
- Position of earth switch (as applicable)
- Phase barriers
- Shutter assembly and Mechanical / Electrical interlocks

5.4.5 **Current Transformer (CT)**

a) The CTs shall be mounted on the switchgear stationary parts. The CTs shall be of cast resin, bar primary type and of Class E or better insulation. CT secondary current shall be 1 Amp.

b) CTs shall be rated for switchgear fault level for 1 sec and conforming to accuracy class mentioned below: -

- Class PS for differential relaying and REF protection
- Class 5P20 for other relaying
- Class 0.2s for ABT metering and general metering (Energy Accounting) with ISF<5

c) Separate cores shall be provided for metering and protection applications. Core balance CT and associated relay combination shall be such as to ensure a pickup sensitivity of 10 A primary ground fault current for all the outgoing feeders.

d) Space for installation of PS class CT for future use in 132 kV Transmission Line feeders shall be provided for use 132 kV Line differential relay (if applicable).

5.4.6 Voltage Transformer (VT)

a) Voltage transformer shall be cast-resin, draw-out type from the front of the panel. Bus VT shall be mounted on adopter panel of bus coupler or shall be provided in separate panel. Line VT shall be mounted on the breaker carriage itself / below the breaker compartment. Separate cores shall be used for metering and protection. Voltage Transformer mounted on breaker carriage is not acceptable. Over voltage factor shall be considered resistance grounded system as 120% for continuous duty and 190% for 8 hours.

b) Accuracy class of the voltage transformer shall be Class 0.2 for metering. Number of cores shown in SLD is indicative and shall be finalized during detail engineering.

c) High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position. Automatic shutters shall be for safety purpose to avoid accidental access to live parts on VT withdrawal and entry of rodents. Low voltage side MCB's shall be provided.

d) Fuse failure relay on voltage balance principle shall be provided for all Bus VT's for monitoring the healthiness of primary fuse/secondary MCBs. For line VT's fuse failure relay shall be provided on the secondary side of the voltage transformers to monitor failure of MCBs. The relay shall initiate alarm and block the tripping etc., which shall operate in case of VT fuse/MCB failure.

e) VTs shall be provided with one delta winding with provision for harmonic suppression arrangement.

5.4.7 **Relays**

a) Each breaker module shall be provided with multifunction numerical relay for protection.

b) Relays in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent and dust tight removable cover from the front.

c) The Numerical relays shall have built in protection, control, metering, monitoring, disturbance recorder and communication facility. The Numerical relays shall be networked through Ethernet switch, Gateway/Data Concentrators and shall be further integrated with SAS based electrical monitoring system (for monitoring, measuring, fault data analysis & relay parameterization).

d) All numerical relays shall be draw out / withdrawable type.

e) All the numerical relays shall have two communication ports; local front port communication to laptop and a second port (RJ45/Fiber optic) on IEC 61850 to communicate with the data concentrator through LAN and Ethernet switches.

f) The successful bidder shall be fully responsible for selection of appropriate relay to provide optimum protection and discrimination of various circuits and equipment including the safety of the devices.

g) All hardware and licensed software required for communication of relays, parameterization, down load / analysis of fault data from relays and interfacing the relays with the SAS system shall be supplied by the Bidder complete with set of cables, accessories, etc.

h) All relays and timers shall be rated for control supply voltage of 220 V DC 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. Interrogation voltage for the binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages.

i) Failure of a control or auxiliary supply and de-energisation of a relay shall not initiate any circuit breaker operation. All relays shall withstand a minimum test voltage of 2 kV AC rms for one minute.

j) Relays shall have separate output for individual functionality and the master trip shall be software configurable in case of multi output relays. Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.

k) All the protective relays shall have inbuilt lock-out (86) facility with manual reset. For all feeders and incomer, a separate lockout relay shall be provided with manual reset. Each circuit breaker feeder shall be provided with, protective relay trip circuit supervision relay, necessary auxiliary relays, timers, etc. to meet circuit requirements.

l) Master trip relay shall be bistable relay with remote reset and its coil supervision system. Lock out relay function contacts shall only be provided for protection trip & reset status for use in close and trip interlocks of the circuit breaker.

m) Comprehensive single numerical relay shall have provision of both current and voltage inputs. The overcurrent relay shall have provision for 3 nos. CT input for phase fault and 1 CT input for earth fault and 1 CT input for CBCT. Relay shall be suitable for both residually connected CT input as well as CBCT input. The voltage-operated relay shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current of 1 A / 5 A selectable at Site.

n) Synchro check numerical Relays shall be provided for incomers and all the outgoing feeders (other than service transformers) and shall have provision of two sets of voltage signal inputs for the purpose of synchronization.

o) All CT and PT terminals shall be provided as fixed type terminals on the relay to avoid any hazard due to loose connection leading to CT opening or any other loose connection. In no circumstances Plug In type connectors shall be used for CT/ PT connections.

p) All numerical relays shall have keypad / 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.

q) Relays shall have suitable output contact for breaker failure protection.

r) Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures.

s) Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC/ ANSI programmable characteristics.

t) For breaker control from SAS/Respective control system, hardwired potential free contacts shall be provided from SAS/Respective control system to the numerical relays.

u) 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 provided as required. Auxiliary relays for interlocking purpose shall be of self-reset type. However, separate auxiliary relays are to be provided wherever mentioned.

v) Bus no volt condition shall be configured to an output contact of the relay of all incomers and shall be wired up to TB.

w) Timer functions shall be programmable for on/off delays.

x) 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.

y) 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.

z) 150-time tagged events/ records should be able to store with time stamping last 5 faults storage including the indication, protection operated, fault location relay and operating time, currents, voltage and time. All Setting parameters, Fault data, waveforms & event logs shall be stored in Non-volatile memory only.

5.4.8 Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be available on the user interface

5.4.9 The alarm/status of each individual protection function and trip operation shall be communicated to Data concentrator/SAS/Respective control system. The numerical relay system shall have built-in features/hardware interface to provide such inputs to Data concentrator / SAS/Respective control system for analog/digital.

5.4.10 Sequence of events shall have 1 ms resolution at device level.

5.4.11 Measurement accuracy shall be 1 % for RMS Current and voltage.

5.4.12 It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.

5.4.13 Relay shall be suitable to accept both AC & DC supplies with 240 V AC and 220 V DC with tolerance of 80% to 120 % of rated voltage

5.4.14 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. All IOs shall have optical isolation. Analog inputs shall be protected against switching surges, harmonics etc.

5.4.15 No separate earth bus shall be required for the relays. It shall be possible to connect the relay earth to the common earth bus in the switchgear panel which shall be connected to the Substation earth mat.

5.4.16 Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

5.4.17 Relays shall be rated for operation on 110 V VT secondary voltage.

5.4.18 Auxiliary supply voltage for Relays and meters shall be 220 V DC. The switchgear shall be provided with DC fail relay and DC fail indication lamp for each DC control supply incomer.

5.4.19 Station Service Transformer feeder shall have separate auxiliary (interposing) relay e.g. Buchholz, PRD, MOG, WTI (for each winding), OTI etc. One contact of relays each allocated for SAS and annunciator integration and one spare contact wired up to TB for future use shall be provided. Auxiliary relay shall have flag.

5.4.20 Breaker auxiliary contacts shall be used directly. In case contact multiplication is inevitable (only if OEM is not supporting number of auxiliary contacts required) then mechanically latched electrically operated contact multiplication relays. 4 NO + 4 NC spare breaker auxiliary contacts wire up to TB for future use shall be provided.

5.4.21 All main protective relays shall be numerical type with IEC 61850 communication interface and should have interoperability during integration of numerical relays to communicate over IEC 61850 protocol with RTU/SCADA/IEDs of different OEMs.

5.4.22 Numerical relay shall have the following features:

- Type of relays shall be latest numerical high-end version with highest display size and features available in make and its product range.
- At least two group of settings
- Min. no. of LEDs - 10 (Minimum 2 LED's for future use)
- LCD/LED Screen
- Front keypad for Parameter / Navigation.
- In built lockout function with front key resetting.
- EMC Compatible.

- No adopter / Convertor is acceptable.
- At least 10 disturbance recorder
- At least 5 Fault recorder
- Event recording at least 50
- Unlimited logic gates
- In-built timers
- Freely programmable DI / DO. (Min 4 DI/DO for future use wired up to TB)
- In built CB control function with interlocking.
- Goose messaging for inter tripping command and interlocking in addition to hardware interlocking.
- Non -Volatile memory with battery backup or suitable arrangement
- Time synchronization
- self-diagnosis / watchdog / relay failure – two output contacts shall be configured. One for SCADA and one for local panel annunciator.

5.4.23 Earth fault protection relay shall initiate tripping of associate breaker.

5.4.24 Requirements of protection, control and supervision functions of various feeders shall include the following. The same shall be achieved using numerical relays:

a) Incoming feeder

- IDMT & DMT overcurrent protection (50/51)
- IDMT & DMT earth fault protection (50N/51N)
- Directional Overcurrent (67) and Directional Earth fault relay (67N)
- Two stage Under voltage protection (27-A, 27-B)
- Two stage Over Voltage (59-A, 59-B)
- Local Breaker Backup (50LBB)
- Cable differential (87C) (if applicable)
- Transformer differential (87T) (if applicable)
- Transformer restricted earth fault protection (64REF) (if applicable)
- Transformer neutral earth fault protection (50G/51G) (if applicable)
- Under frequency (81U) and over frequency (81O)
- Bi-stable Master Trip Relay
- Trip Circuit supervision of VCB in open and Close Condition
- Trip circuit Supervision of master trip relay in set and reset condition.
- Anti-pumping Relay and DC Fail Relay.
- Interposing relay for close and open.
- Bay Control Unit.

- Annunciator.

b) Outgoing feeder

- IDMT & DMT overcurrent protection (50/51)
- IDMT & DMT earth fault protection (50N/51N)
- Under voltage protection (27)
- Over Voltage Protection (59)
- Local Breaker Backup (50LBB)
- Cable differential (87C) (if applicable)
- Transformer differential (87T) (if applicable)
- Transformer restricted earth fault protection (64REF) (if applicable)
- Transformer neutral earth fault protection (50G/51G) (if applicable)
- Auxiliary relays (separate) for WTI-HV, WTI-LV, OTI, PRV, Buchholz, MOG etc.
- Bi-stable Master Trip Relay
- Trip Circuit supervision of VCB in open and Close Condition
- Trip circuit Supervision of master trip relay in set and reset condition.
- Anti-pumping and DC fail Relay.
- Interposing relay for close and open.
- Bay Control Unit.
- Annunciator Relay

c) Bus PT shall have the following protections.

- Two stage Under voltage and over voltage protection
- Voltage displacement protection
- Fuse failure relay

5.4.25 **Control and Interlocks**

- The circuit breaker will normally be controlled from SAS/Respective control system. The control switch located on the switchgear / relay would normally be used only for testing of circuit breaker in TEST position.
- The incomer modules shall be interlocked with their upstream breaker such that they can be closed only when upstream breaker is closed and trip automatically when upstream breaker is tripped.
- The circuit-breaker shall have three distinct positions as follows:
  i. ‘Service’ both power and control contacts connected.
  ii. 'Test' Power contacts isolated; control contacts connected.
  iii. 'Isolated' both power and control contacts isolated.

- Circuit breaker control switches shall be 3-position spring return to `neutral' from both close and trip positions. They shall have `Pistol Grip' handle. The contacts shall be of silver plated, air break type. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.
- 'Red', 'Green' and 'Amber' indication lamps shall be provided on the panel to indicate breaker 'Close', 'Open' and 'Auto-Trip' position. In addition to above, mechanical indicator shall be provided which shall be clearly visible to the operator standing in front of the panel.
- Indication lamps to show the circuit-breaker 'Service' and 'Test' positions shall be provided. Further additional indication lamps shall be provided as per scheme requirement.
- Indication lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. Lamps shall have translucent lamp-covers as warranted by the application.
- 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. These facilities shall be accessible only after opening the compartment door.
- The control / interlock schemes for various types of feeders shall be commensurate with their application. Contact multiplication, if necessary to meet the above contact requirement, shall be done through electrical reset latch relay.
- Breaker Panel with forced cooling shall have an online real-time air flow, and breaker compartment temperature monitoring system, and the same shall be integrated into SAS/SCADA/BCU etc.
- Potential free contacts for indications /alarms /SOE points shall be provided in each Breaker panel for remote panel/SAS/Respective control system which shall include the following:
    I. Potential free contacts for remote SAS for Breaker on, Breaker off, Breaker in remote, Breaker in service, Ready to start, lock out relay operation, Trip circuit trouble, PT fuse failure, switchgear disturbed, relay fault etc.
    II. Potential free contacts for interfacing with Bus transfer panels and other upstream/downstream breakers.
    III. For Transformer feeders, potential free contacts for remote SAS for OTI alarm, WTI alarm, Buchholz alarm, Oil level low alarm, OTI Trip, WTI Trip, Buchholz relay trip, Pressure relief device operated, MOG etc.
    IV. For each PT panel, potential free contacts for remote SAS for Bus under voltage relay operated, Bus PT fuse failed, DC supply failed, Bus PT not in service etc.

**Multi-Function Meters (MFM)**

5.4.26 Multifunction meters and energy meters shall be provided as indicated in the Single line diagram. General purpose metering CT of 0.2s class for PQM and MFM meter shall be provided for each feeder and fed from bus PT (0.2 Class).

5.4.27 Energy accounting and audit meters shall meet CEA regulations. It shall be integrated with integrated energy management system. The energy audit meters shall be suitable for measurement, recording and display of cumulative active energy with date and time. It shall have data storage capacity for at least 35 days in a non-volatile memory. It shall have facility to download the parameters through meter reading instruments as well as remote transmission of data over communication network. It shall also have the facility to measure, record and display the following parameters. All parameters excluding instantaneous electrical parameters shall also be stored in memory.

a) Phase to Neutral voltage
b) Average Phase to neutral voltage
c) Phase to Phase voltage
d) Average Phase to Phase voltage
e) Line current (L1, L2, L3 and Average)
f) Active / Reactive Current
g) Frequency
h) Power factor
i) Average Power factor
j) Active Power
k) Total Active Power
l) Reactive Power
m) Total Reactive Power
n) Apparent Power
o) Total Apparent Power
p) Active Total Import / Export Energy
q) Reactive (Q1, Q2,Q3,Q4) Energy
r) Apparent Import / Export Energy
s) Cumulative MD
t) Phase Angle
u) Power On / Off Hours
v) Load On / Off Hours
w) Feeder Interruptions Count (When Aux is also off)
x) THD Voltage
y) THD Current

z) THD Power

aa) RPM with Freq and Voltage unbalance and current unbalance

bb) Modbus on RS 485

5.4.28 Digital Multifunction Meters shall be provided with bright LED/LCD display for local indication and shall be provided with communication port suitable for communicating on MODBUS. Protocol to SAS. It shall display various parameters like 3 phase currents, voltages, PF, MD, KW, KVA, etc. for local indication and shall be provided with minimum 8 nos. of user programmable registers for communicating any of the displayed parameters to the remote.

5.4.29 **Surge arrestor**

a) The surge arrestors shall be provided for all feeders to limit the switching over voltages to 2.2PU. The surge arrestors shall be metal oxide, gapped or gap less type generally in accordance with IEC 60099- 1 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, Surge arrestor 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 feeding equipment.

b) Minimum rating of SA shall be 10 kA, however if as per system studies higher kA rating is required than same shall be provided by the Bidder at no additional expense to the Owner.

5.4.30 **Earthing and Earthing Devices**

- Aluminium or copper earthing bus shall be provided at the bottom and shall extend throughout the length of each switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar.
- The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise.
- All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.
- 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, Test 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.
- All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of suitable size.
- 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.

- Separate earthing trucks (1 No for busbar and 1 no for cables) with making capacity shall be provided for maintenance work. These trucks shall be suitable for earthing the switchgear busbar as well as outgoing/ incoming cables or bus ducts. The trucks shall have a voltage transformer and an interlock to prevent earthing of any live connection. The earthing trucks shall in addition have a visual and audible annunciation to warn the operator against earthing of live connections.
- Built-in earthing facilities for the busbar and outgoing/ incoming connections are also acceptable. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick making type, independent of the action of the operator and shall be suitable for operation from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.
- The earthing device (truck / switch) shall have the short circuit withstand capability equal to that of associated switchgear panel.
- Interlocks shall be provided to prevent:
    a) Closing of the earthing switch if the associated circuit breaker truck is in Service position.
    b) Insertion of the breaker truck to Service position if earthing switch is in closed position.
    c) Closing of the earth switch on a live connection. Three (3) nos. voltage capacitive dividers shall be provided on each phase of the section intended for and three (3) nos. "RED" neon lamps/ LEDs connected to these on the panel front for visual indication.
- The earthing device shall have the short circuit withstand capability equal to that of associated switchgear panel. 4 NO + 4 NC of auxiliary contacts of the earthing device shall be provided for interlocking purpose.
- All hinged doors shall be earthed through flexible earthing braid.

5.4.31 **Painting**

Painting shall be carried out by approved process. Painting procedure and thickness of paint shall be suitable for Site environment as per ISO 12944. After preparation of the under surface the equipment shall be painted with epoxy-based paint by powder coating. Final shade shall be RAL-7035.

## 5.5 Tests

5.5.1 Type Tests

a) All the equipment supplied shall be of type tested quality. Type test reports shall be submitted for Switchgear panel and breaker of each voltage class and current rating as per IS 12729:

b) The Switchgear panel and circuit breaker shall be subjected to the routine test in accordance with the relevant Indian / IEC Standards. Factory acceptance tests shall be carried out (FAT) for bus transfer panel.

5.5.2 Type test reports for the following shall be submitted for Switchgear panel of each voltage class and current rating as per IS 12729:

- Dielectric tests including Lightning impulse withstand test, Power frequency withstand test, switching impulse test, partial discharge test, artificial pollution test, Power frequency withstand test on auxiliary and control circuits.
- Radio interference voltage tests
- Temperature rise test
- Measurement of resistance of the main circuit
- Short time withstand current, and peak withstand current test

5.5.3 Type test reports for the following shall be submitted for Circuit breaker / Contactor of each voltage class and current rating as per applicable standard.

5.5.4 Tariff metering CT/PT testing and specifications shall be as per requirement of competent authority.

5.5.5 For circuit breaker, the list of type tests shall include the following as per IS 13118:

5.5.6 Dielectric tests

- Radio interference voltage test
- Measurement of the resistance of the main circuit
- Temperature-rise tests
- Short time withstand current, and peak withstand current tests
- Verification of the Protection
- Tightness tests
- Electromagnetic compatibility tests
- Mechanical and environmental tests including Mechanical operation test
- Short-circuit current making and breaking tests
- Capacitive current switching tests
- Magnetising and inductive/capacitive current switching tests

5.5.7 Routine Tests

a) The Switchgear panel shall be subjected to the routine test in accordance with the relevant Indian / IEC Standards. The tests shall include the following.

- Power frequency voltage dry test on the main circuit.
- Voltage test on control and auxiliary circuits.
- Measurement of resistance of the main circuit.
- Mechanical operating tests

b) The circuit breakers, Contactors, Switches, voltage transformers and current transformers shall be subjected to the routine test in accordance with the relevant Indian / IEC Standards.

c) For circuit breaker, the list of routine tests shall include the following as per IS 13118:

- Dielectric tests on the main circuit
- Dielectric tests on the control circuit & auxiliary circuit
- Measurement of the resistance of the main circuit
- Mechanical operating tests
- Tightness tests
- Design and visual checks

### 5.6 Drawings & Documents

5.6.1 The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- Feeder list for each switchgear
- General arrangement and section drawing
- Single line diagram & Schematic wiring diagrams
- Metering and protection drawing
- Sizing Calculation for busbar
- Short circuit withstand calculation for busbar (Thermal & dynamic)
- Component list & Bill of Quantities for all the boards
- Panel cutout details
- Foundation Plan & loading details.
- Erection and commissioning procedures
- CT / VT sizing calculation
- Relay setting calculation and protection coordination.
- Catalogues / drawings / leaflets for all items
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan
- Comprehensive memory mapping of ABT meters, Numerical relays and MFM's

### 5.7 Warranty

5.7.1 The warranty period of the HT Switchgear shall be minimum two (02) years from the date of Commissioning of Facility.

5.7.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

5.7.3 During the warranty period, whenever a technical problem is encountered with HT Switchgear, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the HT Switchgear shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

5.7.4 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 6. 33/132kV Power Transformer

## 6.1 Intent of Specifications

6.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, loading and unloading at Site, storage at Site, erection, testing and commissioning of Power Transformer, complete with all materials and accessories for efficient and trouble-free operation. The specification covers many aspects of Owner specifications & the OEM/ Bidder has to ensure that all requirements of Owner as per their latest standards are compiled & all Owner requirements for supply, inspection, testing & commissioning along with installation at Site with all documentation required at various stages is followed.

6.1.2 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 6.2 Codes and Standards

6.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IS-325, IEC-34 | Three phase Induction motors |
| IS-335, IEC-60296, BS-148 | Insulating oils for Transformers and Switchgear |
| IS-778 | Gunmetal gate, globe-valves for general purpose. |
| IS-1886 | Code of practice for installation and maintenance of transformers. |
| IS-2026, IEC-60076 | Specification for Power Transformers (All parts) |
| IS-2099, BS-223 | Bushings for alternating voltage above 1000 V |
| IS-13947 | Degree of protection provided by enclosures for low voltage switchgear & control gear |
| IS-2705, IEC 60044 | Current Transformers |
| IS-3203 | Code of practice of climatic proofing of electrical equipments. |
| IS-3347 | Dimension for porcelain Transformer Bushings. |

| Standard | Description |
|---|---|
| IS-3401 | Silica gel. |
| IS-3637 | Gas operated relays |
| IS-3639 | Fittings & Accessories for power transformers |
| IS-4253 | Cork and rubber. |
| IS-5561 | Electric Power Connector |
| IS-5578<br>IS-11353 | Marking & arrangements for Switchgear: Bus bars, Main connections and auxiliary wiring. |
| IS-6272 | Industrial cooling fans |
| IS-6600 | Guide for loading of oil immersed transformers |
| IS-9434 | Guide for sampling and analysis of dissolved gas in oil filled equipments |
| IS-12676 | Oil impregnated paper insulated Bushing Dimension and requirements. |
| IEC 60071 | Insulation Co-ordination. |
| | Indian Electricity Rules |
| | CBIP Manual on Transformers |
| IS:1885 | Electro-technical Vocabulary (Part XXXVIII) Transformers (first revision) |
| IS:2312 | Propeller type AC ventilating fans |
| IS:3024 | Electrical steel sheets (oriented) |
| IS:3151 | Earthing transformers |
| IS:3231 | Electrical relays for power system protection |
| IS:3588 | Electric axial flow fans |
| IS:3624 | Pressure & vacuum gauges |
| IS:6088 | Specification for Oil-to-water Heat Exchangers for Transformers |
| IS:7358 | Thermocouples |
| IS:8468 | On Load Tap Changers |
| IS:9700 | Specification for activated alumina |

| Standard | Description |
|---|---|
| IS:104 | Ready mix paint, brushing, zinc chrome Priming |
| IS:900 | Code of Practice for installation and maintenance of induction motors |
| IS:1554 | PVC insulated electric cables for working Voltage up to and including 1100Volt |
| IS: 10028 | Code of Practice for selection, installation and maintenance of transformers |
| IS: 2266 | Steel Wire Rope for General Engineering Purposes |
| IS: 2932 | Enamel, synthetic, exterior,<br>a) undercoating<br>b) finishing |
| IS: 3043 | Code of Practice for earthing |
| IS: 3638 | Application Guide for gas operated relays |
| IS: 3832 | Hand operated chain pulley blocks |
| IS: 5216 | Guide for safety procedures and practices In electrical work electric power connector |
| IS: 5528 | Guide for short circuit calculations |
| IS: 6034 | Edge type vacuum filters |
| IS: 6132 | General requirements & dimensions of Deck Shackles and Bow shackles |
| IS: 7689 | Guide for the control of undesirable Static electricity |
| IS: 8270 | Guide for preparation of diagram, charts and table for electro technology |
| IS: 8478 | Application guide for on-load tap changers |
| IS: 8923 | Warning symbol for dangerous voltages |
| IS: 9615 | Guide on general aspects of electromagnetic Interference separation |
| IS: 1448 | Methods for test for petroleum and its products– Part I to IV |
| IS: 1783 | Drums, large, fixed ends |

| Standard | Description |
|---|---|
| IS: 1966 | Code of Practice for maintenance and supervision of insulating oil in service |
| IS: 2362 | Determination of water by Karl Fischer method |
| IS: 6103 | Method of tests for specific resistance (Resistivity) of electrical insulating liquids |
| IS: 1876 | Method of voltage measurements by means of Sphere gaps |
| IS: 2071 | Method of High voltage testing – Part I to Part III (Part I -1974 & Part 2&3-1976) |
| IS:2165 | Insulation Co-ordination |
| IS:3716 | Application Guide for Insulation Co-ordination |
| IS:4004 | Application Guide for nonlinear resistor type Surge arrestor for AC system |
| IS:4850 | Application Guide for expulsion type lightning arrestors |
| IS:6209 | Method for partial discharge measurement |
| IS:8690 | Application Guide for Measuring Device for High voltage testing |

Note: - It is not the intent of this specification to mention each and every reference standard to be followed. The above listed standards are the minimum standards to be followed as per their latest amendments which shall be applicable at the time of offer. The transformers shall conform in all respects to high standards of engineering, design, workmanship and shall adhere to the most stringent requirements in case of conflict between two standards & such aspects shall be brought to the Owner's notice.

### 6.3 Scope of Work

6.3.1 The scope of work shall include the following equipment.

a) One (01) nos. minimum 30MVA (Shall be decided during detail engineering), 132/33kV, Three phase, Two winding Power transformers with OLTC, Bushing CTs for the 132kV Pooling substation at Plant.

b) Remote tap changer panel (RTCC) for each transformer

c) Nitrogen fire protection system for each transformer

d) Power and control cable between RTCC panel/ cooler control cabinet/ fire protection system for each transformer

e) Foundation plinth with rail arrangements

f) Foundation bolts

g) Insulating oil

### 6.4 Design Requirement

6.4.1 The Transformer will be installed in Plant to evacuate power to 400/220/132kV Kukurmara (Mirza) GSS.

6.4.2 The power transformer shall be suitable to be used for bi-directional power flow.

6.4.3 The transformers and all their accessories like CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and short circuits at the terminals of any winding for a period of 2 sec. The short circuit level of the EHV (Primary) system to which the subject transformer will be connected shall be considered 40kA (Symm, rms, 3 phase fault) for design purposes. Transformers shall be capable of withstanding thermal and mechanical stress caused by symmetrical or asymmetrical faults on any winding.

6.4.4 The transformer shall be capable of being loaded in accordance with IS: 6600 clause 4 (a) up to loads of 150%. There shall be no limitation imposed by bushings, tap changer etc.

6.4.5 The transformer shall be capable of operating continuously at the rated MVA without overheating/without any danger, on any tapping with voltage variation of +/- 10% corresponding to the voltage of that tapping.

6.4.6 Radio interference and Noise Level:

a) The transformers shall be designed with particular attention for suppression of maximum harmonic voltage, especially the third and the fifth so as to minimize interference with communication circuits.

b) The noise level, when energized at normal voltage and frequency with fans and pumps running shall not exceed, when measured under standard conditions, the values specified in NEMA, TR-1.

c) Transformers shall be capable of operating under the natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by preset contacts of winding temperature indicator and the transformer shall then operate as a forced cooled unit, initially as ONAN up to specified load and then as ONAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the measured winding hot spot temperature exceeding 140 ºC. Also, the stopping of one or two cooling fans should not have any effect on the cooling system. Transformers fitted with two coolers each capable of dissipating 50 percent of the heat at continuous maximum rating shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler, without the measured winding hot spot temperature exceeding 140 ºC at continuous maximum rating.

6.4.7 Transformer shall accept, without injurious heating the following, combined base voltage and frequency fluctuation, which produces over fluxing condition.

a) Withstand time for 150% & 170% over fluxing condition shall be indicated. Over fluxing characteristics up to 170 % shall be submitted.

b) Transformer shall be designed for continuous over fluxing withstand capability due to +/- 10% voltage variation on HV and frequency variation of +/- 5% Hz. Combined variation shall, however, be within +/-10%.

6.4.8 The transformers shall operate below the knee of the saturation curve at 110 percent voltage to preclude Ferro resonance and nonlinear oscillations.

## 6.5 Constructional Details

The features and constructional details of power transformer shall be in accordance with the requirements stated here under

**Tank and Tank Accessories:**

6.5.1 Tank shall be of welded construction and fabricated from tested quality low Carbon steel of adequate thickness.

6.5.2 All seams and those joints not required to be opened at Site shall be factory welded and wherever possible they shall be double welded with horizontal welding procedure. After completion of tank construction and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment for tank/stress relieving parts shall be based on recommendations of BS: 5500.

6.5.3 Tank stiffeners shall be provided for general rigidity, and these shall be designed to prevent retention of water.

6.5.4 The tank shall be of conventional / bell type with bolted cover on top. In case the joint is welded it shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.

6.5.5 The tanks shall be designed to withstand.

a) Mechanical shocks during transportation.

b) Vacuum filling of oil.

c) Continuous internal pressure of 35 kN/m2 over normal hydrostatic pressure of oil.

d) Short circuit forces

6.5.6 Wherever possible the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipes.

6.5.7 Adequate space shall be provided at the bottom of the tank for collection of sediments.

6.5.8 The base of each tank shall be so designed that it shall be possible to move the complete unit by skidding in any direction without injury when using plates or rails.

6.5.9 Tank shields shall be such that no magnetic fields shall exist outside the tank. They shall be of magnetically permeable material. If required, impermeable shields shall be provided at the coil ends. Tank shield shall not resonate when excited at the natural frequency of the equipment

6.5.10 Suitable guides shall be provided in the tank for positioning the core and coil assembly.

6.5.11 Each tank shall be provided with:

a) Lifting lugs suitable for lifting equipment complete with oil.

b) A minimum of four jacking pads in accessible position at 500 mm height to enable the transformer to complete with oil, to be raised or lowered using hydraulic or screw jacks.

c) Suitable haulage holes shall be provided.

**Tank Cover:**

6.5.12 The tank cover shall be sloped to prevent retention of rainwater and shall not distort when lifted.

6.5.13 At least two adequately sized inspection openings, one at each end of the tank shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. The inspection covers shall be provided with two handles.

6.5.14 The tank covers shall be fitted with pockets at the position of maximum oil temperature corresponding to MCR (Maximum Continuous Rating) for RTD Sensors and bulbs of oil and winding temperature indicators.

6.5.15 Bushings, turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

6.5.16 All bolted connections shall be fitted with weatherproof, hot oil resistant gasket in between for complete oil tightness. If the gasket is compressible, metallic stops shall be provided to prevent over-compression.

**Axles and Wheels:**

6.5.17 The transformers are to be provided with flanged bi-directional wheels and axles. These shall be so designed as not to deflect excessively to interfere with the movement of the transformer. Wheels shall be provided with suitable bearings, which shall be rust and corrosion resistant. Fittings for lubrication shall also be provided.

6.5.18 Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.

6.5.19 The wheels are required to swivel, and they shall be arranged so that they can be turned through an angle of 90º when the tank is jacked up to clear the rails. Means shall be provided for locking the swivel movements in positions parallel to and at right angles to the longitudinal axis of the tank.

6.5.20 The rail track gauge shall be (1676 mm) along a longer axis as well as along shorter axis.

**Anti-Earthquake Clamping Device**

6.5.21 To prevent transformer movement during earthquakes, clamping device shall be provided for fixing transformer to the foundation. The Bidder shall supply necessary bolts for embedding in the concrete foundation. The arrangements shall be such that the transformer can be fixed to or unfastened from these bolts as desired. The fixing of the transformers to the foundations shall be designed to withstand seismic events to the extent that a static coefficient of 0.3g, applied in the direction of least resistance to that loading will not cause the transformer or clamping devices as well as bolts to be over stressed.

**Conservator Tank**

6.5.22 The conservator tank shall have adequate capacity between highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100ºC. The conservator shall have a volumetric capacity of at least 7.5 percent of the total volume of oil in the main tank of the transformer.

6.5.23 The conservator tank shall be bolted into position so that it can be removed for cleaning purposes.

6.5.24 The conservator shall be fitted with magnetic oil level gauge with electrically insulated contact for low oil level alarm.

6.5.25 The conservator shall be provided in such a position as not to obstruct the electrical connections to the transformer.

6.5.26 A separate conservator tank/compartment in the main conservator shall be provided for OLTC.

**Oil Preservation System**

6.5.27 Condition Controlled (Maintenance Free) Regenerating Silica Gel Breather

6.5.28 The conservator shall be fitted with a Condition Controlled (Maintenance Free) Regenerating Silica Gel Breather. The various design aspects of the breather are mentioned below.

**1) Description**

6.5.29 A smart transformer breather is a transformer accessory which removes moisture from air entering oil-filled transformers or LTC conservators. Silica gel desiccant is used to absorb moisture. The system is automated to regenerate when a relative humidity level is exceeded.

**2) Operation:**

6.5.30 Dehydrating breathers shall work according to the following principle. When the oil conservator suctions in air, the air flows through a filter made of high-grade steel wire mesh to the inside of the device. This filter and the dust cap, filters sand, dust and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colourless, moisture adsorbing pellets and is dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The dehydrating breather is mounted on the pipe to the oil conservator. A suitable counter-flange must be installed on the pipe to mount the dehydrating breather. The desiccant contained in the drying assembly is

dehydrated using sensor controlled by microprocessor using the built-in heating unit, thus obviating the need for periodic desiccant replacement. The regeneration of silica gel shall be during exhale mode of transformer.

**3) Mounting & Installation:**

6.5.31 The main transformer tank conservator shall be fitted with a silica gel breather of the Maintenance free type at a height of 1400mm from rail top level. Each silica gel breather shall be equipped with a humidity sensor and suitable heating element.

6.5.32 By providing the Maintenance Free Type of Breather the objective is to achieve reduced Site inspections, Expense reduction by obviating the complete process of ordering, storage and replacement of the desiccant. It also leads to no pollution and disposal problem of the used-up desiccant (which is associated with the conventional pigmented silica gel) is eliminated.

**4) Technical requirements:**

**a) Materials**

6.5.33 The material of regenerative breather shall be stainless steel/Aluminium. Material of External Construction of the Breather shall be such that all external parts are suitable for mounting for outdoor use, resistant against transformer oil and ultraviolet rays, Salt water & pollution. The control unit shall be provided on the breather equipped with suitable heater to prevent moisture condensation. The moisture and temperature measurement system (sensor) installed should be modular, making it easy to replace the same if at all the same is necessary during the service of breather. A self-diagnostic system shall be provided with LED indication and remote signal through a relay shall be provided. There shall be automatic system status and failure indication. There shall be no moving parts to restrict or redirect air flow from the desiccant. No Plastics parts shall be used in the construction of the Breather.

6.5.34 The size and type of Conditioned controlled maintenance free dehydrating breather to be provided shall be selected on the basis of volume of oil of the offered transformer (Minimum quantity of silica gel shall be in proportion of 1 kg for every 30,000 liters of oil in the tank).

**b) Ambient Temperature**

6.5.35 The equipment shall work without any trouble for ambient temperature between 0°C to + 80 Deg C.

**c) Degree of Protection**

6.5.36 The degree of protection shall be at least IP56.

**d) Communication**

6.5.37 The control unit in the breather shall be equipped with an RS485 Port and USB (local) for data logging.

6.5.38 A USB port must be located on the control panel for local communication. This should be amended as all necessary software required for downloading and analyzing the data logging shall be provided by the supplier. The data shall be communicable with the Substation Automation System.

**e) Analog Signal**

6.5.39 The smart breather should provide 4-20mA analog output signal.

**f) LED Display**

i. LED for power of control unit- ON
ii. LED for filter heater- ON
iii. LED & relay contact for "Device Error"
iv. LED & relay contact for Regeneration active (De-humidification in process)

**g) Alarm Capabilities**

6.5.40 The device shall use the self-monitoring function to detect internal faults and report these via the exterior LEDs and the ERROR relay.

**h) Rated Supply**

6.5.41 The equipment shall operate at input supply of 230VAC, 50Hz.

**i) Insulation Level**

6.5.42 500VAC 50 Hz, 1min. withstand voltage: against ground.

6.5.43 500VAC 50 Hz, 1min. withstand analog output against ground.

6.5.44 2.5kVAC 50/60Hz, 1min. withstand relay contact against ground.

**j) Self-Test/ Automatic Error indication**

6.5.45 The Breather shall also be equipped with an integrated test button which should allow to carry out a self-test and to check the functions, like the relay circuits, heating or the signal transmission in the control room etc. at any time.

6.5.46 The Bidder shall provide diaphragm type oil sealing system (Balloon technology) in the conservator. The requirement of this systems are given below:

a) In this system, contact of the oil with atmosphere shall be prohibited by using a flexible or nitride rubber reinforced with nylon cloth air cell.
b) Diaphragm used shall be suitable for continuous operation at a temperature of 100 ºC, to which transformer oil is likely to rise.
c) The connection of the air cell to the top of the conservator shall be by an air proof seal permitting entrance of air into the cell only.
d) The Diaphragm of the conservator shall withstand the vacuum during installation and maintenance. Otherwise, provision shall be made to isolate the conservator from main tank during vacuum by providing vacuum sealing valve in the pipe connecting main tank with the conservator.

**Pressure Relief Device**

6.5.47 Adequate number of pressure relief devices but at least 2 numbers shall be provided at suitable locations preferably close to bushing turret/ cover. These shall have opening diameter of at least 100 mm for rapid release of any pressure that may be generated in the tank and which may result in

damage to equipment. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at sea level. It shall be mounted directly on the tank. One set of electrically insulated contacts per device shall be provided for alarm/tripping. Following routine tests shall be conducted on PRD.

i. Air pressure test
ii. Liquid pressure test
iii. Leakage test
iv. Contact test
v. Dielectric test

6.5.48 The PRD shall be designed so that the pressure due to internal fault shall not over-stress the tank or components. The device shall be designed to give directional flow, with extra flow rate (>12000 SCFM discharge), so as to reduce the tank pressure in least possible time. On operation, it shall initiate tripping of transformer CBs. The PRD shall reclose itself in order to prevent water ingress.

6.5.49 The device shall be mounted near the edge of the tank cover with an adapter provided so that oil chute or pipe which is routed to 300 mm above the base of the Transformer. The supplier shall provide the oil chute or oil pipe to 300 mm above the transformer base of suitable cross-sectional area so as not to cause any back pressure on the pressure relief device. The oil discharge outlet shall be away from the control cabinet and operational controls where field personnel may likely be standing. No barrier shall be placed in front of the PRD opening, on the oil side, to prevent gas accumulation or impede a pressure wave from operating the PRD. Each trip contact shall be terminated individually in the control cabinet. All wiring shall be terminated on terminal block of Control Cabinet.

**Buchholz Relay**

6.5.50 A double float type Buchholz relay shall be provided to detect the gases formed in the transformer. All the gases evolved in the transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper or stainless-steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling, even when the transformer is in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

**Earthing Terminals**

6.5.51 Two (2) earthing pads (each complete with two (2) Nos. tapped holes, M 10 bolts, plain and spring washers) suitable for connection to 75 x 10 mm grounding flat shall be provided each at position close to the two (2) diagonally opposite bottom corners of tank.

6.5.52 Two earthing terminals suitable for connection to 50 x 6 mm galvanized steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

**Insulating Oil**

6.5.53 The required transformer oil shall be in the scope of transformer manufacturer.

6.5.54 The supplier shall dispatch the transformer filled with Nitrogen. The Manufacturer shall take care of the weight limitation on transport and handling facility at Site. Necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A gas pressure testing valve with the necessary pressure gauge and adapter valve shall be provided.

6.5.55 The quality of the oil supplied with the transformer shall conform to the oil parameters specified in this clause.

6.5.56 No inhibitors shall be used in the oil.

6.5.57 The oil samples will be drawn as follows:

a) Prior to filling

b) Before and after heat run test

c) Before energizing

6.5.58 All tests as per IEC: 60296 shall be conducted on all samples.

6.5.59 The insulating oil shall be subjected to testing at the oil manufacturer's works, before supply, in the presence of the representative of Owner and the representative of the transformer manufacturer.

6.5.60 Sufficient quantity of oil necessary for first filling of all tanks, coolers and radiators at the proper level along with 10% extra oil by weight for topping up shall be supplied in non-returnable containers suitable for outdoor storage.

6.5.61 The Manufacturer shall warranty that characteristic of oil furnished shall comply with the requirements specified in IEC: 60296 with the latest amendment /revision and shall be suitable for EHV grade transformers.

6.5.62 The Manufacturer shall submit a valid type test report (conducted at ERDA/CPRI) of the oil to be used in the transformer.

6.5.63 Acceptance tests on transformer oil which is to be used for transformers being supplied by the successful Manufacturer shall be carried out at the works of transformer oil manufacturer in presence of Owner's representative /Owner's appointed consultant's representative.

6.5.64 New (unused) uninhibited naphthenic based high grade mineral insulating oil conforming to IEC-60296.

**Note: The colour of the barrels in which Naphthenic based transformer oil is to be supplied shall be Red.**

**Core**

6.5.65 Material to be used for the transformer core shall be made of prime grade Imported Cold Rolled Grain Oriented M4 or higher Grade (CRGO) laminations and not from second grade steel laminations. Only those Manufacturers who directly import CRGO either from the manufacturer or through their accredited marketing organization of repute (and not through any agent) shall be considered & in this context the manufacturer shall provide a document giving details of sourcing of the core.

6.5.66 The CRGO shall be cut at Mill's authorized Processing unit only.

6.5.67 The core shall be constructed from high-grade non-ageing cold rolled Super grain-oriented silicon steel laminations.

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

6.5.69 The core and its clamping plates shall form a rigid unit structure, which shall maintain its form and position under the severe stresses encountered during shipment, installation and short circuits. Care shall also be taken to secure uniformly distributed mechanical pressure over all the laminations to prevent setting of the core and to limit noise and vibrations to a minimum under service conditions. Adequate measures shall be taken to reduce the stray losses and the eddy current losses.

6.5.70 The insulation of core to bolts and core to clamps plates shall be able to withstand a voltage of 2 kV (rms) for one minute.

6.5.71 Core and winding shall be capable of withstanding the shock during transport, installation and service and adequate provision shall be made to prevent movement of core and winding with respect to tank during these conditions.

6.5.72 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

6.5.73 When bell type tank construction is offered, suitable projecting guides shall be provided on core-assembly to facilitate removal of tank.

6.5.74 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

6.5.75 The supporting framework of core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

6.5.76 The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency at any tap shall not exceed 1.6 Tesla.

**Windings**

6.5.77 The supplier shall ensure that windings of the transformers are made in dust proof environment. The conductors shall be of electrolytic grade copper.

6.5.78 The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse or be catalytic and chemically active in transformer oil during service.

6.5.79 Coil assembly and insulating spacers shall be arranged to ensure free circulation of oil and to reduce the hot spot of the winding.

6.5.80 The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices, if necessary, shall be provided for taking up possible shrinkage of coils if any, in service. The provision made in this respect shall be clearly brought out in the Bid.

6.5.81 Windings shall be of best modern design with conductors having constant cross-section along the whole windings, and the current densities shall not exceed 3 A/mm2 in any part of the windings. Electrolytic copper of a high conductivity and insulation material of high quality, class 105 (A) in accordance with IEC 60085, shall be used. The conductors shall be transposed at suitable intervals in order to minimize eddy current and to equalize the distribution of current and temperature along the windings.

6.5.82 The coils must be capable of withstanding movement and distortion caused by all operating conditions as specified in IEC 60076-7. Adequate barriers shall be provided.

6.5.83 between windings and core and between the windings. All leads or bars from the windings to the terminal boxes and bushings shall be rigidly supported. Stresses on coils and connections must be avoided. To increase the capability of the transformers of withstanding the stresses under short-circuit conditions modern technology in design and construction shall be applied (e.g., low current densities as above, and pre drying and pre-compressing of the windings before mounting onto the core, etc.)

6.5.84 The coils shall be supported between adjacent sections by insulating wedge type spacers and the barriers, bracings and other insulation used in the assembly of the windings shall be so arranged as to ensure a free circulation of the oil and to reduce hot sports in the windings.

6.5.85 The windings shall be so designed that all coil assembly of identical voltage rating shall be interchangeable and field repairs to the windings can be added without special equipment.

**Terminal Arrangements**

**Bushing:**

6.5.86 The electrical and mechanical characteristics of bushings shall be in accordance with IS: 2099 and IS: 3347 (Part-III/Section-I). The dimensions and requirements of condenser bushings shall be in accordance with IS 12676, 1989.

6.5.87 145 kV bushings shall be oil filled condenser type & 36 KV bushings shall be of porcelain. No arcing horns shall be provided on any bushing. Bushings of identical rating shall be interchangeable.

6.5.88 Condenser type bushings shall be provided with: -

a) Oil level gauge.

b) Oil filling plug and drain valve if not hermetically sealed.

c) Tap for capacitance/tan delta measurement.

6.5.89 Porcelain used in bushing manufacture shall be homogenous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Glazing of porcelain / bushing shall be of uniform brown colour and free from blisters, and burrs.

6.5.90 Special precautions shall be taken to eliminate moisture from paper insulation during manufacture, assembly, transport and erection.

6.5.91 Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through the Buchholz relay.

**Terminal Connectors:**

6.5.92 Bushing terminals shall be provided with terminal connectors of approved type and size for connection to external parts. Terminal connectors should have been successfully type tested strictly as per IS: 5561.

6.5.93 Connectors shall be of electrolytic grade copper forged and silver plated/tinned.

6.5.94 No part of a clamp shall be less than 10 mm thick.

6.5.95 Non-magnetic stainless-steel nuts, bolts and plain washers shall be used. Nuts and bolts shall have hexagonal head with threads as per IS and shall be fully threaded type. Instead of spring washers, check/lock nuts shall be provided.

6.5.96 The connectors shall be designed for a minimum of 120% of the maximum current carrying capacity of the Moose conductor and the temperature rise under these conditions shall not be more than 50% of that of the main conductor.

**Bushing current transformers**

6.5.97 Current transformers shall comply with IS: 2705.

6.5.98 It shall be possible to remove turret mounted CTs from the transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize the eddy currents and local heat generated in the turret.

6.5.99 All secondary leads shall be brought to a terminal box near each bushing. These terminals shall be wired up to the Cooler Control Cabinet using separate cables for each core/phase.

6.5.100 Bushing CT parameters indicated in the specification are tentative and liable to change within reasonable limits. The Manufacturer shall obtain the Owner's approval before proceeding with the design of Bushing CTs.

**Terminal Marking**

6.5.101 The terminal marking and their physical position shall be in accordance with IS: 2026 unless otherwise specified.

**Neutral Earthing Arrangement**

6.5.102 The neutral terminals of the star connected windings shall be brought to the ground level by two (2) 75x10 mm copper flats which shall be supported from the tank by porcelain insulators of highest system voltage.

6.5.103 The ends of the 2 Nos. of above flats shall be brought to the ground level at a convenient point and shall be connected to two separate earth pits provided by the Owner with two (2) 75x10 mm copper flats. Ultimately the two earth pits shall be connected to Owner's ground network (earth mat).

6.5.104 Suitable flexible copper strip connection of adequate size shall be provided for connecting to Neutral Bushing terminals to avoid tensile load on the Bushings.

**Auxiliary Power Supply for OLTC, COOLER CONTROL AND POWER CIRCUIT**

6.5.105 All loads shall be fed by one of the two feeders through an electrically interlocked automatic changeover scheme housed in any one of the local control cabinets for tap changer control and cooler circuits.

6.5.106 Design features of the changeover scheme shall include the following:

a) Provision for the selection of one of the feeders as normal source and the other as standby.

b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay, to the standby source.

c) Indication for 'failure of normal source' and for 'transfer to standby source' and also for 'failure to transfer' shall be provided in the local cubicle as well as in RTCC panel.

d) Automatic re-transfers to normal source with an adjustable time delay following re-energization of the normal source.

e) During both the transfer and the re-transfer of auxiliary supply, the incoming AC feeders shall be 'dead transfers' and AC feeders shall not be paralleled at any time.

f) Necessary isolating switches, MCB's and other components for the above power supply transfer arrangement shall be provided by the supplier.

**Valves**

6.5.107 All valves up to and including 100 mm size shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counterclockwise when facing the hand wheel.

6.5.108 Suitable means shall be provided for locking the valves in the open and close position. Provision is not required for locking individual radiator valves.

6.5.109 Each valve shall be provided with the indicator to show clearly the position of the valve.

6.5.110 All valve flanges shall have machined faces.

6.5.111 All valves in oil line shall be suitable for continuous operation with transformer oil at 100°C.

6.5.112 The oil sampling point for the main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10mm size to facilitate oil sampling.

6.5.113 A valve or other suitable means shall be provided to fix the online dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location and size of the same shall be finalized during detailed engineering stage.

6.5.114 Suitable valves shall be provided to take samples of oil from the OLTC chamber during operation of the transformer.

6.5.115 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS:2932 and of a shade (preferably red or yellow) distinct and different from that of main tank surface. The outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS:2074 followed by two coats of fully glossy finishing paint.

6.5.116 All hardware used shall be cadmium plated/electro galvanized.

**Fittings**

a) The following fittings shall be provided with each transformer covered in this specification.

b) Conservator for main tank, with oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low oil level alarm contacts and dehydrating breather: Buchholz relay, double float type, with isolating valves on both sides, bleeding pipe with petcock at the end to collect gases and alarm and trip contacts.

c) Conservator for OLTC with drain valve, Buchholz (Oil Surge) relay, filling hole with prismatic oil level gauge and condition-controlled regenerating silica gel breather.

d) Oil preservation equipment.

e) Pressure relief device with alarm contact.

f) Air release plug.

g) Inspection openings and covers.

h) Bushing with metal parts and gaskets to suit the termination arrangement.

i) Winding temperature indicators for local and remote indication. One RWTI along with a four-point selector switch shall be provided for all the windings (HV, IV/LV) as applicable.

j) Oil temperature indicators.

k) Covers lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.

l) Protected type mercury (or alcohol) in glass thermometer.

m) Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

n) Rating and diagram plates on transformers and auxiliary apparatus.

o) Earthing terminals.

p) Flanged bi-directional wheels.

q) Cooler Control Cabinet.
r) On load tap changing equipment and OLTC control cabinet.
s) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.
t) Bushing CTs.
u) Insulating oil (as per specification)
v) Cooling fans
w) Oil pumps (wherever required)
x) Oil flow indicator (wherever required)
y) Terminal marking plate.
z) Jacking pads.
aa) Lifting bollards.
bb) Haulage lugs
cc) Cover lifting lugs.
dd) Valve schedule plate
ee) RTCC Panel
ff) Temperature Indicator compatible with SCADA
gg) N2 injection fire protection system along with associated fittings, control equipment and required oil collection tank. (Wherever required)
hh) Transformer monitoring cum Tap Changer system.
ii) Tank mounted ladder with provision of anti-climbing device.
jj) On-line Dissolved Gas Analyzer
kk) Sudden Pressure Relay

Note: The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

**Bolts and Nuts**

6.5.117 All bolts and nuts exposed to weather shall be 8.8 grade hot dip galvanized with coating thickness more than 65 microns. Bolts and nuts below M12 (12mm) size shall be of non-magnetic stainless steel (SS 304). The nut bolts & washers shall be non- magnetic, shall be free of cracks, any foreign deposition and shall have smooth finish.

**Wiring and Cabling**

6.5.118 Cable box/sealing end shall be suitable for the following types of cables: -

i) 415 Volt power : Power cables shall be of 1100 volts grade, XLPE PVC insulated armoured cable as per IS: 7098 (PART-I)

ii) Control : 1100 Volt grade XLPE PVC insulated 7/0.737 mm copper multi strand conductor cable with armour.

6.5.125 Compression type cable connector (lugs) shall be provided for termination of power and control cables.

6.5.126 All controls, alarms, indicating and relaying devices provided with the transformer shall be wired up to the terminal blocks inside the Local Control Cabinets (both Cooler and OLTC Control Cabinets.)

6.5.127 All devices and terminal blocks with the Cooler Control Cabinet shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagrams.

6.5.128 Not more than 2 wires shall be connected to one terminal. Each terminal shall be suitable for connecting two nos. of 7/0.737 mm stranded copper conductors from each side.

6.5.129 All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks.

6.5.130 Engraved code identification (plastic) ferrules marked to correspond with schematic diagrams shall be fitted at both ends of wires. Ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal block.

6.5.131 All interconnecting control and power cables emanating from various parts of transformer like CTs, Marshalling box, Fans, OTI, WTI, MOG, Buchholz, PRV etc. shall be routed through covered GI cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Cables of type tested design and from approved sources shall be provided. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply.

**Motors**

6.5.132 Motors shall be "Squirrel Cage" type three / single phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment. Motors shall conform to IS 325

## 6.6 Tap Changing Equipment

**Tap Changer Switch (General Requirement):**

6.6.1 The OLTC shall be of In Tank, Hi Speed Resistor Type. The OLTC shall be provided at neutral end of HV winding.

6.6.2 OLTC gear shall be motor operated for local as well as remote electrical operation. An external hand wheel/handle shall be provided for local manual operation.

6.6.3 On load tap changer shall be sourced from reputed manufacturer and it should be type tested as per relevant IEC 60214 and test methods shall be in full conformance to the procedures indicated in IEC 60214.The OLTC shall be type tested for 50,000 operations. All type test reports shall be submitted.

6.6.4 The OLTC shall be equipped for remote operations through RTCC panel. RTCC panel shall be supplied by transformer manufacturer for automatic operation of OLTC. The RTCC shall have interface with SCADA/SAS for operation and alarm.

6.6.5 Each transformer unit shall be provided with on load tap changer driving gear mechanism having a protection class IP56 or better.

**On Load Tap Changing Gear (OLTC)**

6.6.6 The details of the method of diversion of the load current during tap changing; the mechanical construction of the gear and the control features for OLTC gear shall be submitted with the bid. Information regarding the service experience on the gear and a list of important users shall be furnished. The tap changer shall change the effective transformation ratio without producing phase displacement and shall meet the following requirements:

a) The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer and the chamber shall be designed to withstand the vacuum. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

b) The voltage class, maximum tapping current, step voltage of OLTC shall have adequate design margin for safe & reliable service life of both OLTC and transformer. OLTC shall have long contact life, quick & easy to disassemble diverter switch inserts, simple to adjust & control and easy to replace diverter's contacts etc.

c) On load tap changer shall have maximum rated through current of 500 Amps to meet the normal rated load as well as overload as per standards. The OLTC should also be suitable for an occasional switching at 200% of the OLTC Rating as per IEC 60214 which shall be validated with by the type test. The OLTC shall have BIL rating corresponding to 72.5 kV class and short circuit withstand current as per relevant IEC standards but not less than 8 kA for 3 seconds.

d) The supplier shall indicate the safeguards provided in order to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under over-load conditions of the transformer. Necessary tools and tackles shall be furnished for maintenance of OLTC gear.

e) The diverter switch or arcing switch shall be so designed as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc.

f) The tap changer shall be so mounted that cover of transformer can be lifted without removing connections between windings and tap changer.

g) The drive mechanism chamber shall be mounted on the tank in an easily accessible position. It should be adequately ventilated and provided with anti-condensation metal clad heaters. All contactors, relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.

6.6.7 Local-remote selector switch mounted in the local control cubicle shall switch control of OLTC in the following manner.

a) When the selector switch is in LOCAL position, it shall be possible to operate the RAISE / LOWER control switch specified in section (iii) below. Remote control of RAISE/LOWER functions shall be prevented.

b) When the selector switch is in REMOTE, the local control cubicle mounted RAISE/ LOWER switches specified in Section (iii) shall be inoperative. Remote control of the raise/lower function shall be possible from the remote-control panel. The LOCAL-REMOTE selector switch shall have at least two spare contacts per position which are closed in that position but open in the other position.

c) A RAISE/LOWER CONTROL SWITCH shall be provided in Local Control Cubicle. The switch shall be spring loaded to return to the center 'OFF' position and shall require movement to the RIGHT to raise the voltage of the transformer. Movement to the left shall lower the voltage. This switch shall be operative only when 'local remote', selector switch is in 'local' position.

d) Operating mechanism for on load tap changer shall be designed to go through one step or tap change per command. Subsequent tap changes shall be initiated only on receipt of a new or repeat command. This should be ensured through Snap Action Mechanism in the Drive Mechanism

e) The on-load tap changer shall be equipped with a time delay for "INCOMPLETE STEP" alarm consisting of a normally open contact which closes if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.

f) The resistor based potentiometric unit shall be installed in the local OLTC control cabinet to provide tap position indication for the transformer. The supplier shall also provide a spare set of instruments as per the clause for tap position indication in the control room. Complete mounting details shall be included with the approved diagram.

g) The OLTC shall be equipped with a fixed resistor network capable of providing discrete voltage steps for input to the supervisory system.

6.6.8 Limit switches shall be provided to prevent over-running of the mechanism and shall be directly connected to the circuit of the operating motor. In addition, a mechanical stop shall be provided to prevent over- running of the mechanism under any condition. Limit switches may be connected in the control circuit of the operating motor provided that a mechanical-de- clutching mechanism is incorporated.

6.6.9 Thermal device or other means shall be provided to protect the motor and control circuit. All relays, switches, MCBS etc. shall be mounted in the drive mechanism chamber and shall be clearly marked for the purpose of identification.

6.6.10 A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.

6.6.11 A five-digit counter shall be fitted to the tap changing equipment to indicate the number of operations completed.

6.6.12 All relays and operating devices shall function correctly at any voltage between the limits specified.

6.6.13 It shall not be possible to operate the electric drive when the manual operating gear is in use.

6.6.14 OLTC shall have a mechanical fuse incorporated in the design to ensure the protection of the diverter switch in the event of undue mechanical stress on Tap Changer.

6.6.15 It shall not be possible for any two controls (i.e. manual, local electrical and remote) to be in operation at the same time.

6.6.16 The Tap Selector Contacts shall not be of the threaded type to ensure positive, full face and firm contact from Transformer leads to Tap Changer.

6.6.17 The equipment shall be suitable for supervisory control and indication with make-before-break multi-way switch, having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches, which may be required for remote tap position.

6.6.18 All electrical control switches and the local operating gear shall be clearly labelled in a suitable manner to indicate the direction of tap changing. OLTC make proposed shall have proven record of installed population in similar ratings of not less than three (03) years.

6.6.19 No continuity break shall be allowed during changeover between any two taps. The OLTC shall be tested for the same by ensuring that there is no open circuit showing while changing two taps.

6.6.20 OLTC design should have been seismic tested and qualified.

6.6.21 OLTC manufacturer shall conduct the following routine tests fully in compliance with IEC 60214 on every unit, as given below, before dispatch to assure the quality of the product.

| S.no. | IEC Reference | Test Description | Acceptance level |
|---|---|---|---|
| 1 | 60214 Cl. No. 5.3.1 | Mechanical Endurance Test | Minimum 1000 operations |
| 2 | 60214 Cl. No.5.3.2 | Sequence Test | Switching operation with timing less than 50 m.sec. |
| 3 | 60214 Cl. No.5.3.4 | Pressure Test | 10 PSI (0.7kg/sq.cm) for 8 hrs at room temperature. |

| S.no. | IEC Reference | Test Description | Acceptance level |
|---|---|---|---|
| 4 | 60214 Cl. No.5.3.4 | Vacuum test | Should withstand 6 x 10-5 bar or better |
| 5 | Special Test | Gas Tightness Test using Halogen/ Freon/Helium gas | Shall withstand 0.7Kg/sq. cm for one (1) hour |
| 6 | 60214 Cl. No.5.3.4 | Auxiliary Circuits Insulation Tests. | Should withstand 2kV relative to earth for 1min |
| 7 | Special Test | Contact resistance test | < 2 milliohms |
| 8 | Special Test | Physical and dimensional Checks | As per approved drawing. |

6.6.22 All the relevant test reports shall be submitted along with the test report on transformer for Owner approval.

6.6.23 The Tap Changer shall be suitably protected through Oil Surge Relay, and it shall be of reed magnetic switch type. This surge relay shall be tested for an Oil flow velocity of 1.20 +/- 0.20 m/s.

**Manual Control**

6.6.24 The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man standing on ground level. The mechanism shall be complete with the following:

a) Mechanical tap position indicator which shall be clearly visible from near the transformer.

b) A mechanical operation counter.

c) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

d) The manual control considered as back up to the motor operated tap changer control shall be interlocked with the motor to block motor-start-up during manual operation. The manual operating mechanism shall be labelled to show the direction of operation for raise / lower

**a) Electrical Control**

6.6.25 This includes the following:

a) Local Electrical control.

b) Remote Electrical control from Remote Tap Changer Cubicle (RTCC)

**b) Remote Electrical Group Control**

6.6.26 The OLTC control scheme offered shall have provision of remote electrical group control during parallel operation of transformers. This is in addition to independent control of OLTC.

a) A four position selector switch having MASTER, FOLLOWER, INDEPENDENT and OFF position shall be provided in the remote OLTC control panel for each transformer. This shall be wired to enable operator to select operation of OLTC in Master, Follower or Independent mode.

b) Out of step relays with timer contacts shall also be provided to give alarm and indication in case of tap positions in all the transformers under group control being not in identical position.

**Master Position**

c) If the selector switch is in MASTER position, it shall be possible to control the OLTC units of other parallel connected transformers in the FOLLOWER mode by operating the controls of the MASTER unit. Independent operation of the units under FOLLOWER mode shall have to be prevented. However, the units under independent mode will be controlled independently.

**Follower Position**

d) If the selector switch is in FOLLOWER mode, control of OLTC shall be possible only from the RTCC panel which is selected as MASTER.

**Independent Position**

e) In this position of Selector Switch, Control of OLTC of individual unit only shall be possible.

## 6.7 Cooling Equipment and Its Controls

6.7.1 The cooler shall be designed using 2x50% radiator banks. The radiator shall preferably be provided on both sides of the transformer's main tank. The manufacturer shall provide adequate support to the radiator banks to avoid leakages due to cantilever action.

6.7.2 Each radiator bank shall have its own cooling fans, shut off valves, lifting lugs, top and bottom oil filling valves, air release plug, a drain valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

6.7.3 Radiators and coolers shall be designed to withstand the vacuum and pressure conditions specified for the tank.

6.7.4 One standby fan for each group shall also be provided and identified with each radiator bank.

6.7.5 Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration.

6.7.6 The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

6.7.7 Cooling fans for each radiator bank shall be located so as to prevent ingress of rainwater. Each fan shall be suitably protected by galvanized wire guard.

6.7.8 Cooling fans shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325.

6.7.9 An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. A provision shall be made in the flow indicator to indicate reverse flow of oil/loss of oil flow.

6.7.10 The cooler and its accessories shall be hot painted with corrosion resistant paint.

6.7.11 Each cooling fan and oil pump motor shall be provided with starter, thermal overload and short circuit protection.

6.7.12 Each radiator shall be provided with

a) One shut off valve at the top (80 mm size)
b) One shut-off valve at the bottom (80 mm size)
c) Air release device at the top.
d) Main & sampling device at the bottom.
e) Lifting lugs.
f) Expansion joints, one each on top and bottom cooler pipe connections.
g) Air release device and oil plug on oil pipe connections

**Cooling Equipment Control (ONAN/ONAF Cooling)**

6.7.13 Automatic operation control (switching in and out) of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The supplier shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start/stop operations for small temperature differential do not occur.

6.7.14 Suitable manual electrical (non-auto) control facility for cooler fans with manual/automatic selector switches and push buttons shall be provided.

**Remote Tap Changer Control (RTCC) Panel**

6.7.15 The auxiliary devices for remote electrical control of the OLTC and Cooler shall be housed in a separate panel to be placed in the Control room. The panel shall be made of sheet steel of thickness not less than 14 SWG and it shall be duly finished with Stoved enamel paint. The size and colour of the control cubicle to be supplied by the supplier shall be 750 mm depth and 2312 mm height and shade no. 631 of IS 5 respectively. The width of the cubicle may be as per the supplier's practice. Control and signal devices required to be mounted in the RTCC Panel shall comprise of the following.

6.7.16 Local – Remote selector switch for OLTC

6.7.17 Actuating switch/push button for electrical raise/ lower control.

6.7.18 Remote tap position indicator with tap numbers and corresponding rated voltage marked on the instrument. The tap position indicators shall be digital type.

6.7.19 One potential-free contact per tap for indication of tap position in the SCADA system.

6.7.20 A four-position selector switch having 'master' follower, 'independent' and 'off' positions.

6.7.21 Repeater dials of transformer winding temperature indicator.

6.7.22 Name plate for each component.

6.7.23 Initiating devices and contacts for alarm as well as for indications of discordance in the tap changer (if any) of the parallel operating transformers.

6.7.24 Cubicle lamp actuated by door switch, space heater, power socket etc. shall be provided inside RTCC panel.

a) Tap changer out of step.

b) Tap changer motor trip.

c) Failure of AC supply to the OLTC local control Kiosk.

d) Fan failure of each group.

e) Pump failure of each group.

f) Control supply failure, main / standby.

g) No flow/reverse flow of oil in oil pump.

h) Cooler supply failure, for each supply.

6.7.25 Signal lamps (LED type) for:

a) Fan 'ON' for each group.

b) Pump 'ON' for each pump.

c) Standby fan 'ON' for each group.

d) Cooling system on manual.

e) Cooling system on automatic control.

f) 415 volts cooler supply auto change over.

g) Healthy supply to control gear.

h) Tap change in progress.

6.7.26 Transformer monitoring cum Tap Changer system (TMCTS) shall be provided on RTCC panel.

6.7.27 The cabinet sealing system shall have a degree of protection not less than IP-42.

**Cooler Control Cabinet**

6.7.28 Each transformer unit shall be provided with a cooler control cabinet having a protection class IP56 or better. The cooler control cabinet shall be fabricated with minimum 2 mm thickness CRCA Sheet and shall have a rain hood & a sturdy mounting frame suitable for mounting on transformer body or grouting at Site and shall have a sight glass properly sealed with nitrile gasket to eliminate possibility of forming a vapour envelope .It shall be complete with all wiring, MCB, Links, Terminals, cubical illuminating LED lamp with door switch, 3 phase industrial socket with MCB along with single phase socket with switch, anti-condensation space heater with switch and thermostat , 3 mm thick gland plate etc. Space heaters shall be rated for 240V, 1Phase 50 Hz supply. Heaters shall be complete with rotary type `ON/OFF' switch, 2 pole MCB and a thermostat to control switching of the heater.

6.7.29 The cooler control cabinet shall be fuse less i.e. instead of control fuse, MCB shall be used of suitable rating. In Marshalling box, wiring shall be done with 1.1kV grade FRLS wires in conduit or XLPE FRLS multi strand cable. Minimum FRLS wire size shall be 4 sq.mm flexible multi strand copper wire for CT Leads and for other leads it shall be flexible 2.5 Sq.mm FRLS multi stranded copper wire. Not more than two wires shall be connected to a single terminal. 20% spare terminals shall be provided. All

internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks.

6.7.30 Compression type cable connector (lugs) shall be provided for termination of power and control cables. All devices and terminal blocks in the Marshalling box /Cooler Control Cabinet shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagrams.

6.7.31 Engraved code identification (plastic) ferrules marked to correspond with schematic diagrams shall be fitted at both ends of wires. Ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal block.

a) The 5A Switch socket combined Industrial duty with MCB shall also be provided for auxiliary supply.

b) The cooler control cabinet shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer shall also be wired up to the terminal board in the cooler control cabinet. All the secondary terminals of the bushing CTs shall also be wired up to the terminal board at the cooler control cabinet.

c) Labels shall be provided for all apparatus such as relays, switches, fuses, contained in the cooler control cabinet. Descriptive labels for mounting indoors or inside cubicles and kiosks shall be of material that will ensure permanence of the lettering. A matt or satin finish shall be provided to avoid dazzle from reflected light. Labels mounted on dark surfaces shall have white lettering on a black background.

d) The cooler control cabinet shall have two (2) sections. One section shall have the control equipment exclusively meant for cooler control. The other section shall house the temperature indicators, and the terminal boards meant for termination of various alarm and trip contacts as well as various bushing CT secondaries. Alternatively, the two sections may be provided as two separate cubicles / kiosks, depending on the standard practices of the supplier.

e) The temperature indicators shall be so mounted that the displays are not more than 1600 mm from ground level Glass door of suitable size shall be provided for convenience of reading

**Terminal Block (for RTCC Panel and Cooler Control Cabinet)**

6.7.32 The terminal block shall be stud type. The terminal blocks should be as per IEC 60947/7-1. The insulating material should be polyamide and all the metal parts should be nonferrous. The screws should be captive, and terminal be shock protected. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring.

6.7.33 All internal wiring to be connected to the external equipment shall be terminated on terminal blocks, preferably vertically mounted on the side of each panel. The terminal blocks shall be 1100 V grade and

have 10 amps continuous rating, molded piece, complete with insulated barriers, non-disconnecting stud type terminals, washers, nuts and lock nuts. Terminal block design shall include a white fiber-marking strip with clear plastic, slip-on/clip-on terminal cover. Markings on the terminal strips shall correspond to wire number and terminal numbers on the wiring diagrams.

6.7.34 Terminal blocks for current transformer secondary leads shall be provided with test links and isolating facilities. Also, current transformer secondary leads shall be provided with short-circuiting and earthing facilities.

6.7.35 At least 20% of spare terminals shall be provided on each cubicle and these spare terminals shall be uniformly distributed on all terminal blocks.

6.7.36 Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors on each side.

a) For all circuits except current transformer circuits: minimum of two nos. of 2.5 mm2 copper.

b) For all CT circuits: minimum two nos. of 4 mm2 copper.

6.7.37 There shall be a minimum edge to edge clearance of 250 mm between the first row of terminal block and the associated cable gland plate. Also, the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

6.7.38 Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run parallel and in close proximity along each side of the wiring duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the Owner's external cable connection. All adjacent terminal blocks shall also share this field wiring corridor. A steel strip shall be connected between adjacent terminal block rows at 450 mm intervals for support of incoming cables.

## 6.8 Painting

6.8.1 The internal and external surfaces including oil filled chamber and structural steel work to be painted shall be shot or sand blasted to remove all rust and scale or foreign adhering matter or grease. All steel surfaces in contact with insulating oil shall be painted with two coats of heat resistant, oil insoluble, insulating varnish. All steel surfaces exposed to weather shall be given a primary coat of zinc chromate, second coat of oil and weather resistant varnish of a color distinct from primary coat. Two coats of glossy oil and weather resisting Light Grey paint in accordance with shade no.: 631 of IS-5 shall be given finally. All paints shall be carefully selected to withstand extremes of the weather. The paint shall not scale off or crinkle or be removed by abrasion during normal handling. The minimum thickness of the outside painting of tank shall be 20 microns and the total thickness shall be minimum 80 microns.

## 6.9 Fire Protection System

6.9.1 The Transformer shall be provided with 'Nitrogen Injection, Drain and Stir Method type fire prevention and extinguishing system along with all associated fittings and control equipments including tank above the ground or below the ground (as per the latest norms).

6.9.2 The fire protection/prevention system shall work on the oil drain, Nitrogen Inject and Stir method. The system shall operate correctly during fire on transformer due to internal or external factors, including fire due to bursting of transformer bushing. Fire detectors (bulb type or linear heat detector type) provided on the transformer top cover / body shall take minimum time for detection of fire and initiate the fire protection system. The Manufacturer shall give complete details of the system and also arrange to demonstrate the operation of the firefighting system,

6.9.3 The system may have its own power supply unit for operation during A/C failure condition. Alternatively, systems suitable for operation on station DC aux. supply (220V DC) may be offered. The system shall operate in 'Auto'/'Remote Electrical'/ 'Local Manual' modes. Provision shall be available to keep the system "OUT", which is necessary for preventing any mal operation during transformer maintenance.

6.9.4 The firefighting system shall be compatible to be hooked on to the station SCADA/ fire alarm system. Systems using microprocessor/micro-controller will be given preference.

6.9.5 The firefighting system should have its own temperature sensors to detect all types of fires. On detection of fire (by the sensors) and receipt of positive feedback signal regarding "Master trip relay operated'' the system shall start operation, initially draining out top level oil in the main tank and simultaneously closing the valve in the conservator line and then start nitrogen injection into the transformer tank. The operational logic of the system shall be generally as shown in Annexure-1. Any modification shall be subject to approval of the Owner.

6.9.6 The system shall have a built-in online testing facility, which will be operable without affecting the functioning of the transformer.

6.9.7 On initiation of the fire extinguishing system on detection of fire, if the circuit breakers fail to trip/trip-relay fails to operate, suitable audible alarm should be sounded so as to call the attention of the operator to trip the breakers manually, and simultaneously initiating the oil drain and nitrogen injection system. The manual operating system shall be used only in case the automatic system fails to operate and hence the arrangement for manual operation shall be provided in a box and shall be accessible only after breaking the glass cover on this box.

6.9.8 The Manufacturer shall confirm whether it is advisable to initiate the "oil drain and nitrogen injection" manually even when the transformer is not electrically isolated due to stuck breaker problem.

6.9.9 The system shall preferably have built-in facility for monitoring/display of the following:

i. Oil temperature.
ii. Tank pressure.
iii. Healthiness of all sensors.
iv. 'Open'/ 'Close' status of valves.

6.9.10 Provision shall be available for annunciation (along with audible alarm) of the following:

i. Increase in temperature of oil/tank pressure beyond the set limit.
ii. Detection of fire due to external causes.
iii. Low nitrogen pressure.
iv. System initiated (automatic)
v. Automatic operation failed.
vi. Control cable faulty.

6.9.11 All valves used in the system shall preferably be stainless steel ball type together with flanges. By-pass valves along with electrical limit switches shall be provided wherever required. The connecting cables shall be Fire Retardant Low Smoke (FRLS) armoured cables. Cables passing along the top of the transformer shall be fire survival (FS) type.

6.9.12 Fire extinction cubicle shall be of robust design/construction and shall accommodate the Nitrogen gas cylinder of adequate capacity and associated accessories like, regulators, stainless steel tubings, etc. The cubicle shall have a degree of protection not less than IP-56.

6.9.13 The remote-control panel, to be mounted inside the control room shall accommodate the necessary control unit operating switches, push buttons, etc., as also the display unit and alarm annunciation unit.

6.9.14 The Manufacturer shall furnish the complete details including bill of materials of the fire extinguishing/fire prevention system offered. The list of all accessories including FRLS & Fire survival cables, pipes, valves, sensors, control cubicle, Nitrogen gas cylinder, etc. shall be listed out and furnished in the offer.

6.9.15 The Manufacturer/manufacturer shall ensure that the fire protection/prevention system offered is fool-proof and reliable. Installation, testing and commissioning of the firefighting system shall also be in the successful Manufacturer's scope. As such, length of connecting pipes, cables etc., required as per Site conditions, during erection, shall be ensured by the transformer manufacturer.

6.9.16 Fire Protection System should be capable of working on Automatic Mode, Remote Electrical mode and Local manual mode.

6.9.17 The Fire Fighting Scheme for the power transformer should have authentic certification regarding performance issued by any standard approved laboratory.

6.9.18 The manufacturers of such scheme should have past experience and should submit the list of such scheme supplied and commissioned and shall offer the latest firefighting system on an overall basis as per the prevalent best practices followed in the power industry.

### 6.10 Limits of Temperature Rise

| | | |
|---|---|---|
| A. | Temperature rise over 50°C ambient temp. | |
| i | Top oil measured by thermometer | 50°C |
| ii | Average winding measured by resistance method | 55°C |
| B. | Winding hot spot rise over yearly weighted temperature of 32 °C | 66°C |
| C. | Tank hot spot temperature | 110°C |
| D. | Maximum design ambient temperature | 50°C |

### 6.11 Specifications for Control Cabinets

6.11.1 Control cabinets shall be of the freestanding, floor-mounting type.

6.11.2 Control cabinet of the operating mechanism shall be made out of 3mm thick sheet steel or 10mm thick aluminium plate or casting. Hinged door shall be provided with padlocking arrangement. Sloping rain- hood shall be provided to cover all sides. 15mm thick neoprene or better type of gaskets shall be provided to ensure degree of protection of at least IP56 as per IS: 2147. The colour of paint shall be Light Grey in accordance with shade no 631 of IS 5.

6.11.3 Bus bars shall be of tinned copper of adequate cross section to carry the normal current, without exceeding the permissible temperature rise over an ambient temperature of 50 0C outside the cubicle. The bus bars shall be braced to withstand forces corresponding to short circuit current of 25 kA.

6.11.4 Fan Motors & Motors rated 1 kW and above being controlled from the control cabinet shall be suitable for operation on a 415 V, 3 phase 50 Hz systems.

6.11.5 Isolating switches shall be group-operated units (3 pole for use on 3 phase supply systems and 2 pole for single phase supply systems). The contacts shall be quick make quick break type, capable of breaking safely and without deterioration, the rated current of the associated circuit. The switch handle shall have provision for locking in both fully open and fully closed positions.

6.11.6 The push button shall be rated for not less than 6 Amps, 415 V A.C. or 2 Amps, 220V D.C. and shall be flush mounted on the cabinet door and provided with appropriate nameplates.

6.11.7 For motors up to 5 kW, contactors shall be direct-on- line, air break, and single throw type and shall be suitable for making and breaking the starting current of the associated motor which shall be

assumed to be equal to 6.5 times the full load current of the motor at 0.2 p.f. For motors above 5 kW, automatic star /delta type starters shall be provided. 3-pole contactors shall be provided for 3-phase motors and 2-pole contactors for single-phase motors. Reversing contactors shall be provided with electrical interlocks between forward and reverse contactors. If possible, mechanical interlocks shall also be provided. Contractors shall be suitable for uninterrupted duty and shall be of duty category class AC4 as defined in IS: 2959. The main contacts of the contactors shall be silver-plated and the insulation class for the coils shall be class E or better. The dropout voltage of the contactors shall not exceed 70% of the rated voltage.

6.11.8 Bidder shall be provided with three elements. Positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable setting. Hand reset button shall be flush with the front door of the cabinet and suitable for resetting with starter compartment door closed.

6.11.9 Single phasing preventer relay shall be provided for 3 - phase motors to ensure positive protection against single phasing.

6.11.10 Mini starters shall be provided with no- volt coils whenever required.

6.11.11 The Owner's power cables will be of 1100/650 volts grade. PVC insulated/ PVC sheathed single steel wire armoured and PVC jacketed. All necessary cable terminating accessories such as glands, crimp type tinned copper lugs etc. for power as well as control cables shall be included in the Manufacturer's scope of supply. Suitable brass cable -glands shall be provided for cable entry.

6.11.12 Wiring for all control circuits shall be carried out with 1100/650 volts grade PVC insulated tinned copper stranded conductors of size not smaller than 2.5 mm2. At least 20% spare terminal blocks for control wire terminations shall be provided on each panel. The terminal blocks shall be of non-disconnecting stud type. All terminals shall be provided with ferrules indelibly marked or numbered and these identifications shall correspond to the designations on the relevant wiring diagrams. The terminals shall be rated for adequate capacity, which shall not be less than 10 Amps.

6.11.13 Separate terminal blocks shall be provided for terminating circuits of various voltage classes. CT leads shall be terminated on a separate block and shall have provision for short-circuiting the CT secondary terminals.

6.11.14 The control cabinet shall be provided with 240 V, 1- phase 50 Hz, 20 W fluorescent light fixture and a suitably rated 240 V, 1 phase, 5 amps, and 3 pin sockets for hand lamps.

6.11.15 Strip heaters shall be provided inside each cabinet complete with thermostat (preferably differential type) to prevent moisture condensation. Heaters shall be controlled by suitably rated double-pole miniature Circuit Breakers.

6.11.16 Signal lamps provided shall be of LED type with series resistors, enclosed in bakelite body.

6.11.17 Items inside the cabinet made of organic material shall be coated with a fungus resistant varnish.

### 6.12 Special Tools and Tackles

6.12.1 The Manufacturer shall include in it's proposal any special erection and maintenance tools required according to the specialties of the Equipment. The list of such special tools shall be furnished in the offer and expenses of these shall be included in the proposed offer.

### 6.13 Spare Parts and Maintenance Equipment

6.13.1 Bidder shall submit the list of recommended spares, the makes and types of spares offered shall be the same as those offered along with the main transformer.

6.13.2 Owner shall decide the actual quantities of recommended spares to be included in the order. These recommended spares if ordered shall be supplied within six months of the date of order.

### 6.14 On-Line Multi Gas DGA for Transformer Oil

6.14.1 The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect, measure and analyze Acetylene (C2H2), Methane (CH4), Ethane (C2H6), Hydrogen(H2), Ethylene (C2H4), Carbon Dioxide (CO2), Carbon monoxide (CO) and moisture (H2O) and the two atmospheric gases i.e., Oxygen(O2) & Nitrogen(N2) in Transformer Oil, even at very low concentrations. It should be easy to install, and it should be possible to retrofit it on an energized transformer, without shutting down the transformer.

6.14.2 The monitor shall be designed for permanent outdoor use in high voltage substation environments, for environment temperatures of -100 C to 550 C or wider range and oil temperatures of -100 C to 1200 C.

6.14.3 The monitor shall comply to the following standards:

| Codes and Standards | Descriptions |
|---|---|
| IEC 61326-1 | EMI/EMC Standards |
| IEC 60255-21-1/IS 9000 | Basic Environmental Testing Procedures covering Shock, bump and vibration tests. |
| IEC 364-4-41 | Protection against electric shock |
| IEC 61010 | Safety requirements for electrical equipment for Measurement, control & laboratory use. |
| IEC 60529, IP 66 | Weatherproof Standards |

6.14.16 **The Test kit shall meet the technical requirements listed below:**

a) The monitor shall be equipped with an inbuilt oil circulation system to ensure that the oil being sampled is the true representative sample of the oil from the transformer tank/ in continuous

touch with the sensor of the equipment for online continuous monitoring of the oil from the transformer tank.

b) The analyzer should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be IEC 61850 compliant to integrate with SCADA system. The results shall be communicated to control room or remote location (through SCADA) and shall be compared with the standard preset results to indicate the possible severe damage/failure.

c) Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

d) Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

e) Online DGA shall be installed outdoor on transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). The equipment shall be suitable for proper operation in EHV substation (132 kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 degrees C ambient temperature and EMI and EMC compatibility.

f) The equipment shall connect to the transformer's main body in two locations. One connection is for the supply of oil from the transformer. Second connection is for the return of the oil to the transformer. The connecting oil lines must be of Stainless-Steel rigid pipes or flexible hose – shall be freeze during detailed engineering.

g) The equipment should have stabilized extraction and measuring system. The equipment shall be capable of extracting the seven Fault gases and the two Atmospheric gases and measuring them individually and reporting the concentrations from transformer oil.

h) Moisture Measurement must be through a direct oil immersed Relative Saturation (RS) sensor.

i) The monitor shall be equipped with an inbuilt oil circulation system with oil flow Monitoring and alarm for stoppage of flow. The monitor must have facility for collecting an oil sample for external oil tests, such as an external quick connect port plus sampling accessories.

j) The equipment outfitted with the ability to communicate via modem/ethernet or RS232 & RS485 ports and Analog 4-20mA isolated outputs. The result shall be communicated to the local computers and as well as transmitted to remote location computers.

k) The equipment shall be able to measure gas concentration and when downloaded should immediately compare it with user selected alarm and caution level for immediate display. The sampling rate shall be selectable as for example 4 or 6 or 12 hrs. etc. The equipment shall have

inbuilt memory to store these results for complete one (01) year even if sampling is done at the lowest interval.

l) The equipment shall have inbuilt memory to store the results, for a minimum of two (02) years.

m) The equipment should have Front panel display and controls. LCD display to provide up to date information at sight level.

n) The levels of dissolved gases shall be displayed in PPM. Also, it shall be possible to set different alarms levels for dangerous levels immediately.

6.14.17 The technical features of the equipment shall be as below.

**i. Operating Conditions:**

6.14.18 Instrument should work on 230V single-phase, 50Hz supply/ 220 V DC power supply. All the necessary power cables /adapters shall be provided by the supplier. Instrument should have CE certification.

**ii. Detection of Gases:**

6.14.19 The gases extracted shall be detected using a portable Gas Chromatograph (GC) with Thermal Conductivity Detector (TCD) / Flame Ionization Detector (FID) / any other detector. All the fault gases i.e., H2, CH4, C2H4, C2H6, C2H2, CO, CO2 & two atmospheric gases i.e., O2 and N2 concentrations shall be individually measured and displayed.

**iii. Performance Parameters**

6.14.20 The equipment shall comply with the following Performance parameters.

| **Gasses** | **Minimum Detection Limit in ppm** | **Working Range** | **Accuracy** | **Repeatability** | **Resolution** |
|---|---|---|---|---|---|
| Hydrogen (H2) | 5 | Up to 5,000ppm | ±2ppm or ±5% whichever is better | ±2% or ±3ppm whichever is better | 0.5 |
| Hydrocarbons (CH4, C2H4, C2H6,) | 3 | Up to 5,000ppm | | | 0.2 |
| Acetylen (C2H2) | 1 | Up to 3,000ppm | | | |
| Carbon Monoxide (CO) | 10 | Up to 10,000ppm | ±15% | ±10% | 5 |
| Carbon Dioxide (CO2) | 25 | Up to 30,000ppm | ±15% | ±10% | 5 |

| Gasses | Minimum Detection Limit in ppm | Working Range | Accuracy | Repeatability | Resolution |
|---|---|---|---|---|---|
| Oxygen (O2) | 500 | Up to 25,000ppm | ±15% | ±10% | 200 |
| Nitrogen (N2) | 5000 | Up to 100,000ppm | ±15% | ±10% | 1000 |

a) Accuracy + 10%

b) Repeatability +3% to 10% depending upon gases.

c) Oil temperature Range : -10˚C to + 120˚C

d) External Temperature Range : -10˚C to + 55˚C

e) Humidity Range : 10 to 100 %

f) Pressure withstand : The monitor must withstand pressure from Full Vacuum to 40 psi.

g) Degree of protection of the enclosure: IP 66

h) Enclosure material : Stainless Steel

i) Operating Voltage : 230V AC ± 10%; 50 ± 5% Hz or 220V DC

j) Communications : RS-232 ports and Analog 4 – 20 mA isolated outputs/ RS-485, USB, PSTN/GSM Modem, and Ethernet shall be Fiber Optic over Ethernet with IEC 61850 protocol support for substation Automation.

k) Alarm : Sophisticated Programmable alarm system

**Calibration:**

6.14.21 Instrument must have Auto calibration function on Site at regular time interval. The Monitor MUST be calibrated with a Reference Calibration Gas Standard that has a NIST Traceability Certificate.

**Software:**

6.14.22 The software should provide diagnostic reports for individual pieces of equipment or for a full system, using the equipment tree. A laptop PC of Compaq/HP/IBM/DELL/Lenovo make with latest specifications (i.e., Minimum i-5 processor, 4 GB RAM, 320 GB Hard Disk & at-least 14" screen) shall be included in the scope of supply as an accessory to the offered equipment shall be supplied for data Archival, Analysis and reporting. Equipment should be supplied with the user-friendly PC software which provides fault indication and fault diagnostics including the following:

**Fault indication**

- IEEE, IEC or user configurable levels of dissolved gases
- Rate of change trending

**Fault Diagnosis**

- Key gases
- Ratios (Rogers, IEC, etc.)
- Duval's Triangle

Free hardware and software upgrade shall be supplied till expiry of guarantee period.

**Accessories**

6.14.23 The equipment shall be supplied with all necessary accessories required for carrying out online DGA of transformer oil complete in all respect as per the technical specification. Bidder to furnish the list of accessories being supplied with the equipments. Free consumables shall be supplied by the bidder till expiry of guarantee period. The following shall be also forming a part of supply.

6.14.24 Operation Manual: one set for every unit

1. DGA Software Manual
2. PC Software manual
3. Compact disc giving operation procedures of Maint. Manual & Trouble shooting instructions.
4. Basic 8 Gas Monitor with Monitor Mounting Kit
5. Calibration Cylinder
6. Bleed Fixture & Junction Box with 3.5ft. Cables
7. Carrier gas tank regulator, dryer and supply lines
8. Load Guide & Ambient Temperature Sensors
9. Manual DGA sample port assembly
10. Oil supply and return assembly.
11. Associated Software
12. Carrier Gas Cylinder with 99.999% purity with gas regulator and pressure gauges
13. Suitable SS Tubing of required dia and length for oil & gas.
14. Any other accessories required for with the supplied item other than what is specified.

## 6.15 Demonstration

6.15.1 The acceptance of the kit shall be subjected to the successful demonstration by the manufacturer/supplier to the satisfaction of Owner/Owner appointed consultant at prescribed Site at the time of commissioning. The following functions must be demonstrated.

1. The Oil sampling.
2. The Gas extraction

3. The analysis of the gas sample and reporting the concentrations of the various gases
4. The Calibration with reference to a NIST traceable gas standard.

### 6.16 Compatibility for Scada Operations

6.16.1 The transformer should be compatible for SCADA connectivity. Further, TPI, OLTC, ROTI and RWTIs shall suit the following operations through SCADA.

1. TPI indication on SCADA.
2. OLTC operation through SCADA.
3. Winding Temperature Indications on SCADA.
4. Oil Temperature Indication on SCADA.
5. The necessary fittings required for above SCADA operations are to be provided in addition to the conventional fittings as mentioned in clause 6.17.0.

### 6.17 Tests

6.17.1 The transformer offered shall be of fully type and special tested design & the manufacturer shall furnish all the type test reports.

6.17.2 The supplier shall carry out all type tests and routine tests on the transformers as per the relevant standard. Type tests and special tests shall be carried out on one- transformer and routine tests on all transformers. Additional tests required to be carried out are also listed hereunder.

6.17.3 The manufacturer shall confirm to type tests reports for following fittings and shall furnish type test reports along with drawings of the equipment/ fittings, details given below.

a) Bushing (Type test as per IS/IEC:60137)
b) OLTC (Test as per IS 8468/IEC:60214 and degree of protection test for IP-55 on Driving mechanism box)
c) Buchholz relay
d) OTI and WTI
e) Pressure Relief Device (including degree of protection test for IP 55 in terminal box
f) Sudden Pressure Relay (including degree of protection test for IP 55 in terminal box)
g) Magnetic Oil Level gauge & Terminal Box degree of protection test for IP-55.
h) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016
i) Marshalling & common marshalling box and other outdoor cubicle (IP- 55 test)
j) Bus post Insulators
k) Cooling fan & motor assembly
l) RTCC Panel (IP-43 test)

m) Eberley make AVR relay – All type tests.

**Routine Tests**

6.17.4 All standard routine tests in accordance with IS: 2026 (Revised 2011), with dielectric tests corresponding to Method 2 as per amendment No.1 issued in September 1980 to IS: 2026 shall be carried out on each transformer.

6.17.5 Operation and dielectric testing of OLTC shall be carried out as per IS: 2026 Clause no.16.9

6.17.6 Following additional routine tests shall also be carried out on each transformer:

**a) Magnetic Circuit Test**

a) After assembly, each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates, and structural steel work.

b) Oil leakage test on transformer tank as per details given in this Clause subsequently.

c) Measurement of power taken by fans and oil pumps.

**d) Capacitance and Tan delta of Windings**

b) Measurement of capacitance and tan delta to determine capacitance between winding & earth. This measurement shall be carried out before and after series of electric tests. Tan delta value shall not be more than 0.5% corrected at 200C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

**e) Capacitance and Tan delta of bushings**

c) Tan delta value shall not be more than 0.4% corrected at 200 C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

f) Bushing current transformer ratio & polarity tests.

g) Low voltage test for short circuit impedance, Open Circuit and magnetic balance (for field references/signature values).

**h) Pressure Relief Device Test:**

d) The pressure relief device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in 'Tank tests' subsequently in this clause. The device shall seal off after the excess pressure has been released.

**Type Tests**

6.17.7 Following type tests shall be conducted on one transformer:

a) Temp-rise test as per IS: 2026 (Part-I).

a) The temperature rise test shall be conducted at extreme tap corresponding to maximum temperature rise. In case tested losses and / or quoted losses at extreme tap are more than the maximum losses specified at normal tap, the transformer shall be tested by feeding the tested losses or quoted losses whichever is higher. The supplier, before carrying out such tests, shall

submit detailed calculations showing the alternatives possible on various taps and for the two different ratings (ONAN/ONAF) of the transformer and shall recommend the combination that results in highest temperature rise for the test.

6.17.8 Gas Chromatographic analysis on oil shall be conducted along with the test and the value shall be recorded in the test report. The sampling shall be in accordance with IEC-567. For the evaluation of the gas analysis in temperature rise test, a method will be proposed which is based on the rate of increase of particular gases and the permissible limits of minimum detectable value of gases. The maximum limit will be mutually discussed and agreed upon between the Owner and Supplier. This shall be treated as reference during future maintenance of the transformer.

b) Tank vacuum test as per details given in this clause subsequently.

c) Tank pressure test as per details given in this clause subsequently.

d) Pressure Relief Device Test: The pressure relief device shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in 'Tank tests' subsequently in this clause. The device shall seal off after the excess pressure has been released.

**Special Tests**

6.17.9 Following special tests other than type and routine tests shall also be carried out as per IS: 2026 Part-I and Part-III as applicable on one unit.

i. Measurement of acoustic noise level.

ii. Measurement of power taken by cooling fans.

6.17.10 Dynamic short circuit test shall be as per CEA requirements.

## 6.18 Tank Tests

**a) Routine tests**

**Oil leakage test**

6.18.1 All tanks and oil filled compartments shall be tested for oil tightness by completely filling with air or oil of a viscosity not greater than that of insulating oil conforming to IEC-60296 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 kN/$m^2$ measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

**b) Type Tests**

**i. Vacuum Test (On one unit)**

6.18.2 Where required by the Owner one transformer tank shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 kN/$m^2$ absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below.

| Horizontal length of flat plate (in mm) | Permanent Deflection (in mm) |
|---|---|
| Up to and including 750 | 5.0 |
| 751 to 1250 | 6.5 |
| 1251 to 1750 | 8.0 |
| 1751 to 2000 | 9.5 |
| 2001 to 2250 | 11.0 |
| 251 to 2500 | 12.5 |
| 2501 to 3000 | 16.0 |
| above 3000 | 19.0 |

**i. Pressure Test (On one unit)**

6.18.3 Where required by the Owner, one transformer tank of each size together with its radiator, conservator vessel and other fittings shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/$m^2$ whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

**Sequence of Tests**

6.18.4 The sequence of type tests, special tests (whenever applicable) and routine tests required to be conducted on each transformer is as mentioned hereunder:

| S NO. | TEST CATEGORY | DESCRIPTION |
|---|---|---|
| 1 | Type | Parameters as per drawings. |
| 2 | Type | Tank pressure test with measurement of deflection. |
| 3 | Type | Tank vacuum test with measurement of deflection |
| 4 | Routine | Pressure relief device test. |
| 5 | Type | Degree of protection IP 56 for cabinets of OLTC, cooling control. |
| 6 | Routine | Magnetic circuit insulation test 2kV - 1 Min. (Core to Yoke clamp, Core to Tank, Tank to Yoke Clamp) |

| S NO. | TEST CATEGORY | DESCRIPTION |
|---|---|---|
| 7 | Routine | Magnetic balance test at any one tap. |
| 8 | Routine | IR value at 10/60/600 sec (before & after HV & TR Tests) |
| 9 | Routine | Capacitance and tan delta (before & after HV & TR tests.) at 5 KV & 10 KV: HV to LV + TANK; HV + LV to TANK, in grounded and guarded specimen modes. |
| 10 | Routine | Winding resistance at all taps. |
| 11 | Type | Oil DGA test (before and after HV & TR tests) |
| 12 | Routine | Oil BDV test (before and after HV & TR tests |
| 13 | Routine | Voltage ratio at all taps & polarity/phase displacement at normal tap. |
| 14 | Routine | No load loss and excitation current (before & after HV & TR tests) at 90%, 100% and 110% of rated voltage with 3W, 3A & 3V meters method. |
| 15 (a) | Type (Only on that transformer which is to be type tested) | Impulse test: (on all windings)<br>i) One reduced full wave<br>ii) One full wave<br>iii) One reduced chopped wave<br>iv) Two full chopped wave<br>v) Two full waves |
| 15 (b) | Routine (on transformers which are to be routine tested) | Impulse test: (on all windings)<br>i) One reduced (50% to 75%) full wave<br>ii) Three full waves |
| 16 | Routine | Separate source voltage withstand test |
| 17 | Routine | Induced over voltage withstand test:<br>i) ACSD for 132KV class transformers<br>ii) ACLD for 220KV class transformers<br>as pr IS-2026 (part-3)-2011. |
| 18 | Special | Harmonic analysis of no-load current at 90%, 110% of rated V |

| S NO. | TEST CATEGORY | DESCRIPTION |
|---|---|---|
| 19 | Special | Zero sequence impedance test at 10% / 20% / 60%/ 80% /100% of test current at extreme taps and normal tap. |
| 20 | Special | Acoustic noise level test. |
| 21 | Routine | Load loss at extreme taps & normal tap & impedance at all taps by 3W, 3V, 3A meter method. |
| 22 | Type | Temperature rise test at ONAN, ONAF & OFAF ratings and corresponding to quoted max. losses.<br>----- Repeat tests at sr. nos. 8,9,11,12 and 14 ---- |
| 23 | Routine | Measurement of power consumption by fans & pumps |
| 24 | Routine | Oil leakage test at 35 KN/m2 (0.357kg/sq.cm) over max. static head of oil measured at the base for 12 hrs. |
| 25 | Routine | Tests on OLTC:<br>1) Circuit insulation test 2 KV - 1 Min.<br>2) Operations tests: 8 Cycles; 1 Cycle at 85% of rated Voltage, 1 Cycle at no load and rated Voltage, 10 Cycles of +/- 2 steps from normal Tap and at rated current. |
| 26 | Routine | Cooling control test:<br>1) Circuit insulation test 2 KV- 1 Min.<br>2) Operation test. |
| 27 | Type | Jacking test |
| 28 | Routine | Bushing current transformer ratio & polarity tests. |
| 29 | Routine | SFRA |
| 30 | Routine | Low voltage tests (for field references/signature values)<br>(i) Short circuit impedance Test<br>(ii) Open Circuit for measurement of magnetizing current<br>(iii) Magnetic balance |
| 31 | Routine | Capacitance and Tan delta of bushings |

| S NO. | TEST CATEGORY | DESCRIPTION |
|---|---|---|
| 32 | Routine | All functional tests for N2 Fire protection system by actual operation/simulation. |

NOTE:

1) CT, PT, Ammeter, Voltmeter, Wattmeter, Frequency meter shall be of appropriate class of accuracy and shall have valid calibration certificate.
2) T.R – Temperature Rise Test.

6.18.5 The manufacturer shall carry out the Sweep Frequency Response Analysis (SFRA) Test at their works and also during pre-commissioning at Site. The values / data shall be furnished to Owner before charging.

6.18.6 **On-Site tests [ After complete Installation of transformer at Site]**

1. Parameters as per approved drawings including check for any oil leakages.
2. Vector group and ratio checking at all tap positions.
3. Winding Resistance measurement
4. Magnetic balance test
5. Insulation resistance measurement, Polarization index, functional test on marshalling box for all devices (example: WTI, OTI, Buchholz, etc.) by simulating fault conditions.
6. Measurement of short circuit impedance and magnetizing current of the transformer.
7. Oil BDV test.
8. Bushing current transformer ratio and polarity tests.
9. SFRA –Sweep Frequency Response Analysis.
10. Cooling control test:
    a) Circuit insulation test 2 KV- 1 Min.
    b) IR test of fan motors
    c) Cooling fan operation test on WTI for all fans.
11. Checks related to N2 firefighting system.
12. Tan Delta test on bushings & CTs.
13. Checks related to Inline Dissolved Gas Analyzer.

## 6.19 Transformer losses

6.19.1 Apart from rejection due to failure of the transformer to meet the specified test requirements, the transformer shall be liable for rejection on account of any one of the following reasons.

a) The transformer is to be designed with losses not exceeding maximum losses as indicated in Technical Parameters of this specification. The losses indicated are maximum without any positive

tolerance and any transformer with losses (quoted/measured at the time of final testing/ inspection) exceeding this limit shall not be accepted i.e., transformer with positive tolerance will be rejected. Maximum allowable $I^2R$ losses to be 85% (without any positive tolerance) of the total load loss excluding cooler loss. Any transformer with I2R losses above 85% (calculated at the time of technical scrutiny/measured at the time of final testing/ inspection) will be rejected.

b) The percentage impedance voltage on normal tap and at rated MVA shall be as indicated in Technical Parameters of this specification with 0% to +10% tolerance applicable, no negative tolerance is allowed.

c) The transformer's efficiency shall be greater than 99.6%. The selected transformer shall be dynamic short circuit type tested product for similar or higher capacity. All the drawings and design calculations shall be provided for the Owners review and endorsement as per CIGRE 204.

### 6.20 Inspection

6.20.1 The Owner shall have access at all reasonable times to the works and all other places of manufacture where the transformers are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the supplier's works, raw materials, manufacture of all the accessories and for conducting necessary tests.

**I. Stage Inspection**

6.20.2 The supplier / Bidder shall keep the Owner informed in advance of the time of starting and of the progress of the manufacture of equipment in its various stages so that arrangements could be made for stage inspections.

### 6.21 Quality Assurance Plan (QAP)

6.21.1 The Manufacturer shall invariably furnish the following information along with it's offer, failing which the offer shall be liable for rejection.

a) Statement giving list of important raw materials, names of sub-suppliers for the raw material, list of standards according to which the raw material are tested, list of tests normally carried out on raw material in the presence of the transformer manufacturer's representative and copies of test certificates.

b) Information and copies of test certificates as in (i) above in respect of bought out items.

c) List of manufacturing facilities available.

d) Level of automation achieved and list of areas where manual processing exists.

e) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

f) Special features if any are provided in the equipment to make it maintenance free.

g) List of testing equipment available with the transformer manufacturer for final testing of equipment specified and test Plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in the "Schedule of Deviations".

6.21.2 The supplier shall immediately after placement of order, submit the following Information to the Owner.

a) Descriptive list of the raw material as well as bought out accessories and the names of sub suppliers selected from those furnished along with the offer.

b) Type test certificates of the raw material and bought out accessories.

c) Quality Assurance Plan (QAP) withhold points for Owner's inspection. The QAP and hold points shall be discussed between the Owner and the supplier before the QAP is finalized.

6.21.3 The supplier shall submit the routine test certificates of bought out items and raw material at the time of routine testing of the fully assembled equipment.

**6.22 Documentation**

6.22.1 All drawings shall conform to relevant International Standards Organization (ISO) specification. All dimensions and data shall be in S.I Units.

6.22.2 The Bidder shall furnish along with the bid dimensional drawings of Transformer, and all other accessories. These drawings shall include the following information.

a) Dimensions.

b) Tolerances on dimensions.

c) Material designation used for different components with reference standards.

d) Fabrication details such as welds, finishes and coatings.

e) Catalogue or part numbers for each component and the total assembly with bill of materials.

f) Identification marking.

g) Weight of individual components and total assembled weight.

h) Foundation drawing.

i) G.A. drawings of cooler control cabinet and RTCC panels.

j) Schematic drawings of OLTC, RTCC and cooler control.

k) Loss calculations

l) Impedance calculations

m) Short circuit calculations

n) Cooling calculations

o) Manufacturers shall have to furnish following guaranteed technical parameters along with bid:

1. Weight of HV/LV windings for power transformers.

2. Core weight & dimensions.
3. Weight & type of insulation
4. Copper weight.
5. Conductor size for HV/LV windings for power transformer

p) Furnish the documentary evidence regarding NABL accreditation for transformer manufacturer's testing lab.

6.22.3 The supplier shall, immediately after placement of order, submit three sets of final versions of all the drawings as per Schedule – D1 for Owner's approval. The Owner shall communicate his comments/approval on the drawings to the supplier within a reasonable period. The supplier shall, if necessary, modify the drawings and resubmit three copies of the modified drawings for Owner's approval within one week from the date of comments.

6.22.4 The supplier shall also furnish three copies (per unit of transformer) to the Owner, of bound manuals covering erection, commissioning, operation and maintenance instructions and all relevant information and drawings pertaining to the main equipment as well as auxiliary devices. Marked erection drawings shall identify the component parts of the equipment as shipped to enable Owner to carry out erection. Each manual shall also contain one set of all the approved drawings, type test reports as well as acceptance reports of the corresponding consignment dispatched. One set of good quality reproducible of all approved and as-built drawings shall also be supplied.

6.22.5 The manufacturing of the equipment shall be strictly in accordance with the approved drawings and no deviation shall be permitted without the written approval of the Owner. All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawing shall be at the supplier's risk.

### 6.23 Test Reports

6.23.1 The equipment shall be dispatched only when all the required type and routine tests have been carried out and test reports have been approved by the Owner.

6.23.2 The test reports for the tests carried out on the auxiliary apparatus shall be furnished to the Owner for approval prior to dispatch. All auxiliary equipment shall be tested as per the relevant standard. Test certificate shall be submitted for bought out items.

6.23.3 Four copies of type test reports shall be submitted to the Owner within one month of conducting the tests. One copy will be returned duly certified by the Owner to the supplier within three weeks thereafter and on receipt of the same the manufacturer shall commence commercial production of the remaining similar units.

6.23.4 Four copies of acceptance test reports shall be submitted to the Owner. One copy will be returned duly certified by the Owner and only thereafter shall the materials be dispatched.

6.23.5 All records of routine test reports shall be maintained by the supplier at it's works for periodic inspection by the Owner.

6.23.6 All test reports for tests conducted during manufacture shall be maintained by the supplier. These shall be produced for verification as and when requested for by the Owner.

**6.24 Packing and Forwarding**

6.24.1 The equipment shall be packed in crates suitable for vertical/horizontal transport as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit due to improper and inadequate packing. The easily damaging material shall be carefully packed and marked with the appropriate caution symbol. Wherever necessary, proper arrangements for lifting, such as lifting hooks etc. shall be provided. Any material found short / damaged inside the packing cases shall be supplied / made good by supplier without any extra expense to the Owner.

6.24.2 Each consignment shall be accompanied by a detailed packing list containing the following information:

a) Name of the consignee
b) Details of consignment
c) Destination
d) Total weight of consignment
e) Sign showing upper/lower side of the crate.
f) Handling and unpacking instructions.
g) Bill of material indicating contents of each package.

6.24.3 The supplier shall ensure that the packing list / bill of materials are approved by the Owner before dispatch.

**6.25 Training**

6.25.1 The successful tenderer shall be required to provide facilities for in Plant training, at no extra expense to the Owner, to at least five engineers to be nominated by the Owner for a period of one week at his works, where the equipment offered shall be manufactured. The scope of the training shall cover assembly, factory testing, Site testing, periodical maintenance, and operation and possible trouble shooting of the transformers. The Owner reserves the right to depute all / any / no engineer for the training.

**6.26 Warranty**

6.26.1 The warranty period of the Power Transformer shall be minimum five (05) years from the date of Commissioning of Facility.

6.26.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

6.26.3 During the warranty period, whenever a technical problem is encountered with Transformer, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the Transformer shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

6.26.4 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 7. 132kV Surge Arrestor (SA)

## 7.1 Intent of Specification

7.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, loading and unloading at Site, storage at Site, erection, testing and commissioning of surge arrestors, complete with all materials and accessories for efficient and trouble-free operation. The specification covers many aspects of Owner specifications, and the OEM/ Bidder has to ensure that all requirements are as per their latest standards are complied all requirements for supply, inspection, testing & commissioning along with installation at Site with all documentation required at various stages are followed.

7.1.2 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 7.2 Codes and Standards

7.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below.

| Standard | Description |
|---|---|
| IS 3070-3 | Lightning arresters for alternating current systems – Metal oxide lightning arresters without gaps |
| IEC 60099-4 | Metal oxide surge arresters without gaps |
| IEC 60099-5 | Selection and application recommendation |
| IEC 270 | Standard for Partial discharge measurement |
| IS 2071 | High voltage test techniques |
| IS 5621 | Standard for Hollow insulators |
| IS 6209<br>IS:3070 (Part-III) | Methods for Partial Discharge Measurement<br>Specification for Lightning Arresters for Alternating Current Systems (Part-III) |
| IS:4759 | Hot Dip Zinc-Coating on Structural Steel and Other Allied Products. |
| IS:2633 | Method for Testing Uniformity of Coating on Zinc Coated Particles. |
| IS:2147 | Degree of Protection Provided by Enclosures for Low Voltage Switch Gear and Control. |

| Standard | Description |
|---|---|
| IER-1956 | Indian Electricity Rules, 1956 |

### 7.3 Scope of Work

7.3.1 Scope of Supply:

a) 120kV, Station class, heavy duty, metal oxide (ZnO) type single-pole Pedestal mounting, outdoor type.

b) Surge arrester with insulating base and surge counter. Each lighting arrester shall be furnished complete with accessories.

c) Bimetallic terminal connector for Surge arrester as required.

d) One set of special tools and tackles.

7.3.2 All relevant drawings, data and manuals.

### 7.4 Design Criteria

7.4.1 The equipment will be used in high voltage system, i.e. 145kV.

7.4.2 The equipment will be installed outdoor in a hot, humid and tropical atmosphere.

7.4.3 All equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion.

7.4.4 The maximum temperature in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in the relevant standards.

7.4.5 The equipment shall be capable of withstanding the dynamic and thermal stresses of listed short circuit current without any damage or deterioration.

7.4.6 Radio interference voltage shall be limited to a value as per requirement.

7.4.7 The safety clearances of all live parts of the equipment shall be as per relevant standards.

7.4.8 Surge arrester shall be suitable to protect the equipment having insulation level as per standard.

7.4.9 Surge arrester shall be capable of discharging over-voltages occurring during switching of unloaded transformer, reactor and long line.

7.4.10 The arrester shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes.

### 7.5 Constructional Features

7.5.1 The arrester shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes.

7.5.2 Surge arrester shall be single pole, hermetically sealed with non-linear blocks of sintered metal oxide material so as to obtain a robust construction with excellent electrical, thermal and mechanical

characteristics even after repeated operation. The metal oxide discs used for type testing of the arrester as well as bulk supply should be procured by the OEM/bidder from the same source.

7.5.3 The rating and M.C.O.V. of metal oxide disc will be printed on each metal oxide disc. Bidder to give complete details. The housing of surge arrestor shall be of polymer type. A metal oxide surge arrester with a Housing Made of Polymeric Material preferably of Silicon Rubber, without air voids neither between the housing and the metal oxide resistors nor the housing itself All metal parts and hardware shall be hot dip galvanized. Arresters must have directly moulded housings. The surge arresters shall strictly conform to IEC 60099-4/IS:3070 (Part-III) with latest amendment if any in all respects. Maximum residual voltage shall comply with the requirement given hereunder.

7.5.4 Creepage distance shall correspond to specified value. Grading ring, if required, shall be provided to maintain voltage gradient within permissible limit.

7.5.5 Surge arrester shall be provided with pressure relief device to prevent shattering of polymeric housing in case excessive gas pressure builds up. The polymer material which is used for the arrester housing must be tracking and erosion resistant, stabilized against UV radiation and preferably of Silicon Rubber.

7.5.6 The cantilever strength of the surge arrester with polymer housing shall not be less than 150kgs. Polymer housing shall be tested in accordance with IEC 61462.

7.5.7 The surge arrestor shall be capable of withstanding maximum continuous operating voltage (MCOV).

**7.6 Accessories**

7.6.1 Surge arrester shall be furnished complete with insulating base, surge counter, leakage current meter and anchoring hardware for mounting on structure.

7.6.2 A leakage current detector shall be furnished with the counter as an integral part. This is for monitoring the leakage to indicate any possible breakdown.

7.6.3 Surge counter and leakage current meter shall be housed in an IP 67 enclosure and their reading shall be visible through inspection glass panel in the front.

7.6.4 The surge counter housing shall be mounted at a convenient height for reading. Counter terminals shall be such as to permit connections with minimum possible bends. The mounting arrangement shall be such that it can be tilted 45 degrees from horizontal plane for convenient of reading. Type test certificate for surge counter shall also be furnished.

7.6.5 A suitably sized by-pass shunt along with necessary terminals shall be furnished for bypassing the discharge counter if required.

**7.7 Terminals**

7.7.1 All connection terminals shall be of corrosion resistant material and complete connection hardware.

7.7.2 High voltage line terminal shall be provided with bimetallic terminal connector suitable for connection to the type and size suitable for Moose conductor.

7.7.3 All ground terminals shall have provision of connection to cu flat of appropriate size.

**7.8 Test**

7.8.1 Routine Tests

a) During manufacture and on completion, all equipment including surge counter shall be subjected to the Routine Tests and Acceptance Tests as laid down in latest revision of relevant Indian Standard / IEC standards. No surge arrester shall be dispatched without inspection and testing. The inspection may be carried out by the Owner at any stage of manufacture. The bidder shall grant free access to the Owner's representative at a reasonable time when the work is in progress.

b) Inspection and acceptance of any equipment under this specification by the Owner shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.

c) The supplier shall keep the Owner informed in advance, about the manufacturing program so that arrangement can be made for inspection.

7.8.2 Type Tests

a) Type test certificate, dated not more than five (05) years back, shall be furnished for the offered model of the Surge arrester & Surge Counter/monitor.

b) All the type tests must be valid within five (05) years from the date of first submission for drawing approval of Owner. In case these type tests are conducted earlier than preceding five (05) years all the type tests as per the relevant standards will have to be carried out by the successful bidder in the NABL Accredited Laboratories at bidder's own expense before commencement of supply. For any change in the design/type which is already type tested and the design/type offered against this specification, the Owner reserves the right to demand testing without any extra expense.

c) All routine and acceptance tests as stipulated in the specified standards shall be carried out by the supplier in presence of Owner's representative at supplier's expense. The acceptance tests, wherever possible, shall be performed on the completed arresters. The number of samples to be subjected to acceptance tests shall be decided by the Owner at the time of actual testing.

d) The special thermal stability test as per IEC 60099-4 for metal oxide surge arresters shall be carried out as acceptance test.

e) The acceptance tests shall include the galvanization test on metal parts.

f) The functional (operation) acceptance tests shall be carried out on the surge counter by way of checking its operation at following nominal discharge currents: a) 100Amps with 8/20 microSec waveshape. b) 10kA with 8/20 microSec waveshape.

### 7.9 Test Witness

7.9.1 Tests shall be performed in presence of Owner representative if so desired by the Owner. The Contractor shall give at least Fifteen (15) days' advance notice of the date when the tests are to be carried out.

### 7.10 Test Certificates

7.10.1 Certified reports of all the tests carried out at the works shall be furnished in required number.

7.10.2 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

7.10.3 Type test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

### 7.11 Special Tools & Tackle

7.11.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

7.11.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

### 7.12 Technical Parameters

| S.No | Description | Data |
|---|---|---|
| 1. | System voltage (nominal / highest) | 132 / 145 kV |
| 2. | Rated arrester voltage | 120 kV |
| 3. | Installation | Outdoor |
| 4. | Type of earthing | Effectively earthed |
| 5. | Type of arrester | Metal oxide / Gapless |
| 6. | Rated frequency | 50 Hz |
| 7. | Nominal discharge current | 10 kA of 8/20 microsecond wave |
| 8. | One minute power frequency withstand voltage | 275kV (rms) |
| 9. | Full wave microsecond impulse voltage (1.2/50 µs) | 650kVp |
| 10. | Rated thermal energy rating | 7 kJ/k |
| 11. | Continuous operating voltage at 50°C | 102kV (rms) |

| S.No | Description | Data |
|---|---|---|
| 12. | Max. residual voltage at discharge current | 330kV (peak) at 10kA |
| 13. | Long duration discharge class (IEC) | 3 |
| 14. | High current short duration test value | 100kA (peak) |
| 15. | Current for pressure relief test | 40kA (rms) |
| 16. | Low current long duration test value | As per IEC |
| 17. | Partial discharge level at 1.05 COV | As per IEC |

### 7.13 Fittings and Accessories

7.13.1 Each Surge Arrester shall be furnished complete with the accessories as listed below:

7.13.2 Insulating Base with anchoring bolts, nuts etc. for fixing the equipment on to structure.

7.13.3 Surge counter with integral leakage current monitor. The surge counter shall have terminals of robust construction for connection to earthing lead and these shall be suitably arranged to enable the incoming and outgoing connection to be made with minimum bends. Degree of protection of surge monitor shall be IP-67.

7.13.4 By-pass shunt with connection provision.

7.13.5 Clamp type bimetallic terminal connectors, Suitable for Moose conductor.

7.13.6 Ground terminals.

7.13.7 The surge arrester shall be suitable for hot line washing.

7.13.8 Grading ring, if necessary.

7.13.9 Other standard accessories which are not specifically mentioned but are usually provided with Surge Arrester of such type and rating for efficient and trouble-free operation.

**NOTE: The surge arresters shall be fitted with pressure relief devices and arc diverting parts and shall be tested as per the requirement of IEC 60099-4 specification for minimum prospective symmetrical fault current of 40kA$_{rms}$.**

# 8. 132kV Isolator with Earth Switch

## 8.1 Intent of Specification

8.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, loading and unloading at Site, storage at Site, erection, testing and commissioning of Isolator and Earth switch, complete with all materials and accessories for efficient and trouble-free operation. The specification covers many aspects of Owner specifications & the OEM/ Bidder has to ensure that all requirements of Owner as per their latest standards are complied & all Owner requirements for supply, inspection, testing & commissioning along with installation at Site with all documentation required at various stages is followed.

8.1.2 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 8.2 Codes and Standards

8.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below.

| Standard | Description |
|---|---|
| IS 9921 | Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 volts. |
| IEC 62271-102 | Alternating current disconnectors and earthing switches for voltages above 1000 volts |
| IS: 1239 | Standard for Electric Resistance Welded (ERW) pipes. |
| IEC 60129 | High Voltage Switchgears |
| IS: 2544 | Tests on Indoor and Outdoor post– insulators |
| IEC 60168 | Tests on Indoor and Outdoor post– insulators |
| IS: 2147 | Degree of protection provided by enclosures for Low voltage switchgear and control gear. |
| IS: 4691 | Degree of protection provided by enclosures for Rotating electrical machinery |

| Standard | Description |
|---|---|
| IS: 325 | Three phase induction motors. |
| IS: 4722 | Rotating electrical machines. |
| IS: 2629 | Recommended practice for hot dip galvanizing of iron and steel. |
| IS: 4759 | Hot dip Zinc coating on structural steel |
| IS: 2633 | Method of testing weight, thickness and uniformity of coating on fasteners. |
| IS: 1573 | Electro plated coating of zinc on iron and steel |
| IS: 3033 | Spring washers. |
| IS: 2016 | Plain washers. |
| IS: 5561 | Power Connectors |
| IS: 1554 | PVC Cables |
| IS: 375 | Marking and arrangement for switch gear busbar main connectors and auxiliary wirings. |
| IS: 3961 | Recommended current rating for PVC insulated & PVC sheathed heavy duty cables. |
| IS: 8263 | Method for Radio Interference voltage (RIV) test on high voltage insulators. |
| IEC – 437 | Radio Interference voltage (RIV) test. |

### 8.3 Scope of Work

8.3.1 Type and rating of the equipment listed below are detailed. The equipment shall be furnished in strict accordance with the same.

- Horizontal Double Break, triple pole, outdoor air break Motorized Isolator with single / double earth switch and without earth switch

8.3.2 Each isolator and earth switch shall be furnished with fittings and accessories.

8.3.3 Terminal connectors as suitably required.

8.3.4 One set of special tools and tackles.

8.3.5 All relevant drawings, data and instruction manuals.

### 8.4 Design Criteria

8.4.1 The equipment shall be used in high voltage system, having characteristics as listed,

8.4.2 The equipment shall be installed outdoor in a hot, humid and tropical atmosphere.

8.4.3 All equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion.

8.4.4 The maximum temperature in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in the relevant standards.

8.4.5 The equipment shall be capable of withstanding the dynamic and thermal stresses of listed short circuit current without any damage or deterioration.

8.4.6 There shall be no radio interference when the equipment is operated at maximum service voltage.

8.4.7 The safety clearances of all live parts of the equipment shall be as per relevant standards.

8.4.8 Corona / grading ring as required shall be provided.

### 8.5 Specific Requirement

8.5.1 The disconnecting switches shall be double break, rotating type with contact blades moving through horizontal plane break type as per requirement.

8.5.2 The disconnect switch shall carry rated current continuously and short-time current for 3 second.

8.5.3 In addition, the disconnecting switch shall be capable of making and breaking.

- Magnetizing current of the voltage transformer.
- Capacitive current of the buses and short connections

### 8.6 Constructional Features

8.6.1 The 3-pole disconnecting switch shall be gang operated type so that all the poles make and break simultaneously.

8.6.2 The disconnecting switch shall be designed for upright mounting on steel structure unless otherwise indicated.

8.6.3 The disconnecting switch shall have pad locking arrangement in both `Open' and 'Closed' positions.

8.6.4 All current carrying parts shall be of non-ferrous metal or alloy. All live parts shall be designed to avoid sharp points and edges.

8.6.5 All metals parts shall be of such material and treated in such a way as to avoid rust, corrosion and deterioration due to atmospheric condition. Ferrous parts shall be hot dip galvanized.

8.6.6 Bolts, nuts, pins, etc. shall be provided with appropriate locking arrangement such as locknuts, spring washers, key etc.

8.6.7 Bearing housing shall be weather-proof with provision for lubrication. The design, however, shall be such as not to require frequent lubrication.

8.6.8 All bearings in the current path shall be shorted by flexible copper conductor of adequate size.

Current carrying parts:

Material of earthing blades and contacts shall be the same as those of main switch moving blades and contacts respectively. Cross sectional area of earthing blades and contacts shall not be less than 50% of cross-sectional area of main blades and contacts. The earthing blades shall have the same short time current rating (thermal and dynamic) as that of main switch.

**8.7 Main Contacts**

8.7.1 The Contacts shall be made out of hard drawn electrolytic grade copper. Arcing contacts wherever provided shall close first and open last. The contact surface shall be silver plated to 15-micron thickness. Fabrication shall be done with suitable jig to avoid deviations during production. Details of size and shape of contacts, spring, back plate, fixing arrangements, design of contact pressure, life of contacts, limit of temperature rise etc. shall be furnished by OEM/ Bidder. The main contacts shall be of hollow tube sections Copper of 2.0A/sq. mm and other sections shall be of copper of 1.6A/sq. mm and controlled by powerful springs designed for floating and pressure point contact.

8.7.2 The contacts shall have sufficient area and pressure to prevent excessive heating liable to bring about pitting or welding.

8.7.3 Contacts shall be adjustable to allow for wear, shall be easily replaceable and shall have minimum movable parts and adjustments.

8.7.4 The blade shall be made of electrolytic copper/ aluminium tube of liberal section. Rotating feature of the blade at the end of travel for contact wiping shall be provided.

8.7.5 Arcing horns shall be provided to divert the arc from main contacts to the separating horns after the main contacts have opened. Arcing horns shall be renewable type.

8.7.6 Terminal pad: The Terminal pad shall be made out of electrolytic grade copper silver plated to 15-micron thickness. Dimensions of the terminal pad shall be furnished in the drawing. Earth switch terminal pad shall also be made of electrolytic grade copper.

**8.8 Auxiliary Contacts**

8.8.1 Each disconnect switch shall be provided with eight (8) normally closed and eight (8) normally open electrically separated spare contacts, in addition to the auxiliary contacts required for its operation and indication.

8.8.2 The contacts shall be convertible type so that normally open contact may be converted to normally closed contact and vice-versa at Site.

8.8.3 The auxiliary contacts shall be rated 10A at 231.5V A.C. and 2A at 220V D.C.

8.8.4 The auxiliary contacts shall be adjustable type to suit the following requirement: -

- Signalling of 'Closed Position' shall not take place unless the main power contacts have reached a position so that rated normal and short time current can be carried safely.
- Signalling of 'Open Position' shall not take place unless the main power contacts are at a safe isolating distance.

**8.9 Interlocks**

8.9.1 All electrical and mechanical interlocks necessary for safe and satisfactory operation of the disconnect switch and its earthing with shall be furnished.

**8.10 Insulators**

8.10.1 Only solid core insulators shall be used for Isolator. Insulators of identical rating shall be interchangeable. The insulators shall have cantilever strength not less than 4 KN. The insulators shall be provided with a completely galvanized steel base design for mounting on the support. Cap to be provided on top of the insulator shall be of high-grade cast iron/malleable steel casting or Aluminium alloy. The casting shall be free blow holes, cracks and such other defects. It shall be machine faced and hot dip galvanized. The post insulators shall have a creepage distance of 25mm per kV of highest system voltage.

8.10.2 The holes shall be suitable for bolts with threads having anticorrosive protection. The effective depth of threads shall not be less than the nominal diameter of the bolt.

8.10.3 Insulator shall be of wet-process porcelain, brown glazed and free from all blemishes. Metal parts and hardware shall be hot dip galvanized.

8.10.4 Insulator shall have adequate mechanical strength and rigidity to withstand the duty involved.

8.10.5 When operated at maximum system voltage there shall be no electrical discharge. Shielding rings, if necessary, shall be provided.

8.10.6 Insulation shall be co-ordinate with basic impulse level of the system. The creep age distance shall be as indicated in the annexure.

**8.11 Operating Mechanism**

8.11.1 The operating mechanism of the disconnect switch shall be motor operated type, with electrical control from remote as well as local position. Provision for manual operation shall also be provided.

8.11.2 The mechanism shall also have provision for manual operation with detachable handle. The arrangement shall be such that one operator may be able to operate without undue efforts. Manual operated mechanism gang-operated through a lever/handle on operating shaft shall be provided for earth switch.

8.11.3 Interlock shall be provided such that electrical power to the motor is cut off on insertion of manual operating handle.

8.11.4 The mechanism of disconnect switch shall be so designed that its blade(s) are in positive continuous control throughout the cycle of operation.

8.11.5 The operating mechanism shall provide quick, simple and effective operation. The main switch shall close or open with about 20 (TWENTY) revolutions of the crank. The earth switch shall close or open by rotation of lever/handle through 90 degrees. The operating mechanism shall be such that the main switch or earth switch, once operated, will remain stay-put in closed or opened position till the next command (operation) is given by the operating personnel. This feature is important to prevent inadvertent operation by gravity, wind, short circuit forces, seismic acceleration, vibration, shock, accidental touching, etc.

8.11.6 Motor shall be suitable for 3-phase 415V AC supply with variations of (+) or (-) 10%, frequency variation of (+) or (-) 5% & for both variations which may occur simultaneously. Motor shall be squirrel cage induction motor & shall be totally enclosed surface cooled (TESC) type having IP-67 protection class & shall be suitable for direct-on-line (DOL) starting and shall generally conform to IS 325.

8.11.7 The motor shall withstand, without damage, stalled torque for at least three times the duration of tripping device. Motor shall be suitable for intermittent duty with open/close duty actuators capable of 20starts/hour.

8.11.8 Visible indication of switch position and means to prevent false indication if the mechanism fails to complete the operation shall be provided.

8.11.9 Starters, relays, limit switches shall be provided as required for operation, indication and interlocks. Electromagnetic brakes and/or adjustable mechanical stop shall be provided to limit over-travel.

8.11.10 The operating links of Tandem disconnect switches shall be such as to suit the Substation layout.

8.11.11 Motor shall be of minimum class F insulation, with temperature rise restricted to class B.

**8.12 Mechanism Box**

8.12.1 The mechanism box shall house the operating mechanism, electrical, controls, monitoring devices and all other accessories.

8.12.2 The box shall be IP-67, of gasketed weatherproof construction, fabricated from sheet steel minimum 2 mm thick. Sloping rain hood shall be provided to cover all sides. 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protection of not less than IP-67 as per IS 2147. The cabinet shall be suitable for fixing on Owner standard support structure with adjustment for vertical, horizontal and longitudinal alignment. Details of the arrangement proposed for such adjustment as well as for sealing shall be furnished in the drawings.

8.12.3 The box shall have front access door with lock and key, and removable gland plate at bottom for Bidder/Contractor cable entry.

8.12.4 The box shall be suitable for mounting on disconnect switch support structure. The mounting height shall be such as to permit easy manual/electrical operation standing at grade level.

8.12.5 Thermostat controlled space heater, internal illumination lamp and 3 pin 5A socket with individual ON/OFF switches shall be provided in the box.

8.12.6 For local operation following shall be provided:

a) LOCAL/REMOTE selector switch.

b) OPEN / STOP/ CLOSE push buttons.

c) The gear box enclosure should be made of Malleable Cast Iron (MCI) or Ductile Cast Iron (DCI) so as to avoid any misalignment of gears. The disconnector may be required to operate only occasionally, with considerably long idle intervals. Special care shall therefore be taken for selection of material for gear and lubrication of gears to meet this requirement. The gears shall be made of aluminium, bronze or any other better material and lubricated for life with graphite or better-quality non-draining and non-hardening grease. Complete details of components, material, grade, self-lubricating arrangement, grade of lubricants, details of jig, fixtures and devices used for quality check shall be furnished by the tenderer in it's offer.

d) Padlocking arrangement: The isolator and earthing switch shall be provided with padlocking arrangement to permit locking of the isolator main switch and earthing switch in both fully open and fully closed positions.

**8.13 Wiring**

8.13.1 Wiring shall be complete in all respects to ensure proper functioning of the control, protection, monitoring and interlocking schemes.

8.13.2 Wiring shall be done with flexible 1100V grade, FRLS, PVC insulated switchboard wires with stranded copper conductor of 2.5 mm2.

8.13.3 Each wire shall be identified at both ends with permanent markers bearing wire numbers as per Contractor's wiring diagram.

8.13.4 Wire terminations shall be done with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

8.13.5 All spare contacts of relays, push buttons, auxiliary switches etc. shall be wired up to the terminal blocks in the mechanism box.

**8.14 Terminal Blocks**

8.14.1 Terminal blocks shall be 1100V grade, enclosed clamp type with engraved numbers suitable for termination of at least two numbers of 2.5 mm2 stranded copper conductor.

8.14.2 Not more than two wires shall be connected to any terminal. Spare terminals equal in number of 20% active terminals shall be furnished.

8.14.3 Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

**8.15 Earthing Switch**

8.15.1 Earthing switch for 3-pole disconnect switch shall be triple-pole, gang operated type, with provision for padlocking in both open and close positions. The moving contact and blade shall be made of high-conductivity electrolytic copper of adequate strength to withstand all thermal and bending stresses at the time of short circuits. The bimetallic arrangement (moving blade of aluminum /Cast iron and contact tip of copper) shall not be accepted. The fixed contacts shall be identical to the main isolator fixed contacts except for silver plating.

8.15.2 The earthing of the moving contact shall be effected by flexible copper braids having adequate cross-section to safely carry the short circuit current specified.

8.15.3 The earthing switch for all poles of the isolator shall be mounted on the same shaft and operated by a single and common operating handle, which shall be distinct and separate from that used for operating the main blade of isolator.

8.15.4 Earth switch shall have local, remote and manual operating mechanism unless otherwise indicated. The manual operating mechanism shall be located such that it can be easily operated from standing height at grade level.

8.15.5 If electrical operating mechanism of earthing switch is desired, it shall be motor operated type, with electrical control from local position. The various features of the operating mechanism and its mechanism box, wiring requirement etc. are similar to those stipulated for the main disconnect switch.

8.15.6 3 phase 415V motor, class F insulation, temperature rise limited to class B. Motor shall have overloading and single phasing protection. Motor shall be TESC type, IP67 protection with DOL starter.

8.15.7 Mechanical and electrical safety interlocks shall be provided to prevent closing of earthing switch when the main disconnect switch is closed and vice-versa. Further mechanical interlocking between main switch and earth switch shall also be provided ensure that the earth switch can be closed only after the main blade is open and vice versa.

8.15.8 Earthing switch shall be provided with minimum 6 NO + 6 NC contacts for indication and interlocking.

8.15.9 All auxiliary switches & interlocking coils shall be wired up to terminal blocks in mechanism box through G.I. Conduit.

8.15.10 Line side Earthing switch blades shall be required to make rated short circuit current with its peak. Both line and breaker earthing switches shall be suitable for induced current switching as per IEC.

**Moving Blades:**

8.15.11 Moving blade shall be made of electrolytic grade copper. Contact surface of moving blades shall be silver plated to 15-micron thickness. The design shall be such that contact surfaces shall automatically be wiped during closing and opening operations to remove any film, oxide coating, etc. Wiping action shall not cause scouring or abrasion of surfaces. The moving contact pipe should be supported with self-greased Teflon /Brass bushes at the rotating points for smooth operations.

**8.16 Assembly**

8.16.1 The disconnect switch along with its base frame and operating mechanism, earthing switch and its operating mechanism shall be completely assembled and checked for correct alignment and operation at manufacturer's works prior to dispatch.

8.16.2 All parts and accessories shall have appropriate benchmarks and part numbers for identifications at Site.

**Turn and Twist Mechanism:**

8.16.3 Turn and twist mechanism shall be provided with suitable self-locking property to avoid inadvertent opening or closing of contacts by wind, short circuit force, etc. on moving blade. The contact holding springs shall be made out of stainless steel or phosphor bronze or any other better material to have adequate strength and resilience and shall be encased with grease to avoid exposure in rain. The clamps and plates shall be made out of M.S. Plate or flat having at least 10mm thickness. Fasteners with lock nuts shall be used wherever necessary. Vulnerable parts shall be fabricated by tubular gas cutting or milling. The entire mechanism shall be fabricated in suitable jig and template to avoid deviations/ errors during production. The Turn & twist assembly of moving contact should be provided with sealed double ball bearing.

**Bearings:**

8.16.4 Rotating - insulator shall be mounted on housing with bearings. The housing shall be made of gravity die cast Aluminum with smooth surfaces and suitably machined for seating the bearings. Two no. of bearings with adequate shaft diameter and distance between the bearings shall be provided to avoid wobbling during operations. The bearings shall be of at least 75 mm internal diameter for 145kV class rating isolators. The bearings shall be of reputed make and lubricated for life. All other friction locations shall be provided with suitable bearings of stainless steel or brass bushes. The bearings, bushes, joints, springs, etc. shall be so designed that no lubrication shall be required during the service. Complete details of bearings, bushes, housing, greasing, etc. shall be furnished with the drawings.

**Balancing of Heights:**

8.16.5 Fixed insulators shall be provided with elevator base plate with four studs for balancing of heights. Thickness of plate and diameter of stud shall be 10mm and 25mm respectively for isolators of rated

voltage of 145 kV and above. Adequate numbers of nuts, lock nuts and washers shall be provided. Taper washer shall be provided to match inclined surface of steel section.

**Tandem Pipe:**

8.16.6 Tandem pipes shall be of at least 32mm ID and class B for isolators of 145kV. Two nos of tandem pipes shall be used for phase coupling of double break isolators. Base plate of insulators for connection of tandem pipe shall be made out of one piece of M.S. Plate of at least 10mm thickness. Bolt and shackle device shall be used to connect tandem pipe to the base plate. Wherever unavoidable, sliding clamps may be used. These clamps shall be made out of at least 10 mm thick M.S. Flat with four nos. of nuts and bolts. A grub screw shall be provided for securing connection on tandem pipes.

**Down Pipe:**

8.16.7 50mm ID class B pipe shall be used for the operating rod of disconnects. The pipe shall be terminated into a suitable swivel or universal type joint between the insulator bottom bearing and the operating mechanism to take care of marginal angular misalignment at Site. All brackets, guides, etc. shall be mounted on the base of the isolator. Arrangement of mounting any guide, bracket, etc. on support structure, except the operating mechanism and the base, shall not be accepted.

**Base:**

8.16.8 Each phase of isolator shall be provided with a rigid base fabricated from steel sections made out of hot rolled Steel of 125x65mm channel connected back-to-back. Weight shall be as per latest IS.

**Grounding:**

8.16.9 Each equipment shall be provided with two ground pads for connection to station ground.

8.16.10 The ground pad shall comprise buffed metal surface with two tapped holes, M10 G.I. bolts and spring washers for connection to CU flat of appropriate size.

8.16.11 Disconnect and earth switch operating rod shall be separately grounded at a point above the mechanism box. This is done by flexible copper braid of adequate section but in no case less than 70 mm2.

**Interlocking:**

8.16.12 Operation of isolator Main switch and earth switch is required to be interlocked with associated switchgear/breaker and protection schemes of the Owner so that it will not be possible to operate the isolator and/or the earth switch when the switchgear/ breaker is in closed position. Further, mechanical interlocking between main switch and earth switch shall also be provided to ensure that the earth switch can be closed only after the main blade is open and vice-versa. Any modifications to scheme suggested by the Owner on scrutiny of the offered drawing shall be acceptable to the tender.

**8.17 Painting**

8.17.1 Base frame, operating rod and all hardware shall be hot dip galvanized. Thickness of zinc coating shall not be less than 610gm of zinc per sq. meter of surface. Zinc coating shall be smooth, clean and of uniform thickness and free from any defect. Preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material. The quality shall be established by tests as per IS 2633.

8.17.2 Paint inside the metallic housing shall be anti-condensation type and the paint/powder coating on outside surfaces shall be suitable for outdoor installation. Epoxy Powder coating will be preferable over the conventional enamel painting.

8.17.3 All components shall be given adequate treatment of climate proofing as per IS: 3202 so as to withstand corrosion and severe adverse service conditions.

8.17.4 Sufficient quantity of touch-up paints shall be furnished for application at Site.

**8.18 Routine Tests**

8.18.1 During manufacture and on completion, all equipment shall be subjected to the Routine Tests as laid down in Indian Standard.

8.18.2 All acceptance and routine tests as stipulated in the relevant standards shall be carried out by the supplier in presence of Owner's representative during pre- dispatch inspection.

8.18.3 Mechanical operation test (routine test) shall be conducted on the complete disconnector (Main switch and Earth switch) at manufacturer works in presence of Owner representative.

**8.19 Type Tests**

8.19.1 Type test certificates, dated not more than five (05) years back, shall be furnished for the offered model of disconnecting switch.

8.19.2 Type tests shall be as per IEC 62271-102 or IS 9921 and the report shall include measurement of radio interference level also.

**8.20 Test Witness**

8.20.1 Tests shall be performed in presence of Owner representative if so desired by the Owner. The Contractor shall give at least Fifteen (15) days' advance notice of the date when the tests are to be carried out.

**8.21 Test Certificates**

8.21.1 Certified reports of all the tests carried out at the works shall be furnished in required number of copies for approval of the Owner.

8.21.2 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

8.21.3 Type test certificate on any equipment or component, if so desired by the Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

### 8.22 Special Tools and Tackles

8.22.1 SA set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

8.22.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

### 8.23 Technical Parameters

| S.No. | Item | Parameters |
|---|---|---|
| 1) | Type | Double break, horizontal type, outdoor, air break. (With single/double earth switch or, without earth switch) |
| 2) | Highest system voltage | 145kV |
| 3) | Rated voltage | 132kV |
| 4) | Rated continuous current | 1600A |
| 5) | Rated frequency | 50Hz |
| 6) | No. of phases | 3 |
| 7) | Mounting | Horizontal, upright |
| 8) | Rated short circuit | 40kA |
| 9) | Rated short circuit making current | 100kA (peak) |
| 10) | Short time current carrying capability | 40kA (rms) for 3 second |
| 11) | Temperature rise | As per IEC |
| 12) | Lightning Impulse with stand voltage | 650kV (peak) |
| 13) | Switching Impulse with stand voltage | - |
| 14) | One minute power frequency withstand voltage | 275kV (rms) |
| 15) | Type of operating mechanism | Motor operated for isolator & earth switch |

| S.No. | Item | Parameters |
|---|---|---|
| 16) | Operating mechanism voltage | 3 phase 415V / 1 phase 231.5V operation |
| 17) | Control supply | 220V DC, + 10% to -15% |
| 18) | Auxiliary contacts | |
| | a) No. of contacts for isolator | As required plus 8 NO and 8 NC contacts per pole as spare |
| | b) No. of contacts for earth switch | Total 6 NO and 6 NC |
| 19) | Reference ambient temperature | 50°C |
| 20) | Creepage distance | 25mm/kV |
| 21) | Support structures | Hot dip galvanized steel structures |

### 8.24 Fittings & Accessories

Each disconnect switch shall be furnished complete with fittings and accessories as listed below:

1. Clamp-type terminal connector for Moose conductor.
2. Ground pads for 75x10 mm flat.
3. Base frame with anchor bolts, nuts and washers.
4. Operating mechanism with all accessories including operating rod of required length, for disconnect switch and for earth switch.
5. Starters, relays, and auxiliary switches.
6. Local / Remote selector switch with Motor & manual operation selection.
7. Open / Stop / Close push buttons
8. Spare auxiliary switches 8 NO + 8 NC.
9. Mechanical ON-OFF indicator
10. Weather-proof mechanism box with lock and key for disconnect switch and for earth switch, where indicated.
11. Set of fuse switches for A.C. and D.C. supply.
12. Space heater with thermostat and ON-OFF switch.
13. Internal illumination lamp with ON-OFF switch.
14. 3 pin 5A socket outlet with ON-OFF switch.
15. Terminal blocks and wiring - lot.
16. Earthing switch, if specified, complete with safety interlocks and 6 NO + 6 NC auxiliary switches.

17. Flexible copper braid for grounding of operating rod

# 9. 132kV Circuit Breaker (CB)

## 9.1 Intent of Specification

9.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, storage at Site, erection, testing and commissioning of 132 kV circuit breakers, complete with all materials and accessories for efficient and trouble-free operation. The specification covers many aspects of Owner specifications & the OEM /Bidder has to ensure that all requirements of Owner as per their latest standards are complied & all Owner requirements for supply, inspection, testing & commissioning along with installation at Site with all documentation required at various stages is followed.

9.1.2 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 9.2 Codes and Standards

9.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards and guidelines are listed below:

| Standard | Description |
|---|---|
| IEC 62271–100 | Specification for high voltage alternating current circuit breakers |
| IEC 62271-1 | High voltage switchgear and control gear |
| IEC 60376 | Specification and acceptance of new supply of Sulphur hexafluoride. |
| IEC 60529/IS 2147 | Degree of protection provided for enclosures for low voltage switchgear and control gear. |
| IS 325 | Specification for 3 phase induction motor |
| IS 2629 | Recommended practice for hot dip galvanizing of iron and steel. |
| IEC- 2331 | High voltage porcelain bushings |
| IEC 60060 | High voltage test techniques |
| IEC 60071 Part –I & II | Insulation co-ordination, Terms, definitions, principles and rules |
| IEC 60270 | Partial discharge measurements |

| Standard | Description |
|---|---|
| IS 4379<br>IS 7311 | High pressure cylinder in which SF 6 gas is transported and stored at Site |
| IS 1893 (Part I) 2002 | Seismic Test |
| IS 2516 | Specification for Circuit Breakers |
| IS 2147 | Degree of protection provided for enclosures for low voltage switchgear and control gear |
| IS 5621 | Hollow insulator for high voltage equipments |
| IS 13118 | Specification for high voltage alternating current circuit breakers |
| IS 7285 | Specification for gas cylinders |
| IS-2825 | Specification for pressure vessels |
| IS-13947 | Specification for Degree of Protection |
| IS 2099 | Specification for bushings above 1000V of Alternating Voltage |
| IS 5 | Colour for ready mixed paints and channel. |
| BS 162 | Specification for compressed air piping |
| CEA Guidelines | General Guidelines for 765/400/220/132 kV Substation and Switchyard |

### 9.3 Scope of Supply

9.3.1 Circuit breaker shall be provided for 132kV line bay at BESS yard and 132kV proposed line bay at Kukurmara (Mirza) Grid substation. Each circuit breaker shall be complete with fittings and accessories as per requirement.

9.3.2 Expansion type terminal connectors, suitable as per requirement.

9.3.3 Following Auxiliary equipment shall be supplied in case of SF6 breaker.

a) One (1) set of Portable SF6 gas evacuating & filling equipment.

b) One (1) no. SF6 filled gas cylinder with trolley.

c) One set of special tools and tackles.

d) Commissioning spares.

e) Recommended spare parts list for three (03) years operation.

9.3.4 All required relevant drawings, data and instruction manuals.

## 9.4 Design Criteria

9.4.1 Circuit Breakers shall be of sulphur hexafluoride (SF6) gas type and of class C2-M2 as per IEC-62271-100. Each circuit breaker shall be executed with 3 nos. single pole units. The circuit breaker shall be live tank type of proven design and they shall be gang operated.

9.4.2 The equipment shall be installed outdoor in a hot, humid & dusty and tropical atmosphere.

9.4.3 All equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion.

9.4.4 The maximum temperature in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in the relevant standards.

9.4.5 The equipment shall be capable of withstanding the dynamic and thermal stresses of listed short circuit current without any damage or deterioration.

9.4.6 There shall be no radio interference when the equipment is operated at maximum service voltage.

9.4.7 The safety clearances of all live parts of the equipment shall be as per relevant standards.

9.4.8 Corona shall be reduced to the minimum as per relevant standard by using suitable devices.

## 9.5 Technical Requirement

9.5.1 The breaker shall be complete with the following Type and Duty:

a) Chamber insulators for each pole.
b) Support insulators for each pole.
c) Mechanism cubicle for each pole.
d) SF6 density monitor for each pole.
e) SF6 pressure gauge / density meter blocks for pressure monitoring for each pole.
f) Support structure for each pole with anchor bolts
g) Control cubicle
h) Interrupters housed in porcelain weather shields.
i) Terminal connectors including bimetallic sleeves suitable for connection with international pipe standard (IPS) tube / Moose conductor as per requirement of tender specification and shall be decided during detail engineering stage.
j) Interconnecting cables with conduits and accessories

9.5.2 The gap between the open contacts of the breaker shall be such that it can withstand rated phase to ground voltage for eight (8) hours at zero-gauge pressure of SF6 gas. The breaker shall be able to withstand all dielectric stresses in open condition at lockout pressure continuously.

9.5.3 Where multi-break interrupters are used, it shall be ensured that the voltage distribution across them is uniform.

9.5.4 The circuit breaker shall be single pressure type. The SF6 gas leakage shall not exceed 0.5% per year and the leakage rate shall be guaranteed for at least ten (10) years. Each pole shall form an enclosure filled with SF6 gas independent of two other poles and the SF6 density of each pole shall be monitored.

9.5.5 The dial type SF6 density monitor shall be temperature compensated. Suitable interlocked non-return valve coupling shall be provided to enable dismantling the density monitor for checking / replacement without draining the SF6 gas. The SF6 gas density monitor shall be provided with two potential free contacts of suitable rating. One of these contacts shall be used for annunciation of low density. The other contact shall be used by the manufacturer/bidder to ensure breaker lockout in the event of low SF6 gas density. The successful manufacturer/bidder shall furnish a chart showing relation between pressure and density of SF6 gas, as well as settings for alarm and lockout. ii) Preferably Temp. compensated pressure gauges shall be provided for SF6 gas, pneumatic air, as applicable. Gauge dials shall be clearly visible with naked eye to an observer standing on ground. iii) Adequate number of pressure contacts shall be provided for monitoring pressure of SF6 gas/air. The pressure switches shall be provided with sufficient number of potential free NO & NC contacts for Owner's use in control, protection and alarm circuits.

9.5.6 Vibration measurement pads shall be provided for vibration measurement during operation.

9.5.7 In the interrupter assembly, there shall be an absorbing box to minimize the effect of SF6 decomposition products and moisture.

9.5.8 Provisions shall be made for attaching an operational analyzer after installation of circuit breakers at Site.

9.5.9 Each circuit breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

9.5.10 The SF6 gas shall comply with IEC 60376. The SF6 cylinders shall comply with requirements of the relevant standards and regulations.

9.5.11 The support structure design shall be such that during operation of circuit breaker, vibrations are reduced to minimum. A suitable platform with steps on both sides of the circuit breaker shall be provided for easy accessibility for monitoring the density / pressure of gas.

**9.6 Operating Mechanism**

9.6.1 Operating mechanism shall be stored energy type, with motor operated spring charged closing mechanism. Anti-pumping and trip free features complete with 2x100% shunt trip coils shall be provided. The mechanism of the breaker shall be such that the position of the breaker is maintained even after leakage of operating media and/or gas. Operation of the power operated closing device, when the circuit breaker is already closed, shall not cause damage to the circuit breaker or endanger

the operator. Provision shall be made for attaching an operation analyzer to facilitate testing of breaker at Site.

9.6.2 The design of the operating mechanism shall be such that it shall be practically maintenance free. The guaranteed number of years of maintenance free operation, the number of possible full load and full rated short circuit current breaking operations without requiring any maintenance or overhauling shall be clearly stated in the offer.

9.6.3 All three breaker poles shall close simultaneously. Pole discrepancy feature shall be provided to trip the breaker out if all the poles do not close simultaneously within the stipulated time.

9.6.4 Circuit Breakers, where specified, shall have provision of both single and three phase auto re-closing.

9.6.5 The mechanism shall be designed for electrical control from remote as well as local position. In addition, local manual trip button shall be provided.

9.6.6 Operation counter and mechanical ON-OFF indicator shall be provided for each pole.

9.6.7 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

9.6.8 Each breaker pole shall be provided with two (2) independent tripping circuits, two (2) independent closing circuits, valves, pressure switches and coils each connected to a different set of protective relays. The trip coils shall be suitable for trip circuit supervision during both open and close positions of the breaker.

9.6.9 Two numbers of control circuit with independent source of control supply shall be provided.

**Spring Operated Mechanism:**

a) The mechanism shall have spring charging motor, opening and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit.

b) The charging of closing spring for spring charged operating mechanism shall take place automatically after each breaker closing operation. One open –close-open operation of the circuit breaker will be possible after failure of power supply to the spring charging motor. It shall be provided with the facility of spring charging manually.

c) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

d) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

e) All the electrical control equipment/ switches, the operating point for manual spring charging handle etc. shall not be at a height of more than 1500mm from ground level OR from a suitable platform which shall be provided by tenderer on the structure at a height not more than 750mm from ground level. The size of the platform shall be such that clear working space on the platform shall not be less than 300mm from all sides of operating mechanism/control box. The manufacturer/ bidder shall specifically confirm that the offered breaker meets this requirement and furnish the G.A. Drawing showing the arrangement.

**9.7 Sulphur Hexa Fluoride Gas (SF6)**

9.7.1 The SF6 gas shall comply with IEC 376, 376A and 376B and shall be suitable in all respects for use in the circuit breakers under the various operating conditions.

9.7.2 SF6 gas shall be tested for quality, dew point, air, hydrolysable fluorides and water content as per IEC quoted above and test certificates shall be furnished covering all tests for each lot of SF6 gas. Further Site test for moisture and air content to be done prior to commissioning of the breaker.

9.7.3 The high-pressure cylinders in which SF6 gas is shipped and stored at Site shall comply with requirements of the following standards and regulations: IS-4379, IS-7311.

9.7.4 The cylinders shall also meet Indian Boiler Regulations.

**9.8 Control and Interlock**

9.8.1 All electrical and mechanical interlocks which are necessary for safe and satisfactory operation of the circuit breaker shall be furnished. Breaker operation shall be locked in case of low SF6 gas pressure and low air pressure at preset values. Alarms shall be provided for low gas pressure and low air pressure at values higher than lockout pressure of SF6 gas and air. It is intended that before lockout occurs, the breaker shall be in trip position.

9.8.2 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

9.8.3 Each breaker pole shall be provided with two (2) independent tripping circuits, valves, pressure switches and coils each connected to a different set of protective relays. Each tripping circuit shall be fed through separate DC source & the control circuit shall have a DC changeover scheme.

9.8.4 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. Provision shall be made for local electrical/local manual control. For this purpose, local/remote selector switch, close & trip control switch, auxiliary relays, indication lamps etc. shall be provided in the central control cabinet for the breaker. Remote located control switch/push buttons and indicating lamp shall be provided in the remote-control panel which will be installed at electrical control room.

9.8.5 The trip coils shall be suitable for trip circuit supervision during both open and close positions of the breaker. The trip circuit supervision relay would be provided in the remote-control panel. Necessary terminals shall be provided in the control cubicles. Gas analyzer contacts, pressure switch contacts, etc. shall be suitable for direct use as permissive in closing, tripping, annunciation and control circuits. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations.

9.8.6 Motors rated 1 KW and above being controlled from the control cabinet would be suitable for operation on a 415 V, 3 phase 50Hz system. Fractional KW motors would be suitable for operation on a 240V, 1Phase, two pole 50 Hz A.C. supply system, with one pole grounded. Push button shall be rated for not less than 6 Amps, 415 Volts A.C or 2 Amp, 220 V D.C and shall be flush mounted on the cabinet door and provided with appropriate name plates. Red, green and amber indicating lamps shall be flush mounted and provided with series resistors to eliminate the possibility of short circuiting of control supply in the event of fusing of lamps.

9.8.7 For motors up to 5 KW, contactors shall be direct-on-line, air break, single throw type and shall be suitable for making and breaking the stalled current of the associated motor which shall be assumed equal to 6.5 times the full load current of the motor at 0.2 p.f.

9.8.8 3 pole contactors shall be furnished for 3 phase motors and 2 Pole contactors for single phase motors. Reversing contactors shall be provided with electrical interlocks between forward and reverse contactors. If possible, mechanical interlocks shall also be provided. Contactors shall be suitable for uninterrupted duty and shall be of duty category class AC4 as defined in IS 2959. The main contacts of the contactors shall be silver plated and the insulation class for the coils shall be Class E or better. The dropout voltage of the contactors shall not exceed 70% of the rated voltage. Contactor shall be provided with a three element, positive acting ambient temperature compensated, time lagged, hand reset type thermal overload relay having single phasing protection & shall be with adjustable setting. Hand reset button shall be flush with the front door of the cabinet and suitable for resetting with starter compartment door closed. Relays shall be either direct connected or CT operated depending on the rated motor current.

**9.9 Constructional Features**

9.9.1 Line circuit-breaker shall comprise of three (3) identical single-phase poles complete with gang operating mechanism for specified duty. These breakers shall be of three pole gang operated type and shall have simultaneous operation.

9.9.2 The circuit-breaker shall be single pressure type. The design and construction shall be such that there is minimum possibility of gas leakage and ingress of moisture. Further, the arrangement shall be such

that condensation of SF6 gas on the internal insulating surfaces of the circuit breaker must not occur under any condition.

9.9.3 Each pole shall form an enclosure filled with SF6 gas independent of two other poles. The SF6 gas density of each pole shall be monitored and regulated by individual temperature compensated gas density monitoring devices, which shall be mounted at a convenient and easily approachable location. The device shall have provision for low gas pressure alarm and breaker lockout arrangement. Also pressure gauge shall be mounted at a convenient height so that gas pressure can be visually observed.

9.9.4 The circuit-breaker shall have proper sealing so that leakage of gas outside is not more than 0.5% per annum under all conditions of operation. Further, it shall incorporate devices to absorb any moisture which may exist/be released within breaker poles after assembly, gas charging and during operation. The devices shall be so located as to permit easy removal/replacement.

9.9.5 The operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimize distortion and make a tight seal.

9.9.6 The circuit-breaker units shall be complete with associated valves, piping, gauges, pressure switches, seals, lubricants and other accessories/materials to ensure proper assembly and functioning suitable means shall be provided in the gas chamber of circuit breaker for pressure relief so as to avoid damages or distortion during occurrence of abnormal pressure increase or shock waves generated by internal electric fault arcs. The position of vents, diaphragms and pressure relief devices, if provided, shall be so arranged as to minimize danger to personnel in the event of gas or vapour escaping under pressure.

9.9.7 Breaker shall be furnished with first charge of SF6 gas plus additional 20% of total gas used which shall be supplied in non-returnable gas cylinders as spare for future use.

9.9.8 The SF6 gas shall be supplied in properly treated steel cylinder of adequate strength.

9.9.9 The circuit breaker shall be provided with terminal pads of adequate size for connection to Rigid Aluminium tube by expansion type terminal connector. Adequate transversal and vertical force shall be considered for the terminals so as to support the interconnecting tubes spanning around 10 meters, during short circuit and wind force.

### 9.10 Main Contacts and Arc Quenching Chamber

9.10.1 The main contacts shall have adequate area and contact pressure for carrying rated continuous and short time current without excessive heating liable to cause pitting and welding.

9.10.2 The tips of the arcing and main contacts shall be heavily silver plated.

9.10.3 The contacts shall be adjustable to allow for wear, shall be easily replaceable and shall have minimum movable parts and adjustments.

9.10.4 The arc quenching device shall be of robust construction and shall not require any critical adjustment. The devices shall be easily accessible and removable for access to the breaker contacts.

**9.11 Accessories and Attachments**

9.11.1 Necessary provision shall be made in the circuit-breaker for attaching an operational analyzer to it after its installation at Site to record contact travel, speed and for making measurement of operating timings, pre-insertion timing of closing resistors, synchronization of contacts in one pole or all poles.

9.11.2 The SF6 gas density monitor shall be dial type and properly temperature compensated.

9.11.3 The density monitor shall meet the following requirement: -

a) It shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by using suitable interlocked non-return valve coupling.

b) It shall damp pressure pulsation while filling the gas in service so that flickering of the pressure switch contacts does not take place.

**9.12 Auxiliary Contacts**

9.12.1 Each breaker shall be provided with six (6) normally open and six (6) normally closed (6NO + 6NC) electrically separate spare auxiliary contacts, in addition to those required for its own operation and indication.

9.12.2 The auxiliary contacts shall be convertible type so that normally open contacts can be converted into normally close contact and vice-versa at Site.

**9.13 Insulator**

9.13.1 Insulator shall be wet-process porcelain, brown glazed and free from all blemishes. Metal parts and hardware shall be hot dip galvanized.

9.13.2 Insulator shall have adequate mechanical strength and rigidity to withstand the duty involved.

9.13.3 When operated at maximum system voltage, there shall be no electrical discharge. Shielding rings, if necessary, shall be provided.

9.13.4 Insulation shall be coordinated with basic impulse level of the system.

9.13.5 The insulator porcelain shall be in one integral piece in green and fired stage. No jointed porcelain is acceptable.

**9.14 Wiring**

9.14.1 Wiring shall be complete in all respects to ensure proper functioning of the control, protection, monitoring and interlocking schemes.

9.14.2 DC circuit for trip coil 1 & 2 shall be wired separately so as to connect with duplicate DC supply.

9.14.3 Wiring shall be done with flexible 1100V grade, PVC insulated, switchboard wires with 2.5 $mm^2$ stranded copper conductor. Wiring between individual poles and control cubicle shall be routed through G.I. conduits.

9.14.4 Each wire shall be identified at both ends with permanent markers bearing wire numbers as per Contractor's wiring diagram.

**9.15 Tests**

9.15.1 Routine Tests

a) During manufacture and on completion, all equipment shall be subjected to the Acceptance & Routine tests as laid down in IEC/IS Standard.

b) In addition to above tests specified by IEC, the speed curves for each breaker shall also be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto- reclosing and trip-free operation under normal as well as limiting operating conditions (Control Voltage, spring-spring operated mechanism etc.)

9.15.2 Type Tests

a) Type Tests on one set of each voltage class circuit breaker shall carried out as stipulated in relevant IEC/Indian Standards. Following additional type tests are to be conducted.

i. Short line fault test

ii. Basic short circuit tests.

iii. Cable charging breaking current tests.

iv. Single Capacitors Bank breaking current tests.

v. Out of phase making and breaking test as per IEC-60267 & IEC- 63056.

vi. Rated line charging current breaking test.

a) Short time and peak withstand current tests.

b) Lightning impulse voltage test

c) P.F. Voltage withstand test (dry & wet)

d) Temperature rise test.

e) Mechanical operation test

f) Single phase short circuit test (for 3 phase mechanically gang operated breaker)

vii. Seismic withstand test in unpressurised condition.

viii. Corona extinction voltage test for 132kV breaker only.

ix. Degree of protection test for outdoor cubicles

9.15.3 Tests Witness

a) Tests shall be performed in presence of Owner representative.

9.15.4 Tests Certificates

a) Tests Certificates Certified reports of all the tests carried out at the works shall be furnished in requisite no. of copies as stated in the Conditions of Contract.

b) The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

c) Type test certificate on any equipment shall be furnished for Owner Approval / Acceptance. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

d) Type test certificates of similar capacity of equipment furnished by the bidder shall be dated not more than five (05) years from the date of testing.

### 9.16 Special Tools & Tackles

9.16.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

9.16.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

### 9.17 Technical Parameters

| S. No. | Description | Data |
|---|---|---|
| 1) | Type / Application | SF6 gas puffer type, electrically trip free / outdoor, single pressure |
| 2) | Execution of poles | 3 single poles gang operated mechanically coupled for all breakers |
| 3) | Highest system voltage | 145kV |
| 4) | Rated frequency | 50Hz |
| 5) | Rated current at design ambient | As per design |
| 6) | Short circuit breaking current | 40 kA for 3 sec |
| 7) | Symmetrical interrupting capability | 40 kA (rms) |
| 8) | Rated short circuit making current | 100kA (peak) |
| 9) | Auto-reclosing 3 phase for all breakers | For line breakers |
| 10) | Capacitive switching | Class C2 as per IEC |
| 11) | Mechanical endurance | Class M2 as per IEC |
| 12) | Closing resistors (PIR) | - |
| 13) | Temperature rise | As per IEC 55 Deg.C considering ambient temp. 50 Deg.C for main contact |

| S. No. | Description | Data |
|---|---|---|
| 14) | Operating duty | O - 0.3 sec – CO - 3 min - CO |
| 15) | Total break time (Maximum) | 60ms |
| 16) | Total make time (Maximum) | 65ms |
| 17) | First pole to clear factor | 1.3 |
| 18) | TRV | As per IEC |
| 19) | Lightning Impulse with stand voltage | 650kV (peak) |
| 20) | Switching Impulse with stand voltage | - |
| 21) | One minute power frequency withstand voltage | 275kV (rms) |
| 22) | Line charging current breaking | As per IEC 50 A |
| 23) | Cable charging current breaking | As per IEC 160 A |
| 24) | Single capacitor bank switching current | 400 A |
| 25) | Small inductive current breaking | To switch the associated transformer magnetizing current |
| 26) | Max. allowable over voltage under any switching condition | As per IEC |
| 27) | Type of operating mechanism | Spring - Spring operated |
| 28) | Operating mechanism voltage | 3 phase 415V/1 phase 240V operation |
| 29) | Control voltage | 220V DC, +10%, -15% |
| 30) | No. of trip coils per pole | 2 nos. |
| 31) | Design ambient temperature | 50°C |
| 32) | Creepage distance | 25mm/kV |

### 9.18 Fittings and Accessories

9.18.1 Each Circuit Breaker shall be furnished complete with fittings and accessories as listed below:

a) Operating mechanism complete with all accessories, fittings and double tripping coils and closing coil, pole discrepancy feature and low-pressure blocking device etc. as required.

b) Complete SF6 gas system along with valves, pressure switches, pressure gauges, SF6 gas density monitor, etc.

c) Various attachments & accessories for gas filling.

d) Two ground pads per pole suitable for termination of Cu flats of appropriate size.

e) Base frame and anchor bolts and nuts.

f) Set of valves, pressure gauges and pressure switches as required.

g) Auxiliary contacts and relays.

h) Local/Remote Selector switch, TRIP/CLOSE Push Buttons.

i) Manual tripping devices with protective flap.

j) Mechanical ON-OFF indicator.

k) Operation counters.

l) Weatherproof outdoor type control cubicle and pole boxes having IP55 enclosure.

m) Set of switch fuse units/MCCB for A.C. and D.C. supply.

n) Space heater with thermostat and ON-OFF switch.

o) Cubicle illumination lamp with ON-OFF switch.

p) 3 Pin 5A Socket with ON-OFF Switch.

q) Terminal blocks and internal wiring - lot as required.

r) Set of prefabricated copper pipe with fittings, clamps, and hardware for connection between control cubicle and pole boxes as required.

s) Interconnecting wires, G.I. conduits and accessories for connection between control cubicle and pole boxes.

t) The gas filling and internal pressure monitoring devices per pole for SF6 breakers.

u) Other standard accessories which are not specifically mentioned but supplied with breakers of similar type and rating for efficient and trouble-free operation.

v) First filling of SF6 gas along with 20 % additional for the complete lot in non-returnable container.

w) Bimetallic terminal connectors. (Suitable for Al tube / Moose – Horizontal / vertical)

x) Supporting galvanized steel structure.

9.18.2 Auxiliary Equipment Common for All Circuit Breakers

a) Portable SF6 gas evacuation and filing system with necessary gas valves, safety devices, gas purity monitoring devices, regulators, vacuum pump, pressure gauges/switches, hose pipes etc. (One set)

b) Portable SF6 gas leaked detectors (2 sets)

# 10. 132kV Current Transformer (CT)

## 10.1 Intent of Specification

10.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, loading and unloading at Site, storage at Site, erection, testing and commissioning of HV current transformer, complete with all materials and accessories for efficient and trouble-free operation.

10.1.2 The specification shall be read and construed in conjunction with other sections of bidding document.

10.1.3 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 10.2 Codes And Standards

10.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below.

| Standard | Description |
|---|---|
| IS-2165 | Insulation co-ordination of highest voltages for equipment's. |
| IS 2705 (I-IV) | Current transformers |
| IS-2099 | High voltage porcelain bushing |
| IS-3347 | Dimensions of porcelain transformer bushing. |
| IS-2071 | Method of high voltage testing. |
| IS-335 | Insulation oil for transformers and switchgears. |
| IS-2147 | Degree of protection provided by enclosures for low voltages, switchgear and control. |
| IEC-185 | Current transformers |
| IEC-270 | Partial discharge measurement |
| IEC-44(4) | Instrument transformer measurement of PDs |
| IEC-171 | Insulation co-ordination |
| IEC-60 | High voltage test techniques |

| Standard | Description |
|---|---|
| IEC-8263 | Method of RIV tests on high voltage insulators |
| IEC-60044-1<br><br>IEC-60044-2 | International standard for instrument transformers |
| IEC-61869-1,2 | International standard for instrument transformers |
| IS-11322 | Partial Discharge Test |
| | Indian Electricity Rules, 1956 |
| IEC 61869-2 | Additional requirements for current transformers |
| IEC-815 | Porcelain housing for instrument transformers. |

**10.3 Scope of Work**

10.3.1 The equipment shall be furnished in strict accordance with the same and approved SLD.

10.3.2 132 kV current transformer (C.T.) with as required

10.3.3 Each current transformer shall be furnished with fittings and accessories as required.

10.3.4 Bimetallic terminal connector for CTs suitable for Moose conductor/ IPS Al tube of required quantity.

10.3.5 One set of special tools and tackles.

10.3.6 All relevant drawings, data and manuals

**10.4 Design Criteria**

10.4.1 The equipment will be used in extra high voltage system, having characteristics.

10.4.2 The equipment will be installed outdoor in a hot, humid and tropical atmosphere.

10.4.3 All equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion.

10.4.4 The maximum temperature in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in the relevant standards.

10.4.5 The equipment shall be capable of withstanding the dynamic and thermal stresses of listed short circuit current without any damage or deterioration.

10.4.6 There shall be no radio interference when the equipment is operated at maximum service voltage.

10.4.7 The safety clearances of all live parts of the equipment shall be as per relevant standards.

**10.5 Specific Requirements**

**Type and Rating**

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

10.5.2 The current density of conductor shall not exceed the following values:

a) For Copper – 1.65 A/sq. mm @ rated continuous thermal current.

b) For Aluminum – 1.00 A/sq. mm @ rated continuous thermal current.

10.5.3 Current Transformers shall have single primary – either ring type or hair pin type Each Current Transformers shall be furnished with a number of independent cores with ratios and other ratings as required.

10.5.4 Different ratios of each core shall be achieved by secondary taps only and primary reconnection is not acceptable.

**10.6 Constructional Features**

10.6.1 The current transformer shall be single pole unit, designed for upright mounting on steel structure and furnished complete with fixing hardware.

10.6.2 Insulator shall be of wet process porcelain, brown glazed and free from imperfections. All metal parts and hard wares shall be hot dip galvanized.

10.6.3 The creepage distance shall correspond to the value required. Grading ring, if required, shall be furnished to maintain voltage gradient within permissible limit.

10.6.4 Current transformer shall be provided with oil level gauge, drain plug and pressure relief device. An inert gas cushion/ stainless steel bellow shall be provided on top for expansion of the oil.

10.6.5 Insulating oil to be used shall be EHV grade conforming to IS 335 / IEC-60296

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

10.6.7 Current transformer shall be so constructed as to ensure that the oil does not flow out or leak out even when the current transformer is used continuously at the maximum allowable temperature.

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

10.6.9 The insulator shall be one piece without any metallic flange joint.

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

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

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

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

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

10.6.15 Current transformers shall be suitable for high-speed auto reclosing.

**Terminals**

10.6.16 The primary terminals shall be made of heavily tinned electrolytic grade copper when the primary winding is of copper. Palm type Aluminium primary terminals shall be provided when primary winding is of Aluminium.

10.6.17 The current density of the terminal pad shall not be greater than that of primary winding current density. Polarity shall be marked on each terminal.

10.6.18 Suitably insulated copper wire of electrolytic grade shall be used for secondary windings. For multi ratio design, suitable tapping shall be provided on the secondary winding.

10.6.19 Secondary terminals shall be brought out to a terminal box and suitable for connection to 1100V, FRLS, PVC insulated multi strand 6 sq.mm copper conductors per way.

10.6.20 All primary and secondary terminals shall be clearly and indelibly identified as per relevant standard.

10.6.21 The terminal box shall be of 3 mm thick sheet steel, IP-55, weatherproof and dust-tight, complete with gasketed front access cover and removable gland plate at bottom for cable entry.

**Junction Box for CT**

10.6.22 CT junction box shall be outdoor type having IPW-55 class of protection with suitable canopy of gasketed weatherproof construction fabricated from sheet steel minimum 2mm thick.

10.6.23 The box shall have front access door with lock and key and removable gland plate at the bottom for cable entry.

10.6.24 The junction box shall have stud type (non-disconnecting) terminals. Arrangement shall be provided for shorting of the secondary terminals while the CT is in energized condition for testing and other purposes, if necessary. Sufficient space shall be provided so that all terminals are accessible. No. of terminals shall be 20 nos. each in a terminal block and five nos. such blocks in CT junction box and 3 nos. such terminal blocks in VT junction box.

10.6.25 All incoming and outgoing connections in the junction box shall be properly marked with ferrules.

10.6.26 The box shall be epoxy painted to shade 631 of IS 5

**Grounding**

10.6.27 Each current transformers shall be provided with two ground pads for connection to station ground mat.

10.6.28 The ground pad shall comprise buffed metal surface with two holes, M10 G.I. bolts and spring washers to receive Cu flat of appropriate size.

### 10.7 Tests

**Routine Tests**

10.7.1 During manufacture and on completion, all equipment shall be subjected to the Routine Tests as laid down in Indian / IEC Standard.

**Type Tests**

10.7.2 Type test certificates, dated not more than five (05) years back, shall be furnished for the offered model of current transformer.

10.7.3 The bidder/manufacturer shall submit copies of the type test reports along with the drawings submitted for Owner approval.

10.7.4 The type test shall be as per IEC 60044-1 and the report shall include following IEC tests in addition to other mandatory tests specified in the IEC standard.

- Chopped lightning impulse test.
- Measurement of capacitance and dielectric dissipation factor (tan δ)
- Measurement of transmitted over voltages.
- Mechanical tests.

**Test Witness**

10.7.5 Tests shall be performed in presence of Owner representative if so desired by the Owner. The Contractor shall give at least Fifteen (15) days' advance notice of the date when the tests are to be carried out.

**Test Certificates**

10.7.6 Certified reports of all the tests carried out at the works shall be furnished in requisite number of copies for approval of the Owner.

10.7.7 The equipment shall be dispatched from works only after receipt of

10.7.8 Owner written approval of the test reports.

10.7.9 The test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

### 10.8 Special Tools & Tackles

10.8.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

10.8.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

### 10.9 Technical Parameters

| S.No | Description | Data |
|---|---|---|
| 1. | Highest system voltage | 145 kV |
| 2. | Rated system voltage | 132kV |
| 3. | Rated frequency | 50 Hz |
| 4. | Number of phases | 3 |
| 5. | Rated short time thermal current | 40kA for 3 sec |
| 6. | One minute power frequency withstand voltage | 275 kV (rms) |
| 7. | Full wave impulse withstand voltage (1.2 / 50 µs) | 650 kV (peak) |
| 8. | One minute power frequency withstand voltage between secondary terminals & earth | 5 kV |
| 9. | Rated short circuit dynamic current | 100kA (peak) |
| 10. | Temperature rise | As per IEC 60044 |
| 11. | Type of insulation | Oil immersed Class E |
| 12. | Type | Outdoor, oil filled, hermetically sealed |
| 13. | Creepage distance | 25mm/kV |
| 14. | CT particulars | As per enclosed 'Metering & Protection Single Line Diagram' |
| 15. | Accuracy class | Metering – 0.2S<br>Protection – PS |

## 10.10 Fittings and Accessories

10.10.1 Each Current Transformer shall be furnished complete with the accessories as listed below:

10.10.2 Base frame with anchoring bolts, nuts etc. for fixing the equipment on to structure.

10.10.3 Two grounding pads with bolts and spring washers.

10.10.4 Lifting Lugs.

10.10.5 Clamp type bimetallic terminal connectors suitable for Moose conductor/ IPS tube.

10.10.6 Weather-proof secondary terminal box with set of terminals.

10.10.7 Oil level gauge and pressure relief device.

10.10.8 Oil sampling valve.

10.10.9 Nitrogen sealing hole cover where inert gas cushion provided.

10.10.10 Other standard accessories which are not specifically mentioned but are usually provided with current transformers of such type and rating for efficient and trouble-free operation.

# 11. 132kV Voltage Transformer

## 11.1 Intent of Specification

11.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, storage at Site, erection, testing and commissioning of EHV Voltage Transformer (VT), complete with all materials and accessories for efficient and trouble-free operation.

11.1.2 The specification shall be read and construed in conjunction with other sections.

11.1.3 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 11.2 Codes and Standards

11.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IS: 3156 | Specification for Voltage transformers (Part I to IV). |
| IS-2099 | High voltage porcelain bushings. |
| IS-3347 | Dimensions of porcelain transformer bushing |
| IS-335 | Insulating oil for transformers and switchgears. |
| IS-3202 | Code of practice for climate proofing of electrical equipment |
| IS-2147 | Degree of protection provided by enclosures for low voltage switchgears and controls. |
| IEC-186 | Voltage transformers. |
| IEC-815 | Porcelain housing for instrument transformers. |
| IEC-60044-2 | International standard for Potential Transformers |
| IEC 61869-3 | Additional requirements for inductive voltage transformers |
| IS 5 | Colours for ready mixed paints and enamel |
| Indian Electricity Act and rules framed there-under. | |
| Regulations laid by CEA of India. | |

Regulations laid by the office of the Chief Electrical Inspector to Government (CEIG).

### 11.3 Scope of Work

11.3.1 Type, rating, connections etc. of the equipment listed below. The equipment shall be furnished in strict compliance with the same.

11.3.2 132 KV single-phase Voltage Transformer (VT) with double/ triple secondary windings as required.

11.3.3 Each Voltage Transformer shall be furnished with fittings and accessories as listed.

11.3.4 Bimetallic terminal connector for V.T.s as required and shall be suitable for Moose conductor/ IPS Al tube.

11.3.5 One set of special tools and tackles.

11.3.6 All relevant drawings, data and manuals.

### 11.4 Design Criteria

11.4.1 The equipment will be used in extra high voltage system, having characteristics as listed.

11.4.2 The equipment will be installed outdoor in a hot, humid and tropical atmosphere.

11.4.3 All equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion.

11.4.4 The maximum temperature in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in the relevant standards.

11.4.5 The equipment shall be capable of withstanding the dynamic and thermal stresses of listed short circuit current without any damage or deterioration.

11.4.6 There shall be no radio interference when the equipment is operated at maximum service voltage.

11.4.7 The safety clearances of all live parts of the equipment shall be as per relevant standards.

### 11.5 Specific Requirements

**Type and Rating**

11.5.1 EHV Voltage Transformer shall be electromagnetic type two/ three secondary windings, having ratios and ratings as specified, shall be suitable for measuring voltage for both metering and protection in 132 kV line.

**Constructional Features**

11.5.2 Electromagnetic voltage transformer (VT) shall be of outdoor type to be used for 132kV system.

11.5.3 Voltage transformers shall be single pole unit designed for upright mounting on steel structure and furnished complete with anchoring hardware.

11.5.4 Insulator shall be wet process porcelain, brown glazed and free from imperfections. All metal parts and hardware shall be hot dip galvanized.

11.5.5 Creepage distance shall correspond to lightly polluted atmosphere (25mm/kV). Grading ring, if required, shall be provided to maintain voltage gradient within permissible limit.

**Voltage Transformer (VT)**

11.5.6 VT shall be oil-filled, self-cooled, hermetically sealed type.

11.5.7 VT shall be provided with oil level gauge and pressure relief device. An inert gas cushion/stainless steel bellow shall be provided on top for expansion of the oil.

11.5.8 Voltage transformer shall be cast-resin, draw-out type from the front of the panel. Bus VT shall be mounted on adopter panel of bus coupler or shall be provided in separate panel. Line VT shall be mounted on the breaker carriage itself / below the breaker compartment. Separate cores shall be used for metering and protection.

11.5.9 Voltage Transformer mounted on breaker carriage is not acceptable. Over voltage factor shall be considered resistance grounded system as 120% for continuous duty and 190% for 8 hours.

11.5.10 High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position. Automatic shutters shall be for safety purpose to avoid accidental access to live parts on VT withdrawal and entry of rodents.

11.5.11 Low voltage side MCB's shall be provided. MCB's shall be sized to prevent overload, shall be installed in all ungrounded secondary leads. Fuses shall be suitably located to permit easy replacement while the switchgear is energized.

11.5.12 Fuse failure relay on voltage balance principle shall be provided for all Bus VT's for monitoring the healthiness of primary fuse/secondary MCBs. For Line VT's fuse/MCB failure relay shall be provided on the secondary side of the voltage transformers to monitor failure of MCBs. The relay shall initiate alarm and block the tripping etc., which will operate in case of VT fuse/MCB failure.

11.5.13 VTs shall be provided with one open delta winding with provision for harmonic suppression arrangement.

11.5.14 Damping Resistor shall be provided for Voltage Transformer to resist/ damped the Overheating damage or Over induction on account of Ferro resonance.

11.5.15 The accuracy class specified shall be maintained throughout the entire burden range on all the windings without any adjustments during operation.

11.5.16 The guaranteed burdens and accuracy class shall be simultaneous for all cores.

11.5.17 Accuracy class of the Voltage Transformer shall be as follows:

- Class 3P for protection
- Class 0.2 for metering

11.5.18 Core lamination shall be cold rolled grain-oriented silicon steel or another equivalent alloy.

11.5.19 Oil filling and drain plugs and oil sight glass shall be provided.

11.5.20 The expansion chamber at the top of porcelain insulators shall be suitable for expansion of oil.

11.5.21 Transformer tanks and other metallic parts exposed to the atmosphere shall be hot dip galvanized.

11.5.22 The tank shall be designed to withstand internal pressure developed due to short circuit.

11.5.23 Pressure relieving device capable of releasing abnormal pressure shall be provided.

11.5.24 Two earthing pads for earthing connections of equipment to earth bus shall be provided.

11.5.25 The secondary terminals shall be terminated in stud type non-disconnecting terminal blocks located in weatherproof (IP55) chamber. The secondary terminal compartment shall have removable cover. 10% spare terminals shall be provided.

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

11.5.27 Insulating oil to be used shall be EHV grade conforming to IS 335 / IEC-60296.

11.5.28 The current density of conductor shall not exceed the following values:

a) For Copper – 1.65 A/sq. mm @ rated continuous thermal current.

b) For Aluminum – 1.00 A/sq. mm @ rated continuous thermal current.

**Terminals**

11.5.29 Primary terminals shall be made of non-ferrous corrosion resistant material and

11.5.30 Provided with bimetallic terminal connectors, suitable for Moose conductor.

11.5.31 Secondary terminals shall be brought out to a terminal box and suitable for connection to 1100V, FRLS, PVC insulated multi strand 6 sq.mm copper conductor wire per way.

11.5.32 All primary and secondary terminals shall be clearly and indelibly identified as per relevant standard.

11.5.33 The terminal box shall be of 3 mm thick sheet steel IPW-55, weatherproof and dust-tight, complete with gasketed front access cover and removable gland plate at bottom for cable entry.

**Junction Box for VT**

11.5.34 VT junction box shall be outdoor type having IPW-55 class of protection with suitable canopy of gasketed weatherproof construction fabricated from sheet steel minimum 2mm thick.

11.5.35 The box shall have front access door with lock and key and removable gland plate at the bottom for cable entry.

11.5.36 The junction box shall have stud type (non-disconnecting) terminals. No. of terminals shall be 20 nos. each in a terminal block and 3 nos. such terminal blocks in VT junction box.

11.5.37 All incoming and outgoing connections in the junction box shall be properly marked with ferrules.

11.5.38 The box shall be epoxy painted to shade 631 of IS 5.

**Grounding**

11.5.39 Each voltage transformer shall be provided with two ground pads for connection to station ground mat.

11.5.40 The ground pad shall comprise buffed metal surface with two holes, M10 G.I. bolts and spring washers to receive Cu. flat. of approved size.

## 11.6 Tests

**Routine Tests**

11.6.1 During manufacture and on completion, all equipment shall be subjected to the Routine Tests as laid down in Indian Standard.

**Test Witness**

11.6.2 Tests shall be performed in presence of Owner.

**Test Certificates**

11.6.3 Certified reports of all the tests carried out at the works shall be furnished in requisite no. of copies for approval of the Owner.

11.6.4 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

11.6.5 Type test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

## 11.7 Special Tools & Tackles

11.7.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

11.7.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

## 11.8 Technical Parameters

| S.No | Description | Data |
|---|---|---|
| 1. | Nominal system voltage | 132kV |
| 2. | Highest system voltage | 145kV |
| 3. | Rated Frequency | 50Hz |
| 4. | System fault level | 40kA for 3 sec |
| 5. | Temperature rise | As per IEC 60044 |
| 6. | Type of insulation | Oil immersed class E |

| S.No | Description | Data |
|---|---|---|
| 7. | Type | Outdoor, oil filled |
| 8. | Rated lightning impulse withstand voltage | 650kV (peak) |
| 9. | 1minute power frequency withstand voltage | 275kV (rms) |
| 10. | 1 minute power frequency withstand voltage for secondary winding | 3kV |
| 11. | Rated power factor | 0.8 lag |
| 12. | Creepage distance | 25mm/kV |
| 13. | System neutral earthing type | Effectively earthed |
| 14. | Coefficient of earthing | < 0.8 |
| 15. | Rated primary voltage | 132kV/√3 |
| 16. | Rated secondary voltage | 0.11kV/√3 |
| 17. | VT particulars | As per enclosed 'Metering & Protection Single Line Diagram' |
| 18. | Rated voltage factor | 1.2 Continuous & 1.5 for 30 secs. |
| | Accuracy class for tariff metering and general metering | 0.2 |
| 19. | Accuracy for protection core | 3 P |
| 20. | Partial discharge level | 10pC |

### 11.9 Fittings and Accessories

11.9.1 Each Voltage Transformer shall be furnished complete with the accessories as listed below:

11.9.2 Base frame with anchoring bolts & nuts etc. for fixing the equipment on to structure.

11.9.3 Two grounding pads with bolts and spring washers.

11.9.4 Lifting Lugs.

11.9.5 Clamp/pad type bimetallic terminal connectors with S.S. hardware.

11.9.6 Weather-proof secondary terminal box with set of terminals and 3 nos. HRC fuses.

11.9.7 Grading ring, if necessary.

11.9.8 Oil level gauge and pressure relief device, for oil filled type.

11.9.9 Other standard accessories, which are not specifically mentioned but are usually provided with voltage transformers of such type and rating for efficient and trouble-free.

# 12. Control and Relay Panel (CRP)

## 12.1 Intent of Specification

12.1.1 This specification is intended to cover the design, engineering, procurement, assembly, manufacturing, testing at manufacturer's works, supply & delivery, properly packed for transport as per manufacturer requirement, loading and unloading at Site, storage at Site, erection, testing and commissioning of substation protection system (control and relay panels), complete with all materials and accessories for efficient and trouble-free operation.

12.1.2 The relay protection scheme shall be as per the Owner approved single line diagram.

12.1.3 In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

## 12.2 Codes And Standards

12.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below.

| Standard | Description |
|---|---|
| IEC 60255 | Measuring relays and protection equipment |
| IEC 61850 | Communication networks and systems for power utility automation |
| IEC 60359 | Expression of the performance of electrical & electronic measuring equipment |
| IS 3231 | Electrical relays for power system protection |
| IS 3842 | Electrical relay for AC systems |
| IEC 60529 | Degrees of protection provided by enclosures (IP Code) |

## 12.3 Scope of Work

12.3.1 The type and rating of the equipment listed below are further detailed. The equipment shall be furnished in strict accordance with the same.

12.3.2 Electrical Panels containing Substation Protection System and Tariff Metering panels as given below in accordance with this specification, drawings, and annexure as applicable.

12.3.3 The following relay panel shall be located in control room.

- Relay panels for Transformer bay : One (1) Set
- Separate panel for transformer protection relay *(if required)*

12.3.4 Furnishing and internal wiring of all equipment, devices and accessories.

12.3.5 Floor channel sills, vibration damping pads and kick plates complete with holding-down bolts and nuts.

12.3.6 One set of special tools and tackles

12.3.7 All relevant drawings, data and instruction manuals.

## 12.4 Design Criteria

12.4.1 The relay panels shall be used for protection of the feeders of the substation. The tariff metering panels shall be used for accounting purposes based on Availability based tariff.

12.4.2 The panels shall be simplex type, totally enclosed, floor mounted, free- standing, dead-front assemblies conforming to degree of protection IP-31 or better.

12.4.3 Design, material selection and workmanship shall be such as to present a neat appearance outside and inside with no welds, rivets, screws or bolt heads apparent from the exterior surfaces of the Control Boards.

12.4.4 The panels shall be installed in the air-conditioned control room. All the devices shall be suitable for operation at Site maximum & minimum ambient temperature conditions considering the prolonged outage of the air conditioning system.

12.4.5 The panels shall be liberally sized so as to provide spacious layout of equipment and devices with sufficient working space in between.

12.4.6 Maximum three (03) number of relays to be connected to Ethernet switch as per functional requirement.

## 12.5 Specific Requirements

### Construction

12.5.1 Panels mounted side by side are bolted together to form a compact unit. Where two panels meet, the joints shall be smooth, close-fitting and unobtrusive.

12.5.2 Panels shall be free standing type and folded sheet steel construction, assembled on channel/angle base plates with anti-vibration mountings.

12.5.3 Cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of panels such as base frame, front sheets and door frames shall be provided. Minimum 2mm thick cold rolled sheet shall be provided for sides, door, top & bottom portions. The panels shall have sufficient structural reinforcement to ensure a plane surface, to limit vibration and to provide rigidity during shipment and installation.

12.5.4 All access doors shall be provided with channel rubber/neoprene gaskets all round and latches sufficiently strong to hold them in alignment when closed. The operating handle shall have locking arrangement.

12.5.5 The boards shall be complete with floor channel sills, vibration damping pads and stainless steel kick plates. The panels shall be completely dust, moisture & vermin proof.

12.5.6 Pistol grip type Relay transfer switch shall be provided in Line and Transfer bus panels. Each switch shall have following mode of operation.

- Normal mode : The control operation of breaker shall be from respective relay of breaker.
- Intermediate mode : While transferring the line bay from main bus to transfer bus, the relay shall communicate to breaker of transfer bay
- Transfer mode : Relays of the line bay shall communicate to relay of transfer bus for breaker operation

**Equipment Mounting**

12.5.7 All equipment except transducers, auxiliary relays, timers etc., shall be mounted on the front face of the panels and shall be of flush or semi-flush type. The relay panel shall have a complete glass door in the front and relay mounting frame shall be inside the glass door. The mounting frame shall be hinged type front operable.

12.5.8 All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services to others.

12.5.9 All equipment inside the panels shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.

**Name Plate**

12.5.10 Nameplates of approved design shall be furnished for each panel and for each instrument or device mounted on the panel.

12.5.11 The material shall be made of anodized aluminum or approved equal with black letters engraved on white background.

12.5.12 The nameplates shall be held by self-tapping screws. The size of the nameplate shall be approx. 20 mm x 75 mm for equipment and 40 mm x 150 mm for the panels. The letter height for Main label plate at the front shall be 12 mm, Apparatus labels on the front and inside shall have a minimum letter height of 3 mm.

12.5.13 The nameplates for panels shall be provided both on the front and on the rear.

12.5.14 Devices mounted on the face of the control boards shall also be identified on the rear with the instrument or device number. The number may be painted on or adjacent to the instrument or device case.

12.5.15 Name plate shall contain minimum following detail:

a) Manufacturer's Name

b) P.O. Number and Date

c) Drawing reference number pertains to that panel.

**Illumination, Space Heating and Receptacles**

12.5.16 Each panel shall be provided with an interior LED type illumination lamp with door switch, space heater with thermostat and 6A, 3 pin receptacles with plug.

12.5.17 The lamp, heater and receptacle circuits shall be suitable for available A.C. supply and furnished with individual ON-OFF switch.

12.5.18 The lamp shall be located at the ceiling and guarded with protective cages. Space heaters shall be located near the floor so as not to pose any hazard to service personnel.

**AC/DC Power Supply**

12.5.19 The following power supplies will be made available to each board consisting of number of panels bolted together: -

- A.C. Supply : Single Feeder
- D.C. Supply : Duplicate Feeder

12.5.20 The Contractor shall provide isolating switch fuse units for the incoming AC/DC power supplies and run bus wires for power distribution to different panels.

12.5.21 Fuse and link shall be provided for individual circuits for protection and also for isolation from bus wire without disturbing other circuits.

12.5.22 The Contractor shall group the fuse requirements for each panel in a neat, orderly and easily accessible fuse blocks or distribution panel.

12.5.23 Alarm relays shall be provided to annunciate failure of incoming A.C. and D.C. power supplies to each panel.

**Wiring**

12.5.24 Each panel shall be fully wired up at the factory to ensure proper functioning of control, protection and metering schemes.

12.5.25 All spare contacts of relays and switches shall be wired to terminal blocks. All interconnections between the panels of the control board shall be furnished.

12.5.26 Wiring shall be done with flexible, FRLS (fire resistant low smoke), 1100V grade, FRLS, PVC insulated, switch board wires with stranded copper conductor, 2.5 mm2 cable for control & current circuits and 1.5 mm2 cable for voltage circuits.

12.5.27 Each wire shall be identified at both ends with wire designation as per Contractor's wiring diagram. Interlocking type ferrules shall be used for identification.

12.5.28 All wire termination shall be made with insulated sleeve crimping type lugs. Wire shall not be tapped or spliced between terminals.

12.5.29 Wiring shall be neatly bunched in groups by non-metallic cleats or bands. Each group shall be adequately supported along its run to prevent sagging or strain on the termination.

**Selector Switches and Change Over Switches:**

12.5.30 Instrument selector switches shall be provided for indicating instruments while change over switches shall be provided for selective operation of controls such as auto/ non-auto reclose, trip circuit transfer from main breaker to transfer breaker. Protection selector switches are to be provided in the Bus transfer bay and shall be used for adopting the bus transfer bay protection during Bay transfer condition, when line side C.T. operated protection of any bay develops any defect. All these switches shall be stay put type.

12.5.31 The voltmeter selector switch shall be suitable for reading all line to line and line to neutral voltage for effectively earthed system. This selector switch shall be of the rotary oval head or knob type.

12.5.32 The trip circuit transfer switch shall be of 3-position Normal-Inter-Transfer. Operating handle shall be pistol grip, lockable at Normal position and key trapped at transfer position having one common key for all panels respectively for a particular Sub-station

12.5.33 The protection selector in Bus Transfer Bay shall be lockable type, two/ three position depending upon scheme requirement.

12.5.34 One four position selector switch for setting group selection in respect of distance relay in Bus Transfer panel shall be provided.

12.5.35 One three position selector switch for setting group selection in respect of numerical over current &earth fault relay in Bus Transfer panel shall be provided.

**Terminal Block**

12.5.36 All internal wiring are to be connected to external equipment shall terminate on terminal blocks. Terminals shall be 650V grade and have 10Amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and locknuts. Marking on terminal blocks shall correspond to wire number and terminal numbers on wiring diagram.

12.5.37 Disconnecting type terminal blocks for current and Voltage transformer secondary leads shall be provided. Terminals for C.T. secondary leads shall have provision of shorting and earthing.

12.5.38 Not more than two wires shall be connected to one terminal. If necessary, a number of terminals shall be jumpered together to provide wiring points.

12.5.39 Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side.

- All CT & PT circuits : 4Sq. mm. Cu
- AC/DC Power supplies Circuits : 6Sq. mm. Cu

- All other circuits : minimum 2 x 2.5 sq. mm. Cu

12.5.40 Each terminal shall be identified with designation as per approved schematic. Spare terminals equal in number of 20% active terminals shall be furnished.

12.5.41 The wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

12.5.42 The terminal blocks shall be located to allow easy access and also to suit floor openings for cable entry.

12.5.43 Unless otherwise specified, terminal blocks shall be mounted vertically with adequate spacing (not less than 100 mm) between adjacent rows.

12.5.44 The bottom of the terminal block shall be at least 200 mm above the incoming cable gland plate.

**Cable Entry**

12.5.45 The panel shall have provisions of cable entry from the bottom. Bottom plate shall be provided to make entry dust tight.

12.5.46 The panels shall have provisions inside for fixing the multi-core cable glands. The cable gland support plate shall be 4 mm thick and mounted not less than 200 mm above floor level.

**Grounding**

12.5.47 50 x 6 mm copper ground bus shall be provided on each control board extending along the entire length of the assembly.

12.5.48 The ground bus shall be bolted to the panel structures and effectively ground the entire assembly. The cases of meters, relays and switching devices shall be grounded through the steel structure.

12.5.49 Whenever a circuit is shown grounded, a single wire from the circuit shall be run independently to the ground bus and connected to it.

**Painting**

12.5.50 All steel surfaces shall be sand blasted to remove all rust, scale and foreign adhering matters. The steel surfaces shall then be chemically cleaned, rinsed, phosphate, rinsed and dried.

12.5.51 Immediately after phosphating, the surfaces shall be given two coats of high-quality primer and stoved after each coating.

12.5.52 All external surface shall be painted with two coats of epoxy-based paint of colour shade RAL 7032/ RAL 7035. The internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 80-100 microns.

12.5.53 The panels shall have a smooth and uniform matt finish, free from scratches, dents and any other imperfections. Sufficient quantity of touch-up paints shall be furnished for application at Site.

12.5.54 The Bidders are requested to furnish the details process adopted by them for pre-treatment and painting of sheet metal for the control boards.

**Relays**

12.5.55 The protection philosophy of the different feeders of the substation is given in the System single Line Diagram is enclosed. The bidder shall carefully study the same to offer relays of suitable type and setting range to meet the system requirements. The schemes shall be complete and operative in all respects.

12.5.56 The relay shall be numerical type with two sets of communication ports. The relay shall have its own monitoring features with LED display and diagnostic features.

12.5.57 Unless otherwise stated, all AC operated relays shall be suitable for operation at 50Hz. AC Voltage operated relays shall be suitable for 110Volts phase to phase and 63.5 Volt phase to neutral VT secondary and current operated relays for 1 Amp. All DC operated relays and timers shall be designed for the DC voltage specified and shall operate satisfactorily between 80% to 110% of rated voltage.

12.5.58 Relays shall be furnished in rectangular, dust tight, draw- out type cases with built-in test facilities. Small auxiliary relays may be furnished in fixed casing and mounted inside the panels.

12.5.59 Protective relays shall be equipped with externally reset positive action operation indicator.

12.5.60 All relays, unless otherwise approved, shall have minimum two electrically separate pairs of contacts. Contacts shall be silver surfaced, bounce-free and capable of repeated operation without deterioration.

12.5.61 The Contractor shall furnish the recommended relay settings of the relays under it's scope of supply along with co-ordination curves.

**Auxiliary Devices**

12.5.62 The Contractor shall furnish, install and wire-up all auxiliary devices such as interposing current or voltage transformers, timing/switching/lockout/auxiliary relays, transducers etc. as specified or as required for the proper functioning of the schemes offered.

**Tariff Metering Panel/Metering panel**

12.5.63 For energy accounting & Audit, energy meters and associated devices shall be furnished which are to be mounted in the panel. The construction of the panel shall be same as described earlier clauses. The meters shall ABT (for tariff) (Availability Based Tariff) compatible, static type, composite meters. These are self-contained devices for measurement of active and reactive energy and certain other parameters as described in the following paragraphs.

12.5.64 The meters shall be suitable for being connected directly to Voltage transformer having a rated secondary line to line voltage and to current transformer having a secondary rated current.

12.5.65 The meters shall have a non-volatile memory in which the following shall be automatically stored:

- Average frequency for each successive 15-minute block as a two digit code (00 to 99 for frequency from 49.0 to 51.0Hz).
- Net Whr transmittal during each successive 15-minute block, up to second decimal, with plus/ minus sign.
- Cumulative Whr transmittal at each midnight, in six digits including one decimal.

- Cumulative VArh transmittal for voltage high condition, at each midnight, in six digits including one decimal.
- Cumulative VArh transmittal for voltage low condition, at each midnight, in six digits including one decimal.
- Date and time blocks of failure of VT supply on any phase, as a star (*) mark.

12.5.66 In addition, it shall also store all parameters as indicated below (excluding instantaneous electrical parameters).

- Apparent power
- Phase wise kilowatt at peak kVA
- Phase wise kVA (reactive) at peak kVA
- Phase wise voltage at peak kVA
- Power down time
- Average power factor
- Line currents
- Phase voltages
- Date and time
- Tamper events

12.5.67 The meters shall store all the above listed data in their memories for a period of at least for thirty (30) days. The data older than thirty days shall get erased automatically. Each meter shall have an optical port on its front for collecting all data stored in its memory using a hand held data collection device which will be supplied by the supplier.

12.5.68 The meters shall also display (on demand), by turn, the following parameters:

- Unique identification number of the meter
- Date
- Time
- Cumulative Whr register reading.
- Average frequency of the previous 15 –minute block
- Net Whr transmittal in the previous 15-minute block, with+/- sign
- Average percentage voltage
- Reactive power with +/- sign
- Voltage-high VARh register reading
- Voltage-low VARh register reading

12.5.69 The active energy (Whr) measurement shall be carried out on 3-phase, 4-wire principle, with an accuracy as per class 0.2s of IEC-687/IEC-62053-22. The energy shall be computed directly in CT and VT secondary quantities and indicated in watt-hours.

12.5.70 The VAR and reactive energy measurement shall also be on 3-phase, 4-wire principle, with an accuracy as per class 0.2s of IEC-62053-23 or better. The VAR and VARh computation shall be directly in CT and VT secondary quantities. There shall be two reactive energy registers, one for the period when average RMS voltage is above 103% and the other for the period the voltage is below 97%.

12.5.71 The 15-minute Whr shall have a +ve sign when there is a net Whr export from substation bus-bars, and a-ve sign when there is a net Whr import. The integrating (cumulative) registers for Whr and VARh shall more forward when there is Whr /VARh export from substation busbars, and backward when there is an import.

12.5.72 The three line-to-neutral voltages shall be continuously monitored, and in case any of these falls below 70%, the condition shall be suitably indicated and recorded. The meters shall operate with the power drawn from the VT secondary circuits, without the need for any auxiliary power supply. Each meter shall have a built-in calendar and clock, having an accuracy of 30 seconds per month or better.

12.5.73 The meters shall be totally sealed and tamper-proof, with no possibility of any adjustment at Site, except for a restricted clock correction. The harmonics shall be filtered out while measuring Whr, VAR and VARh, and only fundamental frequency quantities shall be measured / computed.

12.5.74 The energy accounting and audit meter shall have data storage capacity for at least 35 days in a non-volatile memory.

12.5.75 Energy accounting and audit meters shall have the facility to download the parameters through meter reading instruments as well as remote transmission of data over communication networks.

12.5.76 The main and check tariff metering panels shall be placed outdoors with IP 65 protection along with extruded canopy.

**Bay Control Unit (BCU)**

12.5.77 One Bay Control Unit shall provide complete functionality for each bay. Each set of BCUs shall have sufficient digital inputs to acquire the status of each and every circuit breaker, isolator, earth switch, non-communicable supervisory relay etc. of that bay. Similarly, the digital output shall be sufficient to control all the switchgears and also for functions like resetting of relays etc. in one bay.

12.5.78 There should not be separate control panel in any case. Only BCU base panel is envisaged, and number of panels may be one or two per bay suitable to accommodate each component required for control / protection scheme & spacious enough to work for O&M and testing. The BCU provided should be compatible for integration to any third-party SAS & also should be able to work in case of non-availability of SAS/SCADA from O&M point of view.

12.5.79 BCU shall have synchro check for interlocking protection.

12.5.80 Emergency breaker control switch may be provided on each BCU panel. Annunciator may be provided on each BCU panel which is required from O&M point of view wherever the panels are being procured

for EHV substations without Bay Control Room in addition to SAS to have provision in case of non-working / failure of SAS/SCADA.

12.5.81 In case of BCR in switchyard, suitable arrangement for Common Audible Alarm & its Accept Button from respective Facia Annunciator may be provided for alertness of operator at control room.

12.5.82 Alarm annunciation shall be provided CRP by means of visual & audible alarms in order to draw the attention of operating staff to the abnormal condition of some protective devices. Visual annunciation in the form of flush mounted facia is to be provided in CRP.

12.5.83 The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.

12.5.84 Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life LED lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (300 Lux), from the location of the operator's desk.

12.5.85 All Trip facia shall have red colour and all Non-trip facia shall have white colour.

12.5.86 Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 220 Volts DC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone, but the facia window shall remain steadily lighted till the supply to annunciation system is restored.

12.5.87 Provision for main & check ABT meter may be kept in BCU panel. The BI/DI provided on BCU should be configurable for operating DC voltage & time delay. The BO should be configurable for latch/unlatch type & sufficiently provided of required rating for trip & non-trip function as required to full fledge the envisaged control & protection scheme.

12.5.88 The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

| | |
|---|---|
| Hooter | Alarm Annunciation |
| Bell | Annunciation DC failure |
| Buzzer | AC supply failure |

12.5.89 Each Bay Protection Unit shall comprise one or more numerical relays to meet the protection requirements specified for each type of feeder.

12.5.90 Bay Protection Units of various bays shall interact with BCUs over inter bay Network Bus to share information related to Bay Level Interlocking, fault data, alarms/events etc. However, the trip

commands from Bay Protection Units shall be hard-wired directly (through suitable trip relay) to appropriate Substation equipment. Also, critical interlocking data between Bay Protection Units and Bay Control Units, including the substation level interlocks such as bus earth switch; bus bar protection trip etc. shall also be hard-wired to ensure complete bay level functionality even in case of failure of substation LAN. The interlocking between Bay Protection Units and Bay Control Units shall be hard-wired.

**Tri-Vector Meter (TVM)**

12.5.91 Tri-Vector Meter (TVM) shall be 3-phase, 4 wire, 0.2s accuracy class, 1A, static electronic TOD Tri-vector energy meters as per Category C1 of IS: 15959 amended up to date and shall comply IS 14697, CEA regulations & MERC guidelines. The TVM shall be with Optical & RS 232 Port or TCP / IP port as required and shall be with DLMS protocol. The meters shall be suitable for measurement of Active Energy (kWh), Reactive Energy (kVArh) Lag and (kVArh) lead separately, Apparent Energy (kVAh), demand (kW), demand (kVA), etc.

12.5.92 The meter shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous operation, in a manner acceptable to Owner. Application: 132kV EHV installations. The meter shall be completely factory sealed except the terminal block cover. A Push button facility shall be provided for high resolution reading / alternate mode of display, as brought out elsewhere in this specification. Facility of scrolling of all the readings up and down in all the display modes shall be provided.

12.5.93 The meter shall record the occurrence and restoration of tamper events of current, voltages, kWh, kVAh power factor, event code, date & time etc. listed in Table 32 to 37 of IS: 15959 / 2011. The meters offered shall be fully type tested at approved laboratory by NABL (National Accreditation Board for Testing and Calibration Laboratories) as per relevant standards within last five (05) years from the date of purchase & the type test reports shall be enclosed with the offer.

## 12.6 Tests

12.6.1 Each Board shall be completely assembled, wired, adjusted and tested at the factory prior to shipment.

**Routine Tests**

12.6.2 The tests shall include wiring continuity tests, insulation tests and functional tests to ensure operation of the protection schemes and individual equipment.

12.6.3 All relays, meters, switches and other devices shall be tested and calibrated in accordance with relevant IS standards.

12.6.4 Verification of Degree of Protection as per IS

12.6.5 High Voltage Test as per IS or IEC as may be applicable.

12.6.6 Mechanical Operation Test.

**Test Certificate**

12.6.7 Certified reports of all the tests carried out at the works shall be furnished in requisite no. of copies for approval of the Owner.

12.6.8 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

12.6.9 Type test certificate on any equipment, if so desired by Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

## 12.7 Warranty

12.7.1 The warranty period of the Control and Relay Panel shall minimum five (05) year from the date of Commissioning of Facility.

12.7.2 The TVM shall have at least five (05) years of guarantee period from the date of Commissioning of Facility.

12.7.3 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

12.7.4 During the warranty period, whenever a technical problem is encountered with Control and Relay Panel, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the Control and Relay Panel shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

12.7.5 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 13. Power Quality Meter (PQM)

PQM shall be complete in all respect including all the technical features as per IS/IEC standard and matching with Owner/ CEA requirements & guidelines.

## 13.1 Codes And Standards

13.1.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification.

| Standard | Description |
|---|---|
| IEC 61000-4-30 | Testing and measurement techniques - Power quality Measurement methods |
| IEC 61000-4-15 | Testing and measurement techniques – Flicker |
| IEC 61000-4-7 | Testing and measurement techniques - General guide on harmonics and inter harmonics measurements and instrumentation, for power supply systems |
| IS 15959 | Data exchange for electricity meter reading, tariff and load control |
| CEA Regulations | Technical Standard for Connectivity to the Grid, February 2019 or, its latest amendment. |

13.1.2 It shall provide continuous monitoring of a three-phase system. It shall provide metering of current, voltage, real and reactive power, energy use, expense of power, power factor and frequency. Ethernet communications shall be available through the optional Multinet module. All meters shall be compliant to IS 15959 and its latest amendments.

13.1.3 The power quality meter shall support 3 elements Wye, 2.5 element Wye, 2 element Delta, and 4 wire Delta systems.

13.1.4 PQM shall be compact, multi-function panel mount power quality monitor, which measures, calculates and displays major electrical parameters of three phase power system like Voltage, Current, Active / Fundamental Reactive / Apparent Power and Energy, Individual Harmonics, Sags and Swells. The power quality meter shall have a frequency range of (45 to 69.9) Hz.

13.1.5 Three phase metering and power quality analysis shall be provided by a power quality meter. Metering shall include A, V, W, Wh, Wcost, VAR, VARh, VA, VAh, Hz, and PF in True RMS or displacement (fundamental) quantities. Power analysis features shall include an event recorder, waveform capture, trace memory, harmonic spectrum display (through the maximum up to 63rd harmonic with total harmonic distortion) and a data logger function. All analysis data shall be non-volatile.

13.1.6 The Power Quality Meter shall have the following features:

- Power Quality measurement according to IEC 61000-4-30, class A
- Harmonic, inter-harmonics and phase angles of the harmonics acc. to IEC 61000-4-7
- Energy management and power monitoring functionality
- Integrated cyber security functions.

13.1.7 Measuring and metering of harmonics shall be a continuous process with meters complying with provisions of IEC 61000-4-30 Class A and complying with CEA guidelines (Technical Standard for Connectivity to the Grid) dated February 2019 or, its latest amendment.

13.1.8 The data measured and metered as mentioned in sub-paragraph (7.2.7) with regard to the harmonics, shall be available with Owner and it shall also be shared in a particular format periodically through SAS/SCADA as and when required.

13.1.9 In addition to harmonics, periodic measurement of other power quality parameters such as voltage sag, swell, flicker, disruptions shall be done as per relevant IEC standard and reports shall be generated as per EN 50160 / relevant IEC/IS standard.

13.1.10 The Power Quality Meter shall convert instantaneous voltage and current values to digital values and use the digital values to calculate parameters.

13.1.11 Power Quality Meter shall Maintain internal data logs and record metering, status, event and alarm data into these logs as specified in the logging configuration for a minimum period of 1 month.

13.1.12 Four switch inputs shall be provided which can be programmed for relay activation, counters, logic, demand sync, reset and alarms. Four output relays shall be provided which can be programmed to activate alarms, set points, switch inputs, kWh pulse, trace memory triggers or communications control. These output relays shall also be able to use demand metering values of A, VAR, W and VA to control load shedding.

13.1.13 Proper interface shall be provided via four isolated 4-20mA outputs programmable from measured and calculated parameters. Transducer monitoring shall be provided via a 4-20mA input. Current inputs shall be via 1 amp CTs and no VTs shall be required for voltages up to 600V. Auxiliary power can be 230V AC or 220V DC. Local user interface shall include a keypad and display for entering all set points and reading all measured values, and LED indicators for output relays, communication status and alarm status.

13.1.14 It shall be panel mount with display, offers an easy local interface. Models shall have RS485 communications for programming and monitoring. Users can replace expensive additional devices by-adding the CONTROL, TRANSDUCER and POWER analysis options to the PQM as required.

13.1.15 Communication Protocols shall be:

- Ethernet: IEC 61850, Modbus TCP, Gateway/Master, NTP

- Serial: Modbus RTU master and gateway function for RS485 devices

13.1.16 Data export shall be made as per below:

- Power Quality Data Interchange Format (PQDIF) as per IEEE 1159.3, measured value recorder
- CSV data for Power Quality recordings, measured value recorder
- COMTRADE according to IEEE/IEC, fault records.

13.1.17 Energy Monitoring System shall access the required format as per above stored in the EMS itself and shall be capable of transferring data in required approved mode to SAS/SCADA as is when basis.

13.1.18 The PQM shall be connected to 0.2S class current transformer (CT) and 0.2 Class CVT at 132 KV Transmission line bay. 132 kV transmission line bay, PQM shall be part of control and relay panel. 132 kV C&R panel in co-ordination with Owner requirement. However, in event, it is not feasible to install the panel in line panel, bidder shall provide required panel / enclose with required CT/PT wiring / cabling etc.

13.1.19 The power quality meter shall be connected.

- Directly for circuits up to 690V L-L
- With Potential Transformers for circuits above 690V L-L

13.1.20 The delivered system is expected to provide meaningful measurement of the acquired data so that it is useful to the operators in assessing the current state of grid and can be used for carrying out the post- facto analysis. PPC bidder has to see that offered PQM should be integrated with PPC on TCP/IP for faster response.

13.1.21 An RS232 computer interface port shall be located on the front panel. Two RS485 and one RS232 communication ports shall be provided for simultaneous access using Mod Bus RTU protocol. Windows® based / any other standard software shall be provided to enable set point programming.

13.1.22 Cyber Security minimum feature of PQM shall be as per below:

- Role based access control (RBAC): password protection against unauthorized usage, central user management.
- Secured and protected communication via IEC 61850 protocol, Web browser communication via https://
- Firmware signature: only firmware signed by Manufacturer of PQM shall be loaded.
- Security log: non-volatile storage of SYSLOG event

13.1.23 Operation and display:

- Graphic display including operation via 4 function keys.
- Integrated web server to interact with PC and HTML pages.

**Time Accuracy**

13.1.24 Each meter shall have a built-in calendar and clock, having an accuracy of 10 seconds per month or better. The calendar and clock shall be correctly set at the manufacturer's works. The date (year-month-

day) and time (hour-min.-sec.) shall be displayed on the meter front on demand. Meter shall have the intelligence to synchronize the time with GPS (Local GPS/CDCS GPS) signal and from PC using software. Limited time synchronization through meter communication port shall be possible at Site. When an advance or retard command is given, twelve subsequent time blocks shall be contracted or elongated by five seconds each. All clock corrections shall be registered in the meter's memory and suitably shown on print out of collected data.

13.1.25 The meters shall be capable of receiving periodic time synchronization signals via proper online system. The meter time shall be in synchronism with GPS time master system. Time synchronization shall be carried out by NTP (Network Time Protocol), and it shall be synchronized with the master time clock. Necessary hardware and software shall be provided for the same.

13.1.26 The power quality meter shall have features similar to Siemens-SICAM Q100 or equivalent.

13.1.27 Power Quality Measurement Parameters

13.1.28 Power Quality Meter Operational measured quantities, Power, Energy, Flicker, MSV Harmonics / Inter harmonics, harmonics power, Data availability and Display list shall be not less than SICAM Q100.

13.1.29 Graphical Analysis

a. Per phase individual harmonic bar graph representation.
b. Real time vector representation of all 3 Phases for complete system analysis.

13.1.30 Alarms, set point triggers, input and output events can be stored in a 150-event record and time and date stamped by the internal clock. This is useful for diagnosing problems and system activity. Minimum and maximum values are also continuously updated, and time stamped.

13.1.31 Wiring/Cabling Requirements

13.1.32 Required cabling / wiring shall be done by bidder with adequate size of cable/wires.

13.1.33 The Power Quality Meter shall be capable of storing the following Logs for period of 1 month minimum.

- Energy Log
- Data Log
- Min/Max log
- Load Factor Log
- Time of Use Log
- Event Log
- Set point Log
- Alarm Log

13.1.34 Power Quality Meter shall be capable of communicating over Ethernet/IP Network and shall have internal web pages for configuration, real time data viewing, diagnostics and maintenance.

13.1.35 The power quality meter shall have virtual wiring correction capability to correct wrong wiring during commissioning.

13.1.36 Power Quality Meter shall have display to provide visualization for data and shall include:

- Real Time viewing of voltage, current, power, demand.
- Accumulated Energy and Time of Use readings
- Flicker readings in Instantaneous, Short Term (PST), and Long Term (PLT).
- Alarm conditions.
- Phasor analysis.
- Harmonic spectrum analysis and waveform scopes for both voltage and current.
- Real Time trending.
- Log status.
- Configuration settings.
- Time of Use.
- Test Mode

13.1.37 The power quality meter shall provide the following accuracies. Accuracies shall be measured as percentage of reading at standard meter test points.

- Power meter shall meet Class 0.2S accuracy requirements according to IEC 62053-22.
- Voltage accuracy shall be within less than 0.05% for the one-second reading and less than 0.1% for 100-millisecond reading.
- Current accuracy shall be within less than 0.025% for the one-second reading and less than 0.1% for the 100-millisecond reading.
- Frequency shall have a display resolution accuracy of less than 0.01 Hz for the one-second readingand less than 0.03 Hz for the programmable 2-20 cycle readings.
- The meter shall have an internal precision real time clock providing max accuracy at full Temperature range to 3.5 ppm, or less than 10 seconds per month drift.

13.1.38 Energy management minimum features shall be as per below:

- Active, reactive and apparent power and energy
- 4 Quadrant Power - consumption and delivery/inductive and capacitive etc.

13.1.39 The power quality meter shall have calibration components that include.

- Precision internal references with real-time auto calibration for voltage and current channels
- The ability to self-calibrate at a rate not longer than every ten seconds, for the life of the Meter.
- The meter must stabilize its readings once "out of the box" and connected, within 10 seconds

13.1.40 The power quality meter shall have 16-bit Waveform and Fault Recorder.

- The meter shall record up to 1024 samples per cycle continuously on all 8 channels simultaneously, and transient captures sensitive to at least 800,000 samples per cycle.
- The meter shall perform voltage and current recording with pre and post-event analysis when a waveform limit is exceeded. Pre and post-events shall be configurable to up to 179 cycles.
- Fault recording shall offer 8 times full scale capture capability.
- The meter shall allow viewing of Harmonic magnitudes to the 511th order. Real time Harmonic magnitudes shall be resolved to the 127th order. The meter's Harmonic measurement shall fully comply with the IEC 61000-4-7 standard.
- Percent THD and K-factor shall be calculated by the meter.
- The Power Quality meter shall be class-A.

**13.2 Drawings, Data and Manual**

13.2.1 The following drawing, data and manual to be submitted after award of contract.

- Technical data sheets
- Dimensional general arrangement drawing
- Interconnection / wiring diagram
- Catalogues / drawings.
- Quality plan
- Test certificates
- O&M manual

**13.3 Tests**

13.3.1 Each complete unit shall undergo routine testing. The list of Routine tests to be performed in the factory shall be as per IEC/IS standard.

13.3.2 The Contractor shall carry out the field-testing of PQMs after installation. The list of field tests shall be as per IEC/IS standard.

a. Type Tests reports / certificates shall be provided by the Bidder and the same shall be valid within last five (05) years.
b. Routine Tests
c. Field Tests

**13.4 Special Tools & Tackles**

- A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.
- The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

## 13.5 Technical Requirements

13.5.1 List of Protection Relays/ units (as applicable) and as required shall be included.

| S.No | Description | ANSI Device Numbers |
|---|---|---|
| 1. | Distance Protection Relay | 21 |
| 2. | Over Excitation Relay | 24 |
| 3. | Synchronizing Relay | 25 |
| 4. | Under voltage Relay | 27 |
| 5. | Thermal Overload Relay | 49 |
| 6. | Instantaneous Overcurrent Relay | 50 |
| 7. | Instantaneous Earth Fault Relay | 50N |
| 8. | IDMT Overcurrent Relay | 51 |
| 9. | IDMT Earth Fault Relay | 51N |
| 10. | Local Breaker Backup Relay | 50LBB |
| 11. | Over Voltage Relay | 59 |
| 12. | PT Fuse Failure Relay | 60 |
| 13. | Pressure Switch Detect | 63 |
| 14. | LV side Restricted Earth Fault Relay | 64RLV |
| 15. | HV side Restricted Earth Fault Relay | 64RHV |
| 16. | Directional Overcurrent Relay | 67 |
| 17. | Directional Earth Fault Relay | 67N |
| 18. | Auto Reclosing Relay | 79 |
| 19. | DC Fail Relay | 80 DC |
| 20. | AC Fail Relay | 80 AC |
| 21. | Master Trip Relay | 86 |
| 22. | Busbar Differential Protection Relay | 87B |

| S.No | Description | ANSI Device Numbers |
|---|---|---|
| 23. | Line Differential Protection Relay | 87L |
| 24. | Transformer Differential Protection Relay | 87T |
| 25. | Trip Circuit Supervision Relay | 95 |
| 26. | Over Fluxing Relay | 99 |
| 27. | Bay control unit | BCU |

### 13.6 Protection Requirements (As applicable)

13.6.1 The Bidder shall furnish, install and co-ordinate the settings of all relays to suit the requirements of protection, operation and interlocks.

13.6.2 Required protections have been generally indicated hereunder for Bidder's reference.

13.6.3 The hardware design for the protection and associated equipment shall use latest state-of-the-art technology and shall be numerical, modular in nature. Where design is based on microprocessor technology adequate self-testing/ monitoring/diagnostic facilities shall be provided.

13.6.4 The relays shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.

13.6.5 The relays shall function satisfactorily being located indoors in non-AC physical environment.

13.6.6 Relay characteristics shall be coordinated for proper functioning in conjunction with associated relays.

13.6.7 All protections shall be furnished complete with necessary auxiliary, supervisory, lock-out etc. relays. Suitably separate sets of single phase auxiliary CT/PT with multiple taps shall be provided with relay whenever required.

13.6.8 Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.

13.6.9 DC circuits shall be supervised by relays.

13.6.10 Tripping shall be done through high-speed lock-out relays.

13.6.11 All relay panels shall be installed inside the Air-conditioned control room which will be located in the Substation.

**Line Protection**

**GENERAL REQUIREMENT FOR THE LINE PROTECTION (AS APPLICABLE)**

13.6.12 The line protection relays shall protect the line and clear online in the shortest possible time with reliability, selectivity and full sensitivity to all types of line fault. The general concept for 132 KV level is to have primary and back-up protection systems having equal performance requirement especially in respect of time as would be provided by two main Protections called Main- I and Main- II. It is desirable that Main- I and Main- II protection should work on two different principles of operation.

13.6.13 The signals from the protective relays shall trip all the three poles. Trip impulses shall go to both the trip coils simultaneously thru' separate potential free contacts.

**NUMERICAL DISTANCE PROTECTION RELAY (21)**

a) The relay shall be numerical type and shall have continuous self-monitoring and diagnostic features.

b) The relay shall be non-switched type with separate measurements for all phase to phase and phase to ground faults.

c) The relay shall have stepped time-distance characteristics and three independent zones (Zone- 1, Zone- 2 and Zone- 3).

d) The relay shall have mho or quadrilateral or other suitably shaped characteristics for Zone- 1, Zone- 2 and Zone- 3.

e) The relay shall have an adjustable characteristics angle setting range of 30-75 Deg. or shall have independent resistance (R) and reactance (X) setting.

f) The relay shall have two independent continuously variable time setting range of 0-3 seconds for Zone- 2 and 0-5 seconds for Zone- 3.

g) The relay shall have resettling time of less than 55 milli-seconds (including the resetting time of trip relays).

h) The relay shall have facilities for offset features with adjustable 10-20% of Zone- 3 setting.

i) The relay shall have variable residual compensation.

j) The relay shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault.

k) The relay shall have a weak end in-feed feature.

l) The relay shall be suitable for single and three phase tripping.

m) The relay shall be suitable for use in permissive under reach/ overreach/ blocking communication mode.

n) The relay shall have a suitable number of potential free contacts for Carrier aided Tripping, auto re-closing, and Data acquisition system/SMS interfacing.

o) The relay shall have a suitable setting range to encircle the distance protection described above.

p) block tripping during power swing conditions.

**DIRECTIONAL OVER CURRENT (67) & EARTH FAULT PROTECTION RELAY (67N)**

a) The relay shall have three over current and one earth fault element(s) which shall be either independent or composite units.
b) The relay shall be numerical type.
c) The relay shall include the necessary VT fuse failing relays for alarm purposes.
d) The Directional Over Current Relay shall have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting.
e) The relay shall have a variable setting range of 50-200% of rated current.
f) The relay shall have a characteristic angle of 30/34 degree lead.
g) The Directional Earth Fault Relay shall have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting.
h) The relay shall have a variable setting range of 20-80% of rated current.
i) The relay shall have a characteristic angle of 45/60 degree lead.

**AUTO RE-CLOSING RELAY (79)**

a) The relay shall be Numerical type.
b) The relay shall have single phase or/and three phase reclosing facilities.
c) The relay shall have a continuously variable single phase dead time range of 0.1 – 2 seconds.
d) The relay shall have a continuously variable three phase dead time range of 0.1 – 2 seconds.
e) The relay shall have a continuously variable reclaim time range of 5-25 seconds.
f) Incorporate a four-position selector switch from which single phase/three phase/single and three phase auto reclosure and non- auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through programming.
g) The relay shall have facilities for selecting check synchronizing or deadline charging features. It shall be possible at any time to change the required feature by reconnection of links.
h) The relay shall be of single shot type.
i) The relay shall have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers.
j) Include check synchronizing relay which shall
    i. have a time setting continuously variable between 0.5 – 5 seconds, with a facility of additional 10 seconds.
    ii. have a response time within 200 milliseconds with the timer disconnected.
    iii. have a phase angle setting not exceeding 35 degree.
    iv. have a voltage difference setting not exceeding 10%.

k) include deadline charging relay which shall have two sets of relays and each set shall be able to monitor the three phase voltage where one set shall be connected to the line CVTs with a fixed setting of 20% of rated voltage and the other set shall be connected to the bus CVTs with a fixed setting of 80% of rated voltage.

**LINE OVER VOLTAGE PROTECTION RELAY (59)**

a) The relay shall be numerical type.
b) The relay shall monitor all three phases.
c) The relay shall have two independent stages and stage-1 relay is acceptable as built in with line distance relay.
d) The relay shall have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage.
e) The relay shall have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 milli seconds for the second stage.
f) The relay shall be tuned to power frequency.
g) The relay shall be provided with separate operation indicators (flag target) for each stage relay.
h) The relay shall have a drop-off to pick-up ratio greater than 95%.
i) provide separate out-put contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirements.

**DISTANCE TO FAULT LOCATOR (21FL)**

a) The relay shall be numerical type.
b) The relay shall be electronic or microprocessor-based type.
c) The relay shall be 'On-line' type.
d) The relay shall be suitable for breaker operating time of 2 cycles.
e) The relay shall have built-in display unit.
f) The display shall be directly in percentage of line length or kilometers without requiring any further calculations.
g) The relay shall have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays.
h) The above accuracy should not be impaired under the following conditions.
i) Presence of remote end in-feed.
j) Predominant DC component in fault current.
k) High fault are resistance

l) shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

m) built in feature of time distance relay is acceptable provided the requirements of above clauses are met.

**BUS BAR PROTECTION (87BB)**

13.6.14 Bus Bar protection scheme decentralized type shall be provided for each main bus and Transformer bus of EHV system. This shall constitute main and cross differential features and shall be engineered such that operation of both main & check features connected to faulty bus shall result in tripping of the same. The scheme shall be provided with the necessary expansion capacity and interfaces for adding features when the Substation is extended in future to its ultimate capacity.

a) The relay shall be of modular construction and have features of a self-monitoring facility to ensure maximum availability. Relay shall be numerical biased differential type with operating and restraining feature.

b) The relay shall have maximum operating time up to trip impulse to trip relay for all types of faults of 15 milliseconds at 5 times setting value.

c) Operate selectively for each bus bar.

d) Provide hundred percent security up to 40kA 3 Sec fault level for 132 KV system.

e) Incorporate check feature.

f) Incorporate continuous supervision of CT secondaries against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate alarm.

g) The relay shall be of phase segregated and triple pole type and provide independent zones of protection for each bus (including transfer bus if any). If a bus section is provided, then each side of the bus section shall have separate busbar protection scheme.

h) Not give false operation during normal load flow in busbars.

i) Incorporate clear zone indication.

j) include high speed tripping relays (hand reset type) and all other auxiliary relays having adequate contacts as required to make a comprehensive scheme and other functions like disturbance recorder, event logger etc.

k) Include continuous DC supplies supervision.

l) Avoid CT switching.

m) The relay shall have necessary auxiliary relays to make a comprehensive scheme.

n) No ICT shall be used for CT Ratio Correction

o) The bus bar protection scheme offered shall be furnished by the Bidder along with it's bid.

**BREAKER FAILURE PROTECTION RELAY (50LBB)**

a) The relay shall be numerical type.
b) The relay shall be triple pole type.
c) The relay shall be of solid-state type.
d) The relay shall have an operating time of less than 15 milli seconds.
e) The relay shall have a resetting time of less than 15 milli seconds.
f) The relay shall have three over current elements.
g) The relay shall be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer, reactor equipment protections.
h) The relay shall have a setting range of 20-80% or rated current.
i) The relay shall have a continuous thermal withstand two times rated current irrespective of the setting.
j) The relay shall have a timer with a continuously adjustable setting range of 0.1-1 seconds.
k) The relay shall have necessary auxiliary relays to make a comprehensive scheme.

**TRANSFORMER DIFFERENTIAL RELAY (87)**

a) High speed percentage Differential relay with harmonic restraint shall be provided for Transformer differential protection.
b) The relay shall have a high set instantaneous trip attachment for clearing.
c) heavy internal fault.
d) The relay shall be capable of compensating mismatch due to CT saturation during heavy through fault and to ensure stable operation.
e) The harmonic restraint feature shall ensure its stability on magnetising inrush without sacrificing its speed of operation for internal fault.
f) For transformer with On-load tap changer, relay characteristic shall be such that relay setting need not be changed between extreme tap positions.

**RESTRICTED EARTH FAULT RELAY (64R)**

a) Restricted ground fault protection shall be used to guard against ground fault in earthed neutral transformer.
b) The relay shall be instantaneous high stability circulating current type.
c) The relay shall be unaffected by uneven CT saturation during through-fault or by presence of DC component in the fault current.

**IDMT O/C & E/F RELAY (51 & 51N)**

a) A set of phase and ground O/C relays shall be furnished as specified to act as a back-up of main protection.

b) The relays shall have inverse definite minimum time current characteristics with adjustable settings as follows: -

Ground fault current - 10 to 40%

Phase over current - 50 to 200%

c) Where specified, the over current relay shall be provided with a high set instantaneous unit (50) with a range of 500-2000%.

d) As an alternative to IDMT relays Bidder may also offer Definite time delay relays.

**OVER FLUXING RELAY (24V/F)**

13.6.15 The relay shall operate on the principle of measurement of voltage to frequency ratio. The relay inverse time characteristic shall be compatible with transformer over fluxing withstand capability, for tripping. Independent alarm shall be provided with delay on actuation.

13.6.16 1st set of time delay unit should give alarm and 2nd set of time delay unit is to trip the main and tie breaker. Necessary auxiliary relays as required to complete the scheme shall be provided.

**TRIP SUPERVISION RELAY (96)**

13.6.17 The relay shall be capable of monitoring the healthiness of each 'phase' trip circuit of circuit breaker during 'ON' and 'OFF' conditions.

a) The relay shall be numerical type/ static.

b) The relay shall have adequate contacts for providing connection to alarm and event

c) The relay shall have time delay on drop-off of not less than 200 milli seconds provided with operation indications for each phase.

d) These supervision relays shall be fed from two separate DC sources.

**LOCKOUT RELAY (86)**

13.6.18 Lockout relays shall be fast operating, hand reset type with multi-contacts for a number of switching operations.

13.6.19 The relays shall be designed for a high degree of mechanical stability and shall have heavy duty contacts. 12 NO + 6 NC minimum contacts shall be furnished per relay.

**LOCKOUT SUPERVISION RELAY/ALARM RELAY (74)**

13.6.20 Each lockout relay circuit shall have supervision relay which will initiate alarm in case of any trouble in lockout circuit/relay.

13.6.21 This relay shall be properly co-ordinated with the characteristic of lockout relay to prevent any mal operation.

**VT SUPERVISION RELAY (60)**

13.6.22 Each core of VT shall be provided with three poles under voltage relays for fuse failure supervision. Alarm shall be initiated on failure of any VT core, Mal- operation shall be prevented in the event of a fuse blowout.

**DC SUPPLY SUPERVISION RELAY (80DC)**

13.6.23 The relay shall be capable of monitoring the failure of DC supply to which, it is connected.

13.6.24 It shall have adequate potential free contacts to meet the scheme requirement.

13.6.25 The relay shall have a time delay on drop-off of not less than 100 milli seconds and be provided with operation indicator/flag.

**FLAG RELAYS**

13.6.26 These shall have

a) hand reset flag indication.

b) have a minimum of two contacts (NO or NC or combination as required) for each relay.

**DISTURBANCE RECORDER**

13.6.27 The disturbance recorder shall contain the following features:

a) Automatic or on-request collection of data

b) Data compression technique

c) Calculation of distance to the fault

d) Versatile digital disturbance recorder module for recording various phenomena in the electric power system, especially during fault conditions.

e) Can be plugged into the location of any protection relay module.

f) No separate wiring for measuring signals or power supply needed because the recorder module is energized and powered from the host relay.

g) Fully self-contained recorder module, no protection relay modules needed for the function.

h) A total of eight analog channels and eight digital channels can be supervised by one disturbance recorder module.

i) Total recording length 12 seconds, when all channels are recorded, extendable to 55 seconds.

j) Increased recording capacity by reducing the number of channels recorded.

k) The total recording time can be divided into shorter parts.

l) Triggering by over current, over voltage, under voltage or by rising or falling edge of a binary signal.

m) Triggering also possible via a serial communication command given manually with push buttons on the front panel or automatically at certain time intervals.

n) Time-tagged events obtained from a built in real-time clock with battery back-up.

o) The history part of the recording, that is the part preceding triggering, can be set within 0...100% of the total recording time.

p) Maximum and minimum values of voltages and currents recorded in a separate limit value register.

q) Events such as triggering, exceeding of limit values and changes in binary signal status are recorded in a log register.

r) Settings and data recorded can be downloaded via the RS 232 port of the module or via the SPA interface of the host relay

s) Settings and recordings retained during an auxiliary supply failure.

t) Easy-to-use PC software available for setting recorder parameters, reading recorded data and printing out recordings.

13.6.28 Laptop and Synchronizing Trolley Requirements

13.6.29 Laptop industrial grade configuration shall have followed as minimum feature:

- Intel core i5 (minimum) 3MB Cache (minimum)
- 8GB DDR3 RAM (minimum) 500 GB HDD (minimum) DVD+/- RW
- 14.0 inch HD
- Intel HD Graphics 3000 Multimedia
- LAN
- Modem
- Speakers
- Dual Pointing Device (Touch Pad & Track Stick) Deluxe Carry Case
- Port: Advance RS485 with Null Modem Cable (RJ-45, RJ-11) Serial Parallel, Keyboard/ Mouse
- External Monitor: Audio/IO, Infra-Red 6 Hrs batteries backup.
- Operating System, Microsoft (latest licensed Version) Antivirus (latest licensed Version)

13.6.30 Synchronizing Trolley

| **Description** | **Quantity** |
|---|---|
| Double Voltmeter | 1 |
| Double Frequency meter | 1 |
| Synchroscope | 1 |
| Lamp for bright lamp synchronization | 2 |

| | |
|---|---|
| Reversing VT | 1 |

Note: This list is indicative and meant for general guidance of the bidder only.

# 14. Tariff Metering Panels

## 14.1 Intent of Specification

14.1.1 This specification is intended to cover the Design, Engineering, Manufacture, Assembly, Inspection, Erection, Testing and Commissioning of the Tariff Metering Panels.

14.1.2 The Bidder shall submit the detailed design calculations, GTP and drawings, bill of materials and their specifications / standards to the Owner for approval before manufacturing commencement.

14.1.3 All design calculations, GTP and drawings shall be submitted to the Owner for approval before execution.

## 14.2 Scope of Work

14.2.1 The scope of work shall include the following equipment.

a) Tariff meters for 132kV Transmission between 25MW/100MWh BESS Power Plant and Kukurmara (Mirza) Grid Substation. However as per CEA Regulation on "Installation and Operation of Meters" Regulations 2010, Clause no. 2 (b), Contractor shall finalize the scheme with concerned competent authorities (CEA, CTU, CTUIL. POSOCO, NERLDC, STU, DISCOM's, CEI, etc.) and number of meters and its locations shall be as per the approval given by the competent authority.

## 14.3 Codes and Standards

14.3.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards, CEA metering regulations and CBIP publications including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards and publications are listed below:

| Standard | Description |
|---|---|
| IS 14697 | Specification for AC static transformer operated watt-hour and var-hour meters, Class 0.2S and 0.5S |
| CBIP Technical Report – 88 | Specification for AC static electrical energy meters |
| CBIP Technical Report – 111 | Specification for common meter reading instrument |
| IS 9000 | Basic environmental testing procedures for electronic & electrical items |
| IS/IEC 60529 | Degrees of protection provided by enclosures |
| IEC 62053-61 | Electricity metering equipment (A.C.) |

a) CEA Installation and Operation of meters Regulations 2006, 2010, 2014, 2019 and 2022.
b) CEA Report on SAMAST (Scheduling, Accounting, Metering and Settlement of Transaction) in Electricity -July 2016.
c) POSOCO, Technical Specification for Interface Energy Meters, Automated Meter Reading System and Meter Data Processing for Inter State System in Western Region as approved in 34th TCC/WRPC meeting held on 28 July 2017.
d) Guidelines on Cyber Security in Power Sector 2021-1, Dated 7-10-2021
e) Any other applicable Codes and standards

**14.4 Technical Requirements**

14.4.1 Tariff metering systems shall meet the requirements of NERLDC, NGEAL, AEGCL, APDCL, etc.

14.4.2 The meter shall be dual power supply with provision of both AC and DC.

14.4.3 The meter shall have hot swappable meter modules with automatic shorting of external current transformers.

14.4.4 The meter shall be equipped with Dynamic error compensation for external current and voltage transformers.

14.4.5 The meter current and voltage range shall be configurable at field level and shall be capable of measuring total harmonic distortion (THD) for current and voltage.

14.4.6 The meters shall be 3-phase, 4 wire, 0.2s accuracy class static electronic tri-vector energy meters with ABT compatibility. Following tariff meters shall be provided in the tariff metering panel.
a) Standby meter for 132 kV Transmission line at PSS

14.4.7 Tariff metering panel for 132kV system shall be installed in the common metering panel (in one or more metering panels as per requirements) and shall be located in relay panel room or as approved by the competent statutory authority.

14.4.8 The panel shall be made of cold rolled sheet steel of thickness not less than 2mm. The panel shall be of double door with front toughened glass. Degree of protection shall be at least IP 54 (minimum). The panel shall be complete with door limit switch operated cubicle lighting

14.4.9 5A switched power socket, hygrostat-controlled space heater, terminal block, panel earth bus, body earth pads, sealing arrangement etc. Make of enclosure shall be Rittal or equivalent make.

14.4.10 All wiring shall be carried out with 1100V grade stranded 1.5 sq. mm (minimum) copper conductor wires with PVC insulation. For current transformer (CT) and voltage transformer (VT) circuits 2.5 sq. mm (minimum) copper conductor wire with PVC insulation shall be used. Wiring shall be colour coded.

14.4.11 Terminal blocks shall be clip-on type 600V grade, 10A rated stud type terminals with markings. Terminals for VT secondary leads shall be stud, disconnecting type. CT secondary leads shall be provided with short circuiting and earthing facility.

14.4.12 At least 20% spare terminals shall be provided for each terminal station and each type of TB. CT / VT test terminals shall be provided separately.

14.4.13 The main meter, standby meter and the check meter (if applicable) shall be connected to same core of CT and VT.

14.4.14 The energy meters shall be capable of receiving periodic time synchronization signals via proper online system. The meter time shall be in synchronism with GPS time master system. Time synchronization shall be carried out by NTP, and it shall be synchronized with the master time clock. Necessary hardware and software shall be provided for the same.

14.4.15 The accuracy class of main meter, check meter and standby meter shall be of 0.2s class.

14.4.16 The accuracy class of current transformers (CTs) shall be 0.2s class and voltage transformers (VTs) shall be 0.2 class.

14.4.17 The meter shall be immune to external influences like magnetic induction, vibration, electrostatic discharge, switching transients, surge voltages, oblique suspension, and harmonics and necessary tests shall be carried out in accordance with relevant standard.

14.4.18 The meters shall safely withstand the usual fluctuations arising during faults etc. as per IS 14697. The immunity to external magnetic field shall be strictly as per latest CBIP recommendations.

14.4.19 Lead cables of CTs and VTs shall be of sufficient cross-section for reducing voltage drop to minimum between end connections (connection between cable lead end and CT / VT terminal as well as between cable lead end and meter terminal). No joints and or intermediate junction boxes (lead wires from instrument transformer secondary terminal box shall be directly terminated to metering panel) shall be allowed in lead cables. The burden on metering cores of CTs and VTs including burden of lead cable and meters connected thereto shall not exceed rated burden. The CT wiring shall be of 6 wire type (i.e. Not 4 wire type) ABT metering system shall be compliant to CEA Guidelines on Cyber Security in Power Sector 2021-1, Dated 7-10-2021.

### 14.5 Functional Requirements

14.5.1 The meter must perform four quadrant measurements. The interface meters suitable for ABT shall be static type, composite meters, as self-contained devices for measurement of active and reactive energy, and certain other parameters as described. The meters shall be suitable for being connected directly to VTs having a rated secondary line-to-line voltage of 110V and to CTs having rated secondary current of 1A. The reference frequency shall be 50Hz.

14.5.2 The active energy (watt-hour) measurement shall be carried out on 3-phase 4-wire principle with accuracy as per class 0.2S of IEC-687 / IEC-62053-22. The VAR and reactive energy measurement shall also be on 3 phase 4 wire principle with accuracy as per class 0.2 of IEC 62053-22 or better.

14.5.3 The meter shall be compatible with time of the day (TOD) tariff. For TOD tariff, meter shall have the provision to define maximum eight (8) TOD registers for different energies.

a) The meter shall continuously monitor and calculate the average demand in KVA during the integration period and maximum out of these shall be stored along with date and time in the meter's memory. The integration period shall be Site programmable for 5/15/30/60 minutes or as per regulatory requirements on real time basis on block / sliding window principle that shall also be programmable. The meter shall also display maximum demand (MD) reset count.

b) The MD resetting shall be possible in any of the following ways: Automatic reset on a predetermined date and time of the months Resetting through a hand held terminal or computer capable of communicating with the meter with password protection Meters shall be suitable for working under balanced / unbalanced loads at all power factor as specified in the relevant IS. The display shall indicate direct values without having to apply any multiplying factor.

14.5.4 The meter shall also store the apparent energy (import and export) and cumulative energy. Registers of the same shall be made available on display as well as on Base Computer Software (BCS) (BCS to be supplied by bidder).

14.5.5 There shall be provision for self-check and diagnosis at regular intervals. The meter shall have indication for unsatisfactory functioning of the following:

a) Time and calendar

b) Real time clock battery

c) All display parameters

d) Non-volatile memory

14.5.6 There shall be programmable facility to restrict access with three level passwords.

14.5.7 On any programme change, the meter shall reset itself to zero and the previous information shall be stored in the non-volatile memory.

14.5.8 There shall be provision for access to the meter by a computer (desktop, PC or laptop) and remote reading or data storage via communication system.

14.5.9 The meter shall log the time and date of all programme changes in a billing period.

14.5.10 The metering system shall be compatible with suitable BCS.

14.5.11 The meters shall have following facilities:

a) Communication port: Two RS 485, RS 232 & front optical port and all communication ports of meter shall be available for simultaneous uninterrupted communication.

b) Load survey capability

c) Missing potential indication in case of failure of potential at the meter incoming terminal.

d) Provision for telemetering using common protocol.

e) Provision for collection of data by meter reading instrument (MRI)

f) Provision for time synchronizing facility from external clock. Provision for correcting real time by MRI.

g) Sliding integration window/block integration

h) Real time clock

i) Non-volatile memory for 35 days

j) Test output device in the form of a pulse indicator accessible from the front and capable of being monitored by suitable testing equipment

k) CT/VT error compensation

14.5.12 Transformers / transducers required for their functioning shall be in-built in the meters. Necessary isolation and / or suppression shall also be built-in for protecting the meters from surges and voltage spikes that occur in the VT and CT circuits of extra high voltage Substations.

14.5.13 The active energy (watt-hour) meter shall display on demand the export / import energy during programmed integration block (As per prevailing regulation 15 min).

14.5.14 Further the meter shall continuously integrate and display on demand the export / import cumulative active energy sent out / in from / to the substation bus bars up to that time in export and import register. The cumulative energy reading at each midnight shall be stored in the meter memory in respective registers. There shall be separate register for export and import.

14.5.15 The meter shall count the number of cycles in VT output during each successive 15 minutes block and divide the same by 900 to arrive at the average frequency (truncated to second place of decimal). This shall be stored in the meter's memory. The average frequency of the previous programmed integration period (As per prevailing regulation 15 min) shall also be displayed on demand in hertz.

14.5.16 The meter shall continuously compute the average of the root mean square (RMS) values of the three line to neutral VT secondary voltage as a percentage of 63.51V and display the same on demand.

14.5.17 The reactive energy (VARh) meter shall store the values in different registers as below:

a) Above 103% voltage: reactive energy import & export

b) Below 97% voltage: reactive energy import & export

c) Reactive energy import with active energy import

d) Reactive energy import with active energy export

14.5.18 Each meter shall have a test output device (visual) for checking the accuracy of active energy (watt-hour) measurement. The preferred pulsing rate is twenty and four per watt-hour for 1A and 5A CT respectively. It shall be possible to couple this device to suitable testing equipment also.

14.5.19 The accuracy of the meter shall not be affected by harmonics circulating in the system of magnitudes within permissible limits stipulated by CEA Grid Standards and Regulations. The meter shall indicate and record the total resultant quantities of fundamental frequency and harmonics or alternatively the

meter shall record fundamental frequency quantities and harmonics related quantities (such as MWh, MVAh and MVARh) separately. Only fundamental frequency values shall be used for billing purpose.

14.5.20 The meters shall normally operate with auxiliary power and shall have an automatic change over system to draw power from the VT secondary circuits in the case of failure of auxiliary power. The total burden imposed by a meter for measurement and operation shall not exceed 10VA on any of the phases. An automatic back up to continue operation of the meter's calendar clock, and for retaining all data in its memory, shall be provided through a long life battery, which shall be capable of supplying the required power for at least two (02) years. The meters shall be supplied duly fitted with the batteries, which shall not require to be changed for at least ten (10) years, as long as total VT supply interruption does not exceed two (02) years. The meters shall does not require any separate auxiliary supply for their operation. All displays may disappear on loss of VT supply. Each meter shall have a built-in calendar and clock having an accuracy of one minute per year or better. The calendar and clock shall be correctly set at the manufacturer's works. The date (day-month-year) and time (hour-min-sec) shall be displayed on the meter front (when VT supply has been connected), on demand. Only limited clock adjustment shall be possible at Site, using the data collection device (DCD). When an advance or retard command is given, six subsequent time blocks shall be contracted or elongated by ten seconds each. The meter shall not accept another clock correction command for seven days. All clock correction shall be registered in the meter's memory and suitably shown on print out of collected data. Each meter shall have a unique identification code, which shall be marked permanently on its front, as well as in its memory. Each meter shall have at least one nine (9) character, nine-segment electronic display, for indication of the various parameters (one at a time), on demand. A touch key or push button shall be provided on the meter front for switching on the display and or changing from one indication to the next. The display shall switch off automatically about one minute after the last operation of touch key / push button. When the display is switched on, the parameter last displayed shall be displayed again.

14.5.21 The three line-to-neutral voltages shall be continuously monitored, and in case any of these falls below 70%, the condition shall be suitably indicated and recorded.

14.5.22 In case of installation of check meter also, this shall be identical to main meter and shall be connected in same core of CT and VT.

14.5.23 Each meter shall have an optical port on its front for tapping all data stores in its memory. Portable or handheld data collection devices shall also be separately provided for this purpose, to serve as the interface between the meters specified above and the local personal computer (PC). The overall intention is to tap the data stored in the meter's memories once in a month and transmit the same to a Substation automation system / control room using communication links, through the local PC. It's all also be possible to obtain a printout (hard copy) of all data collected from the meters using the

local PC. The whole system shall be such as to provide a printout (both from the local PC, and from Substation automation system / control station) in an easily understandable / self-explanatory format. All meters of the same model shall be totally identical in all respects except for their unique identification codes. They shall also be totally sealed and tamper-proof, with no possibility of any adjustment at Site, except for clock correction.

14.5.24 The meters shall also withstand without any damage any mal-operation, reasonable mechanical shocks, earthquake forces, ambient temperature variations from –20°C to 55°C, relative humidity etc. They shall have an IP 51 category dust tight construction and shall be capable of satisfactory operation in an indoor, non-air conditioned installation.

14.5.25 Portable / hand-held data collection devices (DCD) shall be tailor-made for tapping all data stored in a meter's memory and faithfully transferring it to the local PC. Each device shall at least comprise of the following:

a) A lead with optical head for coupling it to the meter
b) A lead for plugging it to a personal computer
c) An internal battery for powering the devices
d) A case for safely carrying it about
e) A battery charger

The total arrangement shall be such that one (1) operator can carry out the whole operation himself, in a quick and reliable manner.

14.5.26 The meters shall continue to function, as specified above, in case of failure of one or two phases of VT supply. In case of a complete supply failure, the computation of average frequency shall be done only for the period during which the VT supply was available in the programmed integration period (As per prevailing regulation 15 min). Any time block contraction or elongation for clock correction shall also be duly accounted for.

14.5.27 Load Survey Capability: -

a) It shall be possible to store previous minimum 35 days data regarding energy consumed (programmed integration period (As per prevailing regulation 15 min) minutes blocks), demand and frequency. That is load survey is needed for the demand and energy consumed in every MD integration time cycle (programmed integration period (As per prevailing regulation 15 min)). The demand to be recorded in the load survey shall match with the recorded in DISPLAY PARAMETERS. The demand and energy consumed as discussed shall be recorded separately under energy import / energy export within a programmed integration period (As per prevailing regulation 15 min) minutes time block. It shall be possible to download and view parameters and load survey data on computers and obtain full details of demand and consumption in statement form and also in graphic form. Necessary software for various programmable features to obtain various details shall

be provided by the supplier. The software shall include provision for load survey graphic presentation and other reports generation in BCS from the data collected from the meter through meter reading instruments. Each of the metering system shall measure and display on demand the following quantities / parameters on demand:

b) Meter Serial No.
c) LCD segment check
d) Real Time: HR:MT
e) Date dd/mm/yy
f) Rising Demand in KVa
g) Maximum demand in kW and kVA (export / import)
h) Cumulative active energy import
i) Cumulative apparent energy import (kVAh)
j) Last 15 minutes block average of the active power / load import
k) Cumulative active energy export
l) Cumulative apparent energy export (kVAh)
m) Last 15 minutes block average of the active power / load export
n) Instantaneous three phase average power factor with sign / display / legend for lag / lead.
o) Instantaneous Phase Voltage (R Phase, Y Phase & B Phase)
p) Instantaneous Line Currents (R Phase, Y Phase & B Phase)
q) Instantaneous Frequency
r) Phase Sequence of voltages
s) Instantaneous Active Load in
t) Instantaneous Reactive Load in WVAR
u) Cumulative VARh injection when, average voltage (RMS)>103%Vn
v) Cumulative VARh drawal when, average voltage (RMS)>103%Vn
w) Cumulative VARh injection when, average voltage (RMS) < 97%Vn
x) Cumulative VARh drawal when, average voltage (RMS) < 97%Vn
y) Cumulative VARh (lag), when watt-hour is import
z) Cumulative VARh (lead), when watt-hour is import
aa) Cumulative VARh (lag), when watt-hour is export
bb) Cumulative VARh (lead), when watt-hour is export

A key shall be provided on the meter front for switching on the display and for changing from one indication to the next.

14.5.28 ABT meters shall have minimum ten (10) years of Guarantee directly to the Owner.

14.5.29 EPC contactor shall finalize the scope of supply of Meters for PSS end 132 KV Transmission line with CTUIL/POSOCO/ NERLDC. If scope of supply is of CTUIL/POSOCO/ NERLDC than metering panel shall be proposed and designed suitably to accept meters supplied by CTUIL /charges, expense etc. is to be borne by Contractor).

14.5.30 ABT Meter shall be manufactured with specific Serial Numbers allotted by Concerned Authority (CTUIL/ NERLDC / POSOCO/STU etc.). Serial numbers for all meters of PSS including spare meters and that of spare feeders are to be obtained by Contractor and communicated to OEM before commencement of manufacturing. Serial numbers are to be obtained by Contractor from the concerned authorizes.

14.5.31 Contractor shall provide following in metering panel.

a) For 132 kV side common metering panel or panels, arrangement and space for providing 03 nos. (Three numbers) of ABT meters along with required mounting, CT/PT wiring, TTB, TB's, space for modem its antenna etc. (i.e. ABT meter and its modem shall be plug and play for future use.

b) Cut out for the meters (if any) shall be properly blanked with required arrangements for good aesthetic look. ABT Meter Software shall be compatible with MDP software's of concerned authorities and "dummy data file" of each ABT meter is to be furnished well in advance as a part of FTC compliance.

c) Contractor shall line up this with the OEM of the meter at ordering stage. Each ABT meters shall be provided with AMR faculty (Automated Meter Reading or Remote Metering) with GPS and GPRS Modem, along with its supply adaptor and antenna, software's/ driver etc. Required SIM card of the meters are to be arranged by Contractor with one-year subscription.

14.5.32 Meter panel shall have provision of dedicated 230 V UPS supply for each ABT meter for future requirements. UPS supply shall have separate MCB with signalling contact integrated to SCADA/SAS.

14.5.33 Auxiliary supply of each ABT Meter shall be from two sources (220 V DC Main-1 and 220 V DC-Main-2) with selection scheme. Each meter shall have dedicated MCB with its trip status monitoring at SCADA as well as at local annunciator.

14.5.34 In case of non-availability of auxiliary and PT supply, it should be possible to download the data from the meters. Required arrangements / equipment's shall be supplied (At least 3 nos. for PSS).

14.5.35 Auxiliary supply systems of ABT meters are to be monitored (NO Volt relay) in SAS and local annunciator.

14.5.36 Each ABT meter shall have separate / dedicated TTB and shall be connected in such a way that it facilitates testing / checking / removal / replacement activates without affecting other ABT meter connected to same core of CT/PT. TTB shall be of 3 phase-4 wire type. TTB shall be mounted below the meter and in front of the panel. Rear side of TTB shall have tamperproof sealing arrangement. TTB shall be of large size and shall be of SCREW type (Tightening of the screw shall short the CT circuit and loosening will open the current path of CT circuit). CMRI shall be provided with required software, optical probe, communication cable, data cable, carrying case shall be provided. (At least three of CMRI

to be provided for PSS) Two nos. of Laptop (HP / DELL make) with required BCS software, probes, cable and all required accessories to be provided for downloading, configuration and time drift correction of ABT Meters shall be provided. Indication circuit of Tariff metering panel is to be protected with dedicated MCB's.

14.5.37 For 132 KV AIS CT/PT, separate / dedicated terminal box shall be provided with temper proof sealing arrangements.

14.5.38 All ABT meters and all CT/PT's including spare feeder metering system are to be tested at approved NABL accredited laboratory in presence of CTU/PGCIL/STU/DISCOM and Owners representative at appropriate stage without any expense to Owner.

14.5.39 Spare ABT meters, shall be duly tested at NABL lab, with specific serial numbers allotted by concerned authorities shall be supplied for future use along with associated Modems (Refer GTS for quantity of spare meters).

14.5.40 Site testing and sealing of metering system (ABT meters and CT/PT's, TTB's, Terminal boxes, Panel doors etc.) by concerned authorizes and applicable charges, if any, is in scope of Contractor.

14.5.41 Terminal Block Station (TB's) shall have proper sealing arrangements.

14.5.42 Comprehensive memory mapping and documentation (User manual, testing and commissioning manual etc.) of ABT meters to be provided.

14.5.43 Required software, equipment's with all accessories for ABT Meter configuration at Site shall be provided.

14.5.44 All software's and Meters permanent passkeys (Passwords) of all levels shall be provided.

14.5.45 ABT meters shall be compatible for future regulatory requirements (e.g. Time Block from 15 minute to 05 minute etc.)

14.5.46 Instrument transformers burden, ratio, CT secondary amp (1A or 5A) and accuracy limit factors shall be proposed by Contractor in consolation and approval with concerned authorities at detail engineering stage.

14.5.47 Tariff metering core of 132kV Instrument Transformers (CT's/CVT's or EMVT's) shall have separate sealable, terminal box for secondary connections.

14.5.48 Indication circuit of Tariff metering panel is to be protected with dedicated MCB's.

14.5.49 Flush mounted ABT meters are preferred or over wall / projection mounting. In case projection mounted / wall mounted type meters are used than the metering panel and mounting of the meter requires special consideration and design.

a) Projection / Wall mounted meters are to be installed in the panel in such a way that no part of the meter is projected outside the panel.

b) Wires to Meter terminals TTB etc. shall not be projected outside the panel.

c) Optical port and display of meter, operating control of meters shall be easily accessible for day to day operation.

d) Overall design shall be aesthetically very good and highly functional.

e) Contractor shall extend fullest co-operation to Owner for finalization of design of "projection mounting meter" during detail engineering stage.

f) All ABT meters, Modems, Software's, Drivers, CMRI equipment and all related accessories shall be exactly identical for PSS Package (i.e. of same make and model number, version etc.).

### 14.6 Constructional Requirements

14.6.1 Meters shall be designed and constructed in such a way so as to avoid causing any danger during use and under normal conditions. However, the following shall be ensured:

a) Personnel safety against electric shock

b) Personnel safety against effects of excessive temperature

c) Protection against spread of fire

d) Protection against penetration of solid objects, dust and water in normal working condition

14.6.2 All the materials and electronic power components used in the manufacture of the meters shall be of highest quality and reputed make to ensure higher reliability, longer life and sustained accuracy.

14.6.3 The meters shall be designed with application of specific integrated circuits. The electronic components shall be mounted on the printed circuit board using latest surface mount technology (SMT).

14.6.4 All insulating materials used in the construction of meters shall be non-hygroscopic, non-aging and of tested quality. All parts that are likely to develop corrosion shall be effectively protected against corrosion by providing suitable protective coating.

14.6.5 The meters shall have an operation indication device such as a blinking LED. The operation indicator shall be visible from the front window.

14.6.6 The front surface of meters once mounted in panel shall conform to the degree of protection IP 51 (minimum) for protection against ingress of dust and moisture.

**Sealing of the Meter**

**a)** Proper sealing arrangement shall be provided on the meter to make it tamper-proof and to avoid mishandling by un-authorized person. At least two (2) seals on the body, two (2) seals on terminal blocks and one seal each on maximum demand resetting device and communication ports shall be provided. Meter base and cover shall be tightened from rear side with at least two nos. unidirectional screws so that meter body could not be opened at Site in any case and two nos. sticker seals bearing serial no., which shall not be repeated shall be provided between meter base and cover.

**b)** A tracking and recording software for all new seals shall be provided by the manufacturer of the meter so as to track total movement of seals starting from manufacturing, procurement, storage, record keeping, installation, series of inspections, removal and disposal.

c) The meter shall be totally sealed and tamper-proof with no possibility of any adjustment at Site, except for a restricted clock correction. The harmonics shall be filtered out while measuring Wh, VAR and VARh and only fundamental frequency quantities shall be measured / computed. Polycarbonate or acrylic seals or plastic seals or holographic seals shall be used. Lead seals shall not be used.

**Marking of the Meter**

14.6.7 The marking on every meter shall be in accordance with IS 14697 / IEC 687. The basic marking on the meter name plate shall be as follows:

a) Manufacturer's name and trademark
b) Type designation
c) Number of phases and wires
d) Serial number
e) Month & year of manufacture
f) Reference voltage / VT ratio / frequency
g) Rated secondary current of CT (-/1A or -/5A)
h) Principal unit(s) of measurement
i) Meter constant (impulse/kWh)
j) Class index of meter
k) Text "Property of ....."
l) P.O. No. & Date
m) Guarantee period

**Connection Diagram & terminal Marking**

14.6.8 The connection diagram of the metering module shall be clearly shown in the inside portion of the terminal cover and shall be of permanent nature. The meter terminals shall also be marked, and this marking shall appear in the above diagram. In case any special precautions need to be taken at the time of testing the meter the same may be indicated along with the circuit diagram.

**Display**

14.6.9 The display shall be LCD type display with back lit. Minimum height of the characters shall be 6mm.

**Real Time Clock**

14.6.10 Each of the meters shall have an independently built-in calendar and clock having an accuracy of ± 5ppm at 25 °C or better. The calendar and clocks shall be correctly set to Indian Standard Time. The

time keeping accuracy of the metering shall be maintained according to the time of load dispatch clock, synchronized with LDC.

**Tamper Detection Features**

14.6.11 There shall be an appropriate display system by which any attempt at tampering with the meter is promptly displayed with date and time tagging. The meter shall have features to detect the occurrence and restoration of, at least, the following:

a) The meter shall not get damaged or rendered non-functional even if any phase and neutral are interchanged.

b) The meter shall register energy even when the return path of the load current is not terminated back at the meter and in such a case the circuit shall be completed through the earth. In case of metallic bodies, the earth terminal shall be brought out and provided on the outside of the case.

c) The meter shall work correctly irrespective of the phase sequence of supply (only for polyphase).

d) In the case of 3 phase 4 wire system, the meter shall keep working even in the presence of any two wires ie. even in the absence of neutral and any one phase or any two phases.

e) The registration must occur whether input phase or neutral wires are connected properly or they are interchanged at the input terminals.

f) The meter shall be factory calibrated and shall be sealed suitably before dispatch.

g) The meter shall be capable of recording occurrences of a missing potential (only for VT operated meters) and its restoration with date and time of first such occurrence and last restoration along with total number and duration of such occurrences during the above period for all phases.

h) Additional anti-tampering features including logging of tampers such as current circuit reversal, current circuit short or open and presence of abnormal magnetic field shall be provided as per the regulations.

i) Last 100 such events in total with date and time shall be stored in the meter memory on first in first out basis.

j) There shall be four separate compartments for logging of different type of tampers as follows:

- Compartment no.1: 20 events of missing potential
- Compartment no.2: 20 events of CT polarity reversal
- Compartment no.3: 40 events shall be allocated for current / voltage unbalance
- Compartment no.4: 20 events of power ON/OFF

k) The logging of various tampers in each compartment shall be as under:

14.6.12 Once one or more compartments have become full, the last tamper event pertaining to the same compartment will be entered and the earliest (first one) tamper event shall disappear. Thus, in this manner each succeeding tamper event will replace the earliest recorded event, compartment-wise. Events of one compartment / category shall overwrite the events of their own compartment / category only.

14.6.13 Tamper count shall increase as per occurrence (not restoration) of tamper events. Tamper data shall be available on

14.6.14 meter display as:

- Date of first occurrence of tampering
- Time of first occurrence of tampering
- Time of last restoration of tampering
- Date of last restoration to normal condition
- Number of occurrences of tampering events

**14.7 Drawings, Data and Manual**

14.7.1 To be submitted after award of contract:

- Technical data sheets
- Dimensional general arrangement drawing
- Scheme diagram
- Catalogues
- Quality plan
- Test certificates
- Operation and maintenance manual
- Comprehensive memory mapping and communication settings including normal and ABT parameters

**14.8 Tests**

14.8.1 The equipment offered shall be type tested proven type and approved by the transmission utility. Type test reports shall be furnished for approval. All routine and acceptance tests in accordance with the latest version of applicable standards shall be conducted.

14.8.2 The meter shall be duly calibrated with ESS meter of class 0.1 accuracy or better.

14.8.3 The energy meter offered shall be fully type tested for the properties / requirement, listed below at independent approved test laboratories as per relevant standards described in this specification.

14.8.4 Following is a list of various tests that shall be conducted

a) Test of insulation properties:
   i. Impulse voltage test
   ii. AC high voltage test
   iii. Insulation test
b) Test of accuracy requirement
   i. Test on limits of error
   ii. Test on starting condition
   iii. Test on no load condition
   iv. Test of ambient temperature influence
   v. Test of repeatability of error
   vi. Test of influence quantities
c) Test of electrical requirement
   i. Test for power consumption
   ii. Test for influence of supply voltage
   iii. Test of influence short time over current
   iv. Test of influence of self-heating
   v. Test of influence of heating
d) Test of electromagnetic compatibility
   i. Radio interference measurement
   ii. Fast transient burst test
   iii. Test of immunity to electrostatic discharges
   iv. Test of immunity to electromagnetic HF field
e) Test for climatic influences
   i. Dry heat test
   ii. Cold test
   iii. Damp heat cyclic test
   iv. Test for mechanical requirements
   v. Vibration test
   vi. Shock test
   vii. Spring -hammer test
   viii. Protection against penetration of dust and water
   ix. Test of resistance to heat and fire

**Submission of Laboratory and Site testing reports.**

14.8.5 Test reports of instruments transformers, ABT meters (Including spare meters, and instrument transformers) at NABL accredited / approved laboratory AND Site testing reports shall be submitted to Owner as well as to the concerned competent authority at appropriate stage.

### 14.9 Warranty

14.9.1 The warranty period of the Tariff Metering Panels shall be minimum two (02) years from the date of Commissioning of Facility.

14.9.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

14.9.3 During the warranty period, whenever a technical problem is encountered with Tariff Metering Panel, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the Tariff Metering Panels shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

14.9.4 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 15. Auxiliary Transformer - Dry type

## 15.1 Introduction

15.1.1 The Auxiliary transformer shall be installed to power up the control circuit and Plant auxiliaries. The transformer shall be installed for 1 X 100% of the total load requirements.

15.1.2 Auxiliary transformer shall be provided for substation also. (if applicable)

## 15.2 Codes and Standards

15.2.1 The Auxiliary System to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC/ IEEE standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IEC 60076 | Dry Type power transformer |
| IEEE C57.12.01-1988 | Dry Type Transformer |
| IEC 60529 | Ingress Protection of Enclosure of Transformer |
| IS 3347 | Dimension for porcelain transformer bushings |
| IS-3639 | Specification for fittings and accessories for power transformers |
| IS 4257 | Porcelain bushings for transformers |
| IS 10028 | Code of practice for selection, installation, and maintenance of transformer |
| IS-5 | Painting |
| IS-2705 | Specification for current transformers |
| IS 2026 | Application guide for power transformers. |
| IS 11171 | Specification for dry-type power transformers |
| IEC 60905 | Loading guide for Dry type transformer |
| IS 1271 | Electrical Insulation – Thermal evaluation and designation |
| IS 1554 (PART I) | PVC insulated (heavy duty) electric cables, Part 1: For working voltages up to and including 1100 V |

## 15.3 Technical Requirement

15.3.1 General Requirement

a. Transformers shall be designed with maximum temperature rise 90˚C over design ambient of 50°C. The core and other associated parts shall also be limited to the same value of temperature rise as for the windings.

b. The transformers shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.
   1. Voltage variation of ± 10% of rated voltage of that particular tap.
   2. Frequency variation of +3% -5% of rated frequency.
   3. Combined voltage and frequency variation of 15% (absolute sum).
   4. The Aux. transformer losses

c. No Load Loss at rated voltage and frequency: <0.25%

d. Full load loss at rated current at 75° C: <1.25%

e. The maximum flux density in any part of the core and yoke at the rated kVA, voltage and frequency shall be such that less than 10% continuous over-voltage conditions it does not exceed 1.70 Tesla.

f. Dry Type AN cooled transformer shall be capable of operating according to IEC 60905 Loading guide for dry type transformer.

g. Design margin of 20% shall be considered during sizing of the Auxiliary transformer.

h. The transformers shall be free from hum and vibration when it is in operation, even at 110% rated voltage.

i. The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth to minimize interference with communication circuit.

j. The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults with full voltage maintained on other winding for a period of 2 seconds.

k. The transformer and all its accessories shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 seconds.

l. The transformer HV winding and bushing insulation shall be suitable for ungrounded system voltage (as determined by inverter output voltage).

m. The noise level of transformer, when energized at normal voltage and frequency with fans running shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.

n. All leads and connections shall be mechanically strong, adequate insulated, protected against mechanical injury and rigidly clamped to withstand dynamic load.

15.3.2 Constructional Requirement

a. Windings

1. Windings shall be fully uniformly insulated. The high voltage shall be wound with high conductivity copper conductors and the insulation shall be done by Vacuum pressure impregnation process. The Current density shall not exceed 2.5A/Sq. mm for HV, LV windings at any tap. Coils shall be separated by a uniform air space that permits free circulation of cooling air between the coils. Windings shall be properly sized, insulated and supported for the voltages and currents to be encountered in operation, including short circuits. Insulation shall be class–H and temperature limited to class-F.

b. Core

1. The transformer core shall consist of thin, individually insulated sheets of high permeability, cold rolled grain-oriented, non-aging silicone steel. They shall be miter-corner-cut without burs, to provide a cross section most nearly resembling the circular cross-section. Laminations shall be cut and stacked utilizing step-lap construction to reduce losses and sound. Designed flux density shall be kept well below saturation. The assembled core shall be braced with heavy structural steel angle or channel to apply uniform clamping forces across the entire width, top and bottom. The core shall be protected from corrosion with high temperature rated rust-resistant coating.

c. Core and Coil Assembly

- Construction shall consist of separate high and low voltage coils for each phase, mounted coaxially, with high/low air space between coils adequate for the rated voltage potentials. Coils shall be mounted concentrically and supported in place on the transformer core so as to restrain movement in shipping and in service.
- Each coil shall be supported on epoxy blocks, top and bottom, with resilient pads to retain the coils while permitting thermal expansion under loading. The core-and-coil assembly shall be designed and manufactured to withstand without damage the short circuit testing.
- All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.

d. Bus

1. All bus work shall be designed to withstand maximum short circuit stresses when connected to a supply system having a specified fault capacity, and to meet all test voltage requirements, without audible or visible corona. Low voltage bus shall be high conductivity copper. Connections of coil windings to bus shall be brazed or welded using shielded arc techniques designed to provide high joint integrity.

2. Connection and terminal bolting surfaces shall be tin or silver-plated. Bolted connections shall include spring washers to maintain bolted surface pressure. All bus shall be sized to conform to industry standards and practices, for the amperes involved and maximum specified ambient temperatures.
3. High voltage bus shall be high conductivity copper. It shall be supported by glazed porcelain insulators for surge strength. It shall have bolt-connected joint and terminal surfaces tin or silver-plated. High voltage leads shall be bus or flexible, insulated cable with industry-accepted types of terminations.
4. Taps shall have flexible cable or solid copper links or jumpers. Ground bus shall be copper bus or comparable bare conductor extending the full length of the enclosure. It shall have provisions to mount appropriate terminal connections for adjacent switchgear or external grounding.

e. Enclosure

1. The enclosure shall be a ventilated enclosure for indoor use and be designed to provide adequate ventilation for the transformer.
2. Protection of enclosure shall be at least IP 54. Screens shall be perforated sheet steel type. Mesh size shall be such that lizard, rats etc. cannot enter inside the enclosure.
3. Double leaf access shall be provided with concealed hinge and neoprene gaskets for easy access to H.V. links and also for withdrawal of core and coil assembly if required. The enclosure shall be of CRCA sheet steel with a minimum thickness of 2 mm while the roof and vertical supports shall be formed from minimum 3 mm thick sheet steel. The enclosure shall be adequately reinforced to ensure rigidity so as to permit transportation of transformer within enclosure.
4. All steel panels shall be cleaned, primed then epoxy painted with a finish coat as required for an indoor installation. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized adequately. Each transformer shall be provided with one set of bidirectional rollers for rolling the transformer parallel to either centre line. Four nos. of heavy-duty eye bolt/lifting lugs suitable reinforces by vertical support shall be provided. Two nos. heavy duty eye bolt/lifting lugs for top cover of adequate size shall be provided.

f. Base

1. The transformer base shall be a separate rigid steel weldment capable of supporting the core and coil assembly and enclosure.
2. Construction shall include provisions for lifting as well as for jacking and skidding or rolling in both directions. Two steel ground pads with two tapped holes for attaching ground leads shall

be provided, one in each diagonally opposite corner of the base. Lifting provisions shall be designed for lifting the transformer and the core-and-coil assembly, separately or together.

g. Temperature Indicators

1. For measuring temperature in the winding PT-100 Resistance temperature detectors shall be embedded in all three phases in LV windings.
2. Potential free alarm and trip contacts shall be provided in to operate alarm and trip circuits. 4 channel temperature scanner & Local winding temperature indicator for winding temperature measurement shall be provided in the marshalling box.

h. Safety Interlock

1. For all dry type transformers following safety interlocks shall be provided:
    - A safety interlock shall be provided to ensure that the enclosure door can be opened only when transformer is de energized.
    - Safety limit switches operated by door handle shall be provided for tripping HV & LV side breaker.
    - Limit Switches
    - Minimum 4 Nos. Limit switches shall be provided for Transformer enclosure Door interlock. Each Limit switch shall have 1 NO & 1 NC contact. All NO contacts of limit switch shall be connected series and NC contacts shall be connected parallel.
    - Limit switch shall be used for HT Circuit breaker tripping and HT Circuit breaker closing permissive. The same shall be made available for communication to SCADA.

i. Bushings

1. The design of the bushing shall be such that stresses due to expansion and contraction in any part of the bushing shall not lead to its deterioration.
2. All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity. The porcelain shall not engage directly with hard metal and, wherever necessary, gaskets shall be interposed between the porcelain and the fitting.
3. All the bushing of same voltage class shall be interchangeable. Bushings located inside cable boxes / busduct flanges can be epoxy-molded types.
4. Clamps and fittings of steel or malleable cast iron shall be galvanized. Bushing location shall provide adequate phase and ground clearances. Creepage distance of bushing shall be 31mm/KV.

j. Cable Box

1. A dust tight air insulated type cable box with IP 54 protection shall be provided for terminating the cables directly of size and type specified. Inspection cover for fixed portion of cable box

shall be provided. Handles for lifting cable box shall be provided. The cable box shall have PRD.

k. Neutral Terminals

1. Two (2) Nos. neutral terminals shall be provided on LV side. One neutral terminal shall be part of phase connection arrangement busduct throat/ LV cable-box (as applicable). Other neutral terminal shall be brought to the transformer bottom by means of earthing bar of 50x6 mm of copper, supported on insulators mounted on transformer body.
2. The neutral earthing bar brought to the bottom for connection to station earth shall be provided with holes and suitable connecting hardware.
3. Neutral bushing CT shall be provided as specified. CTs shall be cast resin type. CT shall be located before formation of 2 nos. terminals.

l. Marshalling Box

1. The marshalling box shall be fabricated using sheet steel of at least 2 mm thickness. All doors, covers and plates shall be provided with neoprene gaskets. Marshalling box shall be complete with all internal wiring and identification ferrules, cables, conduits required for wiring between marshalling box and instruments on transformer.
2. The marshalling box shall be provided with thermostatically controlled space heaters and shall have IP54 degrees of protection. CT terminals shall be with shorting and disconnecting facility. Cable gland plate shall be of removable type. The marshalling box shall have MCB for incoming power supply. Marshalling box shall have temperature scanner & Local winding temperature indicator for winding temperature measurement.
3. Terminal block shall be provided in marshalling box to connect cabling between RTD's and Temperature scanner. The Temperature scanner shall have accuracy of ±1% and the scanner shall be suitable to communicate with SCADA. The Temperature scanner unit shall continuously monitor the winding temperature and shall be provided with auxiliary relays, one for alarm and one for trip (Potential free contacts).
4. The Marshalling box bottom shall be at least 600mm above floor level.

m. Wiring

1. All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
2. PTFE Cable shall be provided for wiring of temperature scanner. For other applications, Wiring shall be done with 1100V grade PVC insulated FRLS wires in conduit or PVC insulated armoured multi strand FRLS cable. Minimum wire size shall be 2.5 sq. mm. stranded copper for control & 6 sq. mm. stranded aluminium or 4 sq.mm stranded copper for CTs. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.

3. All devices and terminal blocks within the marshalling box shall be identified by symbols corresponding to those used in applicable schematic or wiring diagrams. Each wire shall be ferruled by plastic tube with indelible ink print at both end having terminal block no. terminal no. as per approved schematic or wiring diagrams.

n. Grounding

1. Two grounding pads, located on the opposite sides, shall be provided for connection of station ground mat for each transformer.
2. Grounding pads shall have clean buffed surface with tapped holes. M10 GI bolts, nuts and spring washers.
3. The core coil assembly shall be directly connected to this ground bus by removable bolted link for effective grounding.
4. Two ground terminals each shall be provided on marshalling box & cable box. For continuity of earth connection, all gasketed joints shall be provided with minimum two (2) nos. copper strip jumpers of adequate size.

o. Nameplate

1. Each transformer shall be provided with a rating name plate. Plates shall be of weather-resistance (stainless steel) material fitted in a visible position.
2. Rating/ Name plates shall be of white non-hygroscopic material with engraved black lettering. Such plates shall be scripted in English only. Alternatively, two separate plates with English inscription shall be provided.
3. Following information should be mentioned in the name plate.
    - Type of Transformer
    - Governing Specification
    - Manufacture’s name
    - Manufacture's serial number
    - Year of manufacture
    - Rated output
    - Rated frequency
    - Highest voltage equipment
    - Rated voltage.
        - Primary
        - Secondary
    - Rated current.
        - Primary
        - Secondary

- Maximum temperature rise over an ambient of 50 deg.C. of winding.
- Total weight
- Class of insulation
- Insulation levels
- Connection diagram indicating the tap screen.

p. Fittings and Accessories

- Each Dry type of transformer shall be supplied with the following as a minimum:

| Sl.No | Items | Quantity |
|---|---|---|
| 1 | LV Busbar support epoxy insulators | 1 lot |
| 2 | HV Bushing Epoxy | 3 Nos. |
| 3 | HV Cable Box | 1 No. |
| 4 | LV Busduct chamber | 1 No. |
| 5 | Lifting angle for complete Transformer | 1 set |
| 6 | Lifting lug and haulage lugs | 1 set |
| 7 | Jacking arrangement for Transformer. (For Transformer weighing above 3000 kg) | 1 set |
| 8 | Sheet steel enclosure with louvers and Pad lock | 1 No. |
| 9 | Inspection covers | 1 lot |
| 10 | Bi-directional rollers with locking & bolting arrangement. Suitable arrangement for core and winding assembly to draw out the same. | 1 set |
| 11 | Caution plates | 2 Nos. |
| 12 | Limit switches | 4 Nos. |
| 13 | LV neutral grounding insulators | 1 set |
| 14 | Temperature Scanner | 1 No. |
| 15 | Winding temperature indicators with solid state type temperature signaliser with digital read out and requisite sets of remote signalling contacts for alarm and trip operation. | 1 No. |
| 16 | Earthing terminals with lugs | 2 Nos. |
| 17 | Grounding pads for Cable box & Marshalling Box | 1 set. |
| 18 | Marshalling box complete with accessories. | 1 No. |
| 19 | Set of Interconnecting cables with cable glands & lugs | 1 lot |
| 20 | Off circuit tap changer links with accessories in the primary side | 1 No. |

| Sl.No | Items | Quantity |
|---|---|---|
| 21 | Rating plate and terminal marking plate | 1 No. |

- The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included. The transformer fittings and accessories shall be of reputed make and shall be subject to approval of the Owner.

**15.4 Painting**

15.4.1 Painting shall be carried out as per 'CBIP Manual on Transformers'. Painting process shall be approved by the Owner.

15.4.2 The final coat shall be of a glossy oil and weather resisting non-fading paint of shade number RAL 7035. The paint shall be suitable for the Site condition. Primer paint shall be ready made zinc chrome as per IS: 104; intermediate and final coats of paint shall be as per IS:2932. The final thickness of paint film on steel shall not be less than 80 microns. Sufficient quantity of touch-up paint shall be furnished for application at Site.

15.4.3 Any damage to paint work incurred during transport and erection shall be made good by the Bidder by thoroughly cleaning the damage portion and applying the full number of coats of paint that had been applied before the damage was caused. One coat of additional paint shall be given at Site over all external surfaces, including hardware, after erection. Bidder shall supply the requisite quantity of paint.

**15.5 Packing and Delivery**

15.5.1 The Bidder shall arrange transportation of all equipment from the point of manufacture to the Site. The arrangements shall include, but not be limited to, hiring adequate capacity of Wagon, determination of routes, determination of required permits, payment of required taxes and duties, and notification to the Owner. The transformer shall be transported after filling Nitrogen gas at a positive pressure.

**15.6 Tests**

15.6.1 All tests shall be carried out using its own accessories and parts which shall be supplied along with the Transformers.

15.6.2 Offered rating and type of transformer should have type tested. Test reports of short circuit test shall be submitted along with the offer.

15.6.3 The charges for carrying out all routine tests shall be deemed to be included in the Bid Price. The charge of carrying out each type test/ special test shall be given separately in "Schedule of Unit Rates" for expense adjustment purpose, In case of waiver of any of the tests by the Owner at a later date.

15.6.4 The following type/special tests shall be conducted one on each rating of transformer as per IS 11171:

a. Measurement of winding resistance
b. Measurement of voltage ratio and check of phase displacement
c. Measurement of impedance voltage, short circuit impedance (Principal tapping) and load loss.
d. Measurement of no-load loss and current.
e. Separate source voltage withstands test.
f. Induced overvoltage withstand test.
g. Lightning impulse test
h. Temperature rise Test.
i. Degree of protection test.

15.6.5 Following routine tests shall be conducted on each transformer as per IS: 11171

a. Measurement of winding resistance
b. Measurement of voltage ratio and check of phase displacement.
c. Measurement of impedance voltage / short circuit impedance (principal tapping) and load loss.
d. Measurement of no-load loss and current.
e. Separate source voltage withstands test.
f. Induced overvoltage withstand test.

15.6.6 Following Special tests shall be conducted one on each rating of transformer.

a. Partial discharge measurement
b. Measurement of Acoustic noise level

15.6.7 For the various bought out item of the transformer such as bushings, Current Transformers, WTI, marshalling box, enclosure, Cables etc, Type test & routine test reports shall be furnished by the Bidder for Owner's review.

**15.7 Deviation Point**

15.7.1 Bidder shall furnish the list of deviation from the technical specification in it's proposal. Unless or otherwise deviation list submitted it is understood that Bidder is fully in compliance with the Technical Specification mentioned herewith.

**15.8 Documentation**

15.8.1 Bidder shall submit the following documents/ drawings:

a. Technical data sheet
b. General arrangement and section drawing
c. Single line diagram & Schematic wiring diagrams
d. Cross sectional drawing showing various parts including core coil assembly.
e. Component list & Bill of Quantities
f. Erection and commissioning procedures
g. Catalogues / drawings / leaflets for all items
h. Operation and maintenance manual
i. Test reports
j. Sub-vendor list
k. Manufacturing quality plan

### 15.9 Warranty

15.9.1 The warranty period of the Transformer shall be minimum two (02) years from the date of Commissioning of Facility.

15.9.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

15.9.3 During the warranty period, whenever a technical problem is encountered with Transformer, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the Transformer shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

15.9.4 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 16. Auxiliary Transformer - Oil Immersed

## 16.1 Intent of Specification

16.1.1 This specification is intended to cover the Design, Engineering, Manufacture, Assembly, Inspection, Erection, Testing and Commissioning of the Auxiliary transformer (2 X 100%) for PSS (AIS) of 25MW/100MWh BESS Power Plant.

16.1.2 The Bidder shall submit the detailed design calculations, GTP and drawings, bill of materials and their specifications / standards to the Owner for approval before manufacturing commencement.

16.1.3 All design calculations, GTP and drawings shall be submitted to the Owner for approval before execution.

## 16.2 Codes and Standards

16.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IS 2026 | Specification for Power Transformers (All parts) |
| IS 2099 | Specification for Bushings for Alternating voltages above 1000V |
| IS 3347 | Dimension for porcelain transformer bushings |
| IS 3639 | Specification for Fittings and accessories for Power Transformers |
| IS 4257 | Porcelain Bushings for Transformers |
| IS 6600 | Guide for Loading of Oil Immersed Transformers |
| IS 10028 | Code of practice for selection, installation, and maintenance of transformers. |
| IS 335 | New insulating oils |
| IS-5 | Painting |
| IS-2705 | Specification for Current Transformers |
| IS 8478 | Application Guide for On Load Tap changers. |
| IS 10561 | Application Guide for Power Transformers. |
| IEC 60076 | Power Transformers (All parts) |

16.2.2 CBIP Manual on Transformers

16.2.3 Indian Electricity Act and rules framed there-under.

16.2.4 Regulations laid by the office of the Chief Electrical Inspector to Government.

16.2.5 Latest regulation of Central Electricity Authority (Regulation on Technical standards for Construction of Electrical Plants and Electric Lines) Regulations, 2021/2022 and its amendments.

### 16.3 Design Requirements

16.3.1 Oil filled Transformers shall be suitable for outdoor installation in a hot, humid and tropical climate. The transformers shall be capable of operating continuously at its rated output without exceeding the specified temperature limits.

16.3.2 Transformers shall be sized for the following ambient conditions.

- Maximum ambient temperature of 50ºC
- Maximum daily average temperature of 40ºC
- Maximum yearly weighted average temperature of 32ºC
- Minimum ambient temperature of -5ºC

16.3.3 The transformers shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of ± 10% of rated voltage of that tap.
- Frequency variation of +3% -5% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

16.3.4 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over-voltage condition it does not exceed 1.9 Tesla.

16.3.5 Transformers shall withstand, without injurious heating 125% over fluxing for a period of one (1) minute and 140% over fluxing for a period of five (5) seconds. (Over fluxing caused by combined voltage and frequency fluctuations).

16.3.6 Transformers shall be capable of operating at 125% rated voltage for a period of one (1) minute and 140% rated voltage for a period of ten (10) seconds due to sudden load throw off.

16.3.7 The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage.

16.3.8 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

16.3.9 The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults with full voltage maintained on other winding for a period of 2 seconds.

16.3.10 The transformer and all its accessories including CT's etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 seconds.

16.3.11 The transformers shall be capable of being loaded in accordance with IS: 6600/IEC-600354. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

16.3.12 The noise level of transformer, when energized at normal voltage and frequency with fans running shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.

16.3.13 The temperature rise of top oil (by thermometer method) shall not exceed 50ºC over an ambient temperature of 50ºC and Temperature rise of winding (by resistance method) shall not exceed 55ºC over an ambient temperature of 50ºC. Hot spot temperature based on maximum yearly weighted average temperature shall not exceed 98ºC.

16.3.14 Firefighting arrangements for Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/CEA Regulations (latest/amended) / statutory requirements. Firewall & soak pit as applicable (as per statuary requirement/TAC/IS 10028 / IS 1646) shall be provided.

### 16.4 Constructional Features of Oil Filled Transformers

**Tank**

16.4.1 Tank shall be of welded construction and fabricated from tested quality low carbon steel plate of adequate thickness. After completion of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. Tank stiffeners shall be provided for general rigidity, and these shall be designed to prevent retention of water. The main tank body excluding tap changing compartments and radiators shall be capable of withstanding vacuum.

16.4.2 Each tank shall be provided with:

- Lifting lugs suitable for lifting the equipment complete with oil.
- A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks.
- Suitable haulage holes.
- Oil level Site glass

16.4.3 The tank shall be designed in such a way that it can be mounted on the plinth directly.

16.4.4 The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

16.4.5 The tank cover shall be sloped to prevent retention of rainwater and shall not distort when lifted.

16.4.6 At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall be bolted type and shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

16.4.7 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

16.4.8 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

16.4.9 All bolted connections shall be fitted with weatherproof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

**Core**

16.4.10 The core shall be constructed from high permeability grade, non-ageing, cold rolled, super grain oriented, and silicon steel laminations.

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

16.4.12 The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively

16.4.13 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV (rms) for 1 minute.

16.4.14 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

16.4.15 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

16.4.16 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

16.4.17 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

16.4.18 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

16.4.19 The frame work and clamping arrangement shall be earthed.

**Windings**

16.4.20 The conductors shall be of electrolytic grade copper free from scales and burrs.

16.4.21 The windings shall be designed to reduce a minimum out of balance forces in the transformer at all voltage ratios.

16.4.22 The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service.

16.4.23 Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

16.4.24 The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

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

16.4.26 All leads from the winding to the terminal board and bushings shall be rigidly supported to prevent injury/ shock from vibration or short circuit stress. Guide tube shall be used wherever applicable.

**Conservator & Oil Preservation System**

16.4.27 Conservator shall be provided which shall be fitted with oil level gauge with low oil level potential free contacts. The oil level at 30° C shall be marked on the gauge.

16.4.28 Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100°C.

16.4.29 The conservator shall be fitted in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell, wherever applicable. Conservator shall be positioned so as not to obstruct any electrical connection to transformer. The conservator shall be designed so that it can be completely drained by means of the drain valve provided, when mounted as in service.

16.4.30 Conservator shall be fitted with a dehydrating filter breather. The breather shall be with SS cover Passage of air shall be through Silica gel. Silica gel shall be isolated from atmosphere by an oil seal. Breather shall be mounted not more than 1200 mm above rail top level. To minimize the ingress of moisture, three breathers of identical size shall be connected in series for main tank conservator.

16.4.31 It shall be air cell type. Air cell used shall be suitable for operating continuously at 100°C. Contact of the oil with atmosphere is prohibited by using a flexible air cell of Nitrile rubber reinforced with Nylon cloth. Air cell of conservator shall be able to withstand the vacuum during installation/maintenance periods. Otherwise, provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

16.4.32 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.

**Pressure Relief Device**

16.4.33 Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall operate at a static pressure less than the hydraulic test pressure of the transformer tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipes and directed away from the transformer/other equipment and this shall be prevented from spraying on the tank. Means shall be provided to prevent ingress of rain. Pressure Relief device shall be mounted on the main tank in such a position to prevent gas accumulation.

**Buchholz Relay**

16.4.34 Buchholz relay shall be provided to collect any gas evolved in the transformer. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper/stainless steel tube shall be connected from the gas collector to a valve located at 1200 mm (Maximum) above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation/ low oil level conditions and the other for tripping on sudden rise of pressure/ low oil level conditions. A machined surface shall be provided on the top of each relay to facilitate the setting of the relays and to check the mounting angle in the pipe and the cross level of the relay. Adequate clearance between oil pipe work and live metal shall be provided.

**Joints and Gaskets**

16.4.35 All gaskets used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber or synthetic rubber gaskets confirming IS: 4253. with leak proof design and shall be guaranteed for oil leakage for at least five years.

16.4.36 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.

**Oil Temperature Indicators (OTI)**

16.4.37 Transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip

contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Accuracy class of OTI shall be 1.5% or better.

16.4.38 The OTI shall also be provided with in built variable resistor for connecting it to transducers for remote monitoring of the temperature. The transducers shall be provided with dual outputs of 4-20mA signal and shall be mounted in the marshalling box.

**Winding Temperature Indicator (WTI)**

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

- Temperature sensing element.
- Image coil.
- Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet.
- 150 mm dia local indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts besides that required for control of cooling equipment, Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Accuracy class of WTI shall be 1.5% or better.
- Calibration device.

16.4.40 The WTI shall also be provided with in built variable resistor for connecting it to transducers for remote monitoring of the temperature. The transducers shall be provided with dual outputs of 4-20mA signal and shall be mounted in the marshalling box.

**Off Circuit Tap Changer**

16.4.41 Off circuit taps as specified shall be provided on the high voltage winding.

16.4.42 +5% to –5% in steps of 2.5%.

16.4.43 The transformer shall be capable of operation at its rated kVA on any tap provided the voltage does not vary by more than 10% of the rated voltage corresponding to the tap.

16.4.44 The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.

16.4.45 The tap changing shall be possible without disturbing the transformer in any way except de-energizing.

16.4.46 Tap position status shall be integrated with SCADA for remote viewing.

16.4.47 An indicating device shall be provided to show the tap in use.

- A warning plate (SS-304) indicating "The switch shall be operated only when the transformer has been de-energised" shall be fitted.

**Cable Box (HV and LV)**

16.4.48 A dust tight air insulated type cable box with IP:55 (minimum) protection shall be provided for terminating the cables with termination kit.

16.4.49 Inspection cover for fixed portion of cable box shall be provided. Handles for lifting cable box shall be provided.

16.4.50 Gland plate for cable termination shall be of Aluminum. with predrilled holes suitable to cable OD for LV cable box. HV cable box shall be provided with cable support arrangement suitable for 33KV cable.

16.4.51 The cable box (HV and LV) shall have Pressure Relief Diaphragm (PRD).

16.4.52 HV Cable box shall be of phase segregated air insulated type, phase segregation shall be achieved by insulating barriers. HV side cable box shall have disconnecting chamber.

16.4.53 The support from base for the cable box shall be of galvanized iron.

16.4.54 The minimum length provided for terminating 33 kV, cable shall be 1000 mm, for 433V side suitable length shall be provided (shall be finalized during detail engineering).

16.4.55 The cable boxes shall have removable top cover.

**Axles and Wheels**

16.4.56 The transformers shall be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be suitable for transformer dimensions.

16.4.57 To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation. All Wheels shall be detachable and shall be made of cast iron and steel as required.

16.4.58 Wheels shall be arranged so that they can be turned through an angle of 90° when tank is jacked up clear of the rails or floor.

**Bushings and Current Transformers**

16.4.59 The electrical and mechanical characteristics of bushings shall be in accordance with IS: 2099 and IS: 3347.

16.4.60 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

16.4.61 Bushings of identical rating shall be interchangeable.

16.4.62 Porcelain used in bushing manufacturing shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

16.4.63 Clamps and fittings shall be of hot dip galvanised steel. The design of connectors/clamps shall ensure corona free operation at the maximum rated voltage.

16.4.64 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

16.4.65 No arcing horns shall be provided on the bushings.

16.4.66 The terminal marking and their physical position shall be as per IS: 2026.

**Earthing Terminals**

16.4.67 Two (2) earthing pads (each complete with two (2) Nos. holes, Galvanized steel M10 bolts, plain and spring washers) suitable for connection to 65 x 8 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

16.4.68 Two earthing terminals suitable for connection to 50 x 6 mm galvanised steel flat shall also be provided on marshalling box and any other equipment mounted separately.

**Neutral Earthing Arrangement**

16.4.69 For solidly grounded system, The neutral bushing terminal of the Transformer shall be brought to the ground level by a tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to Owner's grounding mat.

16.4.70 For none effectively grounded system, the neutral terminal shall be brought to cable box provided with transformer.

**Valves**

16.4.71 All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

16.4.72 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

16.4.73 Each valve shall be provided with the indicator to show clearly the position of the valve.

16.4.74 All valves flanges shall have machined faces.

16.4.75 All valves in oil line shall be suitable for continuous operation with transformer oil at 100 degree C.

16.4.76 The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling. The sampling device shall not be fitted on the filter valves.

16.4.77 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint of approved shade distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate followed by two coats of fully glossy finishing paint.

16.4.78 All hardware used shall be cadmium plated / electro galvanized.

**Rating and Diagram plate**

16.4.79 Rating, instruction and Diagram plate shall be fixed to the transformer tank at an average height of about 1750 mm above ground level and shall be of stainless steel (SS-304 or higher grade) material. Wiring scheme (TB details) shall be engraved in a SS-304 plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

16.4.80 Rating plate shall have all the data specified in the appropriate clauses of IS : 2026

16.4.81 Diagram plate shall show the internal connections and also the voltage vector relationship of the several windings in accordance with IS: 2026 and in addition a plan view of the transformer giving the correct physical relationship of terminals. No load voltage shall be indicated for each tap.

16.4.82 Valve schedule (table) with diagram shall be provided on a separate plate

16.4.83 Air cell replacement instruction plate shall be provided.

**Wiring and Terminal Blocks**

16.4.84 All, marshalling boxes, junction boxes etc. shall be fully wired at the factory to ensure proper functioning of the control, protection and interlock schemes. All contacts including spare contacts of switches, relays and other devices shall be wired up to the terminal block. The inter-connection cables shall not touch transformer body to avoid heating. The device cables shall be laid in suitable perforated adequately supported SS-304 cable trays with SS cover (tray filling factor not more than 50%). Glands used at device as well as marshalling box end shall be of double compression nickle plated brass glands

16.4.85 Wiring shall be done with flexible 1100 V grade PVC cables with stranded copper conductor of minimum size 2.5 sq. mm. Not more than two wires shall be connected to a terminal. Wiring shall be identified at both ends with ferrules bearing wire numbers as per approved drawing. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

16.4.86 Terminal blocks shall be of 650 V grade suitable for terminating required cable size. Terminals for CT secondary shall have provision for shorting & earthing. Not more than two wires shall be connected to any terminal. 20% spare terminals shall be provided for each terminal station and for each type of TB.

16.4.87 All devices and terminals block within the panel shall have identification numbers as per schematic diagram.

16.4.88 The marshalling box shall have IP 55 (minimum) degree of protection. Material of construction of marshalling box shall be SS 304 or better. Filling factor of troughs for wiring inside marshalling box used shall not be more than 50%.

**Insulating Oil**

16.4.89 The insulating oil shall be uninhibited type mineral oil, and shall conform to IS 335.The transformer and all associated oil filled equipment shall normally be supplied along with the first filling of oil and

excess quantity of oil shall also be supplied as per requirement of /Owner in non-returnable drums The Bidder shall furnish test certificates from the supplier against their acceptance norms as mentioned below, prior to dispatch of oil from refinery to Site. Sufficient quantity of oil necessary for maintaining required oil level in tank, radiators, conservator etc. till commissioning shall be supplied.

16.4.90 Insulating oil used in both the transformers and spare oil to be supplied shall be of same make and type.

**Painting**

16.4.91 All the fabricated surfaces shall be pretreated by degreasing, de-rusting and chemically cleaned prior to application of epoxy resin red oxide primer to give a dry film thickness of 50 microns. The finishing paint shall be half gloss based on an epoxy based. The paint shall be applied in two coats to give a minimum dry film thickness of not less than 150 microns. The final paint shade of external surface of shall be RAL 7035. The painting of all structures &equipment shall be done considering Corrosion zone as per "ISO-12944" for the Site.

**Packing and delivery**

16.4.92 The Bidder shall arrange transportation of all equipment from the point of manufacture to the Site. The arrangements shall include, but not be limited to, hiring adequate capacity of Wagon, determination of routes, determination of required permits, payment of required taxes and duties, and notification to the Owner.

## 16.5 Tests

16.5.1 All tests shall be carried out using its own accessories and parts which shall be supplied along with the Transformers.

16.5.2 Offered rating and type of transformer should have type tested. Test reports of short circuit test shall be submitted along with the offer.

**Type Tests**

16.5.3 Following type tests shall be conducted in addition to routine tests on one of each type (rating) of transformer as per IS: 2026/ IEC-60076//CBIP Manual:

- Temperature rise Test.
- Power frequency voltage withstand test
- Lightning impulse test on line terminal
- Lightning impulse test on neutral terminal (for non-effectively grounded neutral)
- Degree of protection for marshalling cabinet

**Routine Tests**

16.5.4 Following routine tests shall be conducted on each transformer as per IS: 2026/ IEC-60076/CBIP Manual:

- Measurement of winding resistance
- Measurement of voltage ratio and check of phase displacement
- Measurement of impedance voltage / short circuit impedance (principal tapping ) and load loss.
- Measurement of no load loss and current.
- Measurement of insulation resistance.
- Separate source AC withstand test
- Induced overvoltage withstand test
- Lightning impulse test online terminal
- Lightning impulse test on neutral terminal (for non-effectively grounded neutral)

16.5.5 Following additional routine tests shall also be carried out on each transformer:

- Magnetic balance test
- High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

16.5.6 Insulating oil shall be tested for BDV & moisture, at manufacturer's works (oil sample shall be drawn before and after heat run test):

- BDV 60 kV (min.)
- Moisture content 15 ppm
- DGA at factory and before commissioning at Site.

**Special Tests**

16.5.7 Following Special tests shall be conducted on each transformer as per IS: 2026/ IEC-60076 /CBIP Manual:

- Determination of capacitance windings-to-earth, and between windings.
- Measurement of insulation resistance to earth of the windings, and /or measurement of dissipation factor (tan $\delta$) and capacitance of the insulation system at factory and before commissioning at Site. Tan-Delta and capacitance parameters shall be within IEEE C57.152 standards.

**Tank Tests**

16.5.8 During fabrication the following tests shall be carried out as per CBIP Manual for Transformers:

a. The tank shall be tested for leakage by being completely filled with air at a pressure corresponding to twice the normal head of oil or to normal pressure plus 35 KN/Sq.m whichever is lower. The pressure shall be maintained for a period of minimum one hour during which time

no leak shall occur. The equivalent air pressure corresponding to oil pressure calculated at the base of the tank to be considered for air pressure test. Permanent deflection of flat plates shall be measured on one tank of each design, after the excess pressure has been released and shall not exceed the figures specified below:

| ***Horizontal Length of Flat Plate (in mm)*** | ***Permanent Deflection (in mm)*** |
|---|---|
| Upto and including 750 | 5.0 |
| 751 to 1250 | 6.5 |
| 1251 to 1750 | 8.0 |
| 1751 to 2000 | 9.0 |
| 2001 to 2250 | 11.0 |
| 2251 to 2500 | 12.5 |
| 2501 to 3000 | 16.0 |
| Above 3000 | 19.0 |

b. The conservator shall be tested for leakage by being completely filled with air at 35 kN/ m2. The pressure shall be maintained for a period of minimum one hour during which time no leakage shall occur.

c. The radiators shall be tested for leakage by placing them horizontally in a tank filled with clean water and applying air pressure 2 kg/cm2m for at least 15 minutes during which time no leakage shall occur.

d. The Pipes shall be tested for leakage by applying air pressure 4 kg/cm2m for at least 15 minutes during which time no leakage shall occur.

16.5.9 During fabrication the Vacuum test shall be carried out as per CBIP Manual as follows:

16.5.10 Transformer tank of each design shall be subjected to vacuum as follows:

- 250 mm of Hg for upto 1.6 MVA
- 500 mm of Hg for above1.6 MVA and up to 20MVA
- 760 mm of Hg for above 20MVA
- The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values stated in above clause.

16.5.11 Before conducting pressure test, the following shall be taken care of:

a. Pressure relief valve/relief vent shall be removed and opening shall be blanked.

b. Transformer conservator shall be disconnected.

c. Oil should be completely filled, and all trapped air released.

16.5.12 During assembly stage the following test shall be carried out as routine test.

16.5.13 Oil pressure test to be conducted on tank with turret and all other accessories as assembled by filling completely with oil at a pressure corresponding to twice the normal head of oil or to normal pressure plus 35kN/m2 whichever is lower. The pressure shall be maintained for eight hours during which time no leakage shall occur. If any leakage is observed, manufacturer / supplier shall rectify the same and reoffer the Transformer for Pressure test. During the test the pressure shall now be maintained only for 4 (Four) hours during which time no leakage shall occur. This test shall be repeated till there is no leakage from any joints.

**16.6 Drawings & Documents**

16.6.1 The following drawings and documents shall be submitted for approval during detail engineering stage.

- Transformer sizing calculation
- Technical data sheet
- Dimensional General Arrangement drawing of transformer.
- Parts list
- Bushing / Terminal arrangement
- Cable box details
- Busduct termination arrangement
- Catalogues/drawings for bought out items.
- Transport /Shipping dimension drawing
- Foundation Plan & loading details
- Name plate details
- Dynamic short circuit test certificate / test report of similar transformer shall be provided. In case of DSC test certificate is not available; manufacturer shall carry out the test at no additional expense to Owner.
- Design calculations for short circuit withstand capability.
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

### 16.7 Warranty

16.7.1 The warranty period of the Transformer shall be minimum two (02) years from the date of Commissioning of Facility.

16.7.2 Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

16.7.3 During the warranty period, whenever a technical problem is encountered with Transformer, Bidder will report the same to the OEM/Supplier and also inform the same to Owner. All parts of the Transformer shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.

16.7.4 Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

# 17. Auxiliary Power Supply System

## 17.1 Introduction

17.1.1 BESS / Inverter station / pooling substation /MCR has its own auxiliary power supply system comprising of Alternating Current Distribution Box (ACDB) which shall be fed from Low Voltage winding of the auxiliary transformer to power its auxiliary loads and control circuit.

17.1.2 ACDB in MCR room shall have two incomer (100% rated) fed from two different sources, at MCR the auxiliary transformer shall fed from 33kV HT switchgear.

17.1.3 ***The same specifications are applicable for auxiliary system for the HT substation, however the complete system for HT substation (for pooling substation and HT panel) shall be 2x100%.***

17.1.4 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)/DC charger. Input AC supply for Uninterrupted Power Supply (UPS)/DC charger shall be fed from ACDB. Bidder shall consider any one of the supply options for feeding different equipment loads:

| Type of Load | Equipment Name | ACDB | Backup System (UPS/DC) |
|---|---|---|---|
| Critical Loads | SCADA/EMS including remote RTU panel | | ✓ |
| | SCADA/EMS HMI | | ✓ |
| | Data logger (WMS) | | ✓ |
| | Fire Detection /Alarm Panel | | ✓ |
| | 20% Emergency Lighting (min 10% AC lighting, Min 10% DC lighting) | | ✓ |
| | CCTV | | ✓ |
| | Inverter Transformer's Auxiliary supply (if applicable) | | ✓ |
| | Power Transformer's Auxiliary supply | | ✓ |
| | NIFPS, RTCC and other Critical equipment | | ✓ |
| | 132kV Substation equipment (CB/ISO/Illumination) | | ✓ |
| | Energy Meter/MFM | | ✓ |
| | CRP panels including relay/SAS | | ✓ |
| | HT Panel - spring charge motor | | ✓ |
| | HT/ICOG - DC Loads (using 2x 100% AC-DC converters adequately rated) | | ✓ |
| | HT/ICOG Panel - Relays and contactors | | ✓ |
| | Any DC Load (using 2x 100% AC-DC converters | | ✓ |

| Type of Load | Equipment Name | ACDB | Backup System (UPS/DC) |
|---|---|---|---|
| | adequately rated) | | |
| Non-Critical Loads | ICOG Panel - Space heater and power receptacles | ✓ | |
| | Illumination and Ventilation supply etc. | ✓ | |
| | Pumps and other auxiliaries | ✓ | |
| | Other non-critical auxiliary loads | ✓ | |

17.1.5 The UPS/DC shall be 2X100 % of total load demand with 20 % design margin.

17.1.6 The input voltage and output voltage shall be 415V, 230V respectively.

17.1.7 Each Backup system shall comprise of 1 x 100% UPS/DC with 1 x 100% Battery bank for providing 8 hours backup for HT substation and 4 hours for Inverter station. 1 x 100% backup DB, and other necessary Protective devices and accessories. Backup DB (sectionalised buses) shall have two incomers fed from two separate UPS/DC as mentioned above. Suitable auto change over logic shall be provided.

17.1.8 Control and protection supply of main HT switchgear shall be sourced by DC supply only, providing 4 hours backup for HT station and 2 hours backup for inverter station and SCADA shall be sourced by AC.

17.1.9 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 Owner's review and approval.

17.1.10 Communication equipment at substations shall be provided with battery backup as per requirement of Central Electricity Authority Technical Standards for Communication System in Power System Operation) Regulations 2020/other regulations.

**17.2 Part - A - Uninterrupted Power Supply System (UPS)**

17.2.1 UPS Introduction

a. The Uninterrupted Power Supply (UPS) system shall be designed to meet the electrical power requirements of SCADA systems and other essential load requirement. The UPS System shall be designed to give the voltage at approximate mid-level of the tolerance band of the power supply modules/packs of Control System, when the charger is feeding the load. In case the Power Supply Output of a charger exceeds the voltage band tolerated by the power supply modules/packs of Control System, provision for safe tripping of that charger is to be ensured. Bidder shall clearly bring out in the proposal the redundancy feature along with configuration

diagram, single line diagram and data sheets etc. & this shall be finalized subject to Owner's approval during detailed engineering.

17.2.2 Codes and Standards

a. The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

| Codes and Standard | Description |
|---|---|
| IEC: 62040 | Uninterruptible Power Systems (UPS) |
| IS: 3895 | Mono crystalline semiconductor rectifier cells and stacks. |
| IS: 4540 | Mono crystalline semiconductor rectifier assemblies and equipment. |
| IS: 6619 | Safety code for semiconductor rectifier equipment. |
| IS 6297 | Electrical test methods for low voltage energy cables. |
| IS 6553 | Transformer and inductors for electronic equipment |
| IEEE 1184 | Environmental requirements for semi-conductor devices and integrated circuits |
| IEC 60529 | Guide for Batteries for Uninterruptible Power Supply System |

## 17.3 Design Criteria-UPS

17.3.1 Design Basis

a. UPS System provides a regulated and uninterrupted single / three phase A.C. power, within specified tolerances, to critical loads during normal and emergency operation of the Plant.

b. UPS system shall be compatible for satisfactory and well-coordinated operation with other related equipment as well as with input and output systems.

c. Energizing or de-energizing any portion of the system serviced by the UPS shall not cause output changes which will affect the operation or integrity of the remaining portions of the system in any way.

d. The equipment shall be self-protecting against all A.C. and D.C. transients, voltage surges, and steady state abnormal voltages and currents.

e. The circuit protection shall be coordinated with UPS short circuit capacity and protective device characteristics so that a fault on any circuit shall result in minimum loss of function.

f. All non-interrupting components of UPS system shall be capable of withstanding the available short circuit current without damage.

g. All circuit interrupting components shall be capable of withstanding and interrupting the available short circuit currents without damage.

h. For continuous operation at specified ratings, temperature rise of the various components of UPS system shall be limited to the permissible values stipulated in the relevant standards and/or this specification.

i. Following data to be considered:

| | | | |
|---|---|---|---|
| 1. | Maximum temperature | : | 50 ºC |
| 2. | Minimum temperature | : | -10 ºC |
| 3. | Design margin | : | 20 % |

j. UPS shall have automatic online battery health checking facility. It shall have connectivity with the SCADA status monitoring.

k. A 2-pole MCCB of suitable rating shall be provided near the battery bank (at suitable location on the frame of the battery bank) to allow disconnection of the batteries from the rectifier/charger unit and inverter. This shall also provide over-current protection to the battery circuits. MCCB specifications are provided elsewhere in this document.

17.3.2 System Concept

a. A D.C. power source and an A.C. power sources are available to each UPS system. The system is so designed that its load shall be served without interruption as long as one of the above power sources is available within specified limit of voltage and/or frequency.

b. UPS of 100% capacity with 100% redundant battery back-up for 480minutes backup, each sharing 100% UPS load. On failure of any UPS, its load gets automatically transferred to the other inverter through static transfer switch.

c. If one UPS is out of service for any reason, then the second UPS shall be working with 100% UPS load. On failure of this UPS the standby A.C. source shall back up to supply the 100% UPS load automatically through static transfer switch.

d. Each UPS shall have UPS by-pass facility. SMPS type voltage stabilizer technology shall be used. Power supply input shall be from ACDB.

17.3.3 Layout Criteria

a. The UPS system including batteries shall be located indoor in the Control Room.

b. The UPS should be placed in such a way that any equipment can be fully isolated for maintenance without affecting in any way the operation of other panels/components.

c. Sufficient clear space shall be provided for attending individual cells.

d. Sufficient clear space shall be kept inside the control room building to accommodate a battery of identical capacity in future.

### 17.4 System Requirements-UPS

17.4.1 To provide uninterrupted power supply to LT & HT Electrical system, SCADA, emergency lighting, Fire detection and protection system, metering system, and other auxiliaries. The UPS system shall be parallel redundant consisting of inverters and static switches.

17.4.2 Bidder shall carry out sizing calculation and provide required rating. A design margin of 20 % shall be considered in UPS system sizing calculation. The calculation shall be submitted to the Owner for approval. The power factor to be considered for UPS shall be 0.8.

17.4.3 The overall efficiency of UPS system shall not be less than 88%.

17.4.4 The UPS system shall be capable of operating without 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.

17.4.5 The UPS shall have an overload capacity of 110% of rated capacity for 1 hour, 125% of rated capacity for 10 minutes and 150% of rated capacity for 1 minute. The inverter shall have sufficient I2t capacity to clear fault on the maximum rated branch circuit.

17.4.6 The UPS shall have programmable power walk in facility.

17.4.7 The design shall provide high reliability by ensuring high mean time between failures (MTBF) and low mean time to repair (MTTR). The availability shall be more than 99.99% per year. The formula for availability is : Availability = (1 – (MTTR/MTBF)) x 100%

17.4.8 The static inverter shall be solid state type using pulse width modulation (PWM) insulated gate bipolar transistor (IGBT) design. The steady state voltage regulation shall be less than ±1% and frequency regulation less than ±0.5% for all conditions of input supplies, loads and temperature occurring simultaneously or in any combination. The total harmonic content shall be less than 2% at full load.

17.4.9 All necessary equipment shall be provided to protect the inverter against overload, output short circuit, 100% loss of load, input under / over voltage, output under/over voltage, battery current limit, Rectifier over voltage, battery low, battery overvoltage, over temperature etc. The inverter shall be self-protecting against damage if energized with full load connected.

17.4.10 Inverter equipment shall include all solid-state circuitry and devices to enable inverters to operate in parallel sharing mode with each inverter taking 50% load during normal operation.

17.4.11 Upon failure of normal AC source, the loads shall continue to get supply from batteries through inverters without any interruption. In case of failure of both UPS and battery bank, UPS shall work in UPS bypass mode for that AC supply shall be used.

17.4.12 In case of either inverter being out of service, 100% load shall automatically be transferred to healthy inverter without any break and degradation in the quality of UPS output and disconnecting the faulty inverter automatically.

17.4.13 The inverter failure shall be alarmed, and the healthy inverter shall get synchronizing signal from the standby AC source (bypass supply) and remain synchronized within set limits. The limits for the synchronization between healthy inverter and bypass supply shall be field adjustable.

17.4.14 On failure of both inverters, the loads shall be transferred to bypass supply without a break if within synchronization limits. However, such transfer shall be inhibited, during operation of inverter on its internal oscillator, if bypass supply frequency is beyond the synchronization limits. Provision of asynchronous transfer with a break in case of inverter being out of synchronization limits shall be provided.

17.4.15 Static switch shall perform the following operations:

a. Connects inverter output to the load under normal operation.
b. Automatically transfers the load to its bypass supply within 5ms if any both inverters fail or are overloaded.
c. Automatically retransfers the load from bypass supply to the inverter once the inverter is healthy or the overload condition has ceased.

17.4.16 Maintenance bypass switch shall be used for isolating UPS during maintenance.

17.4.17 The rectifier transformer shall be dry type copper wound with Class F insulation with temperature rise limited to Class B.

17.4.18 If Bidder shall provide active front end type, single isolation transformer is sufficient. Same shall be submitted for approval.

17.4.19 The UPS shall have the following measuring functions:

a. Voltage & current at input side and output side
b. Frequency at output

17.4.20 The UPS shall have microprocessor based self-diagnostic features.

17.4.21 For remote indication / annunciation in SCADA, required communication link and potential free contacts for essential signals shall be provided:

17.4.22 The UPS shall have the following alarm / status indications:

a. System normal
b. AC Input supply failure
c. Inverter ON/OFF
d. Inverter on load
e. Inverter failure
f. Over temperature
g. Overload trip
h. AC Input over voltage
i. AC Input under voltage

j. Static switch failure
k. Fuse failure
l. Transfer inhibited.
m. Standby ON
n. Fan failure
o. Oscillator failure

17.4.23 During detailed Engineering additional alarm/status indication shall be added if required by Owner and bidder shall provide the same without any further claim to Owner.

17.4.24 UPS shall be provided with required MCB protected outgoing feeders either integral or in a separate distribution board. 20% spare feeders subject to a minimum of one of each rating and type shall be provided.

17.4.25 The UPS shall be capable to work in non-air-conditioned room; room shall be well ventilated located in control room.

17.4.26 The UPS system consisting of chargers, inverters etc. shall be suitably housed in sheet steel panels and shall be complete with all interconnections. The panels shall be fabricated with 2mm thick cold rolled sheet steel and structural steel. Degree of protection of cubicles shall be IP55.

17.4.27 UPS shall have sufficient number of cooling fans. UPS system training shall be provided to the Owner at Site for free of charge.

17.4.28 UPS shall be mounted on base frames made of ISMC100 all around and their base is to be bolted with the ISMC frame. The pad between UPS panel and mounting base frame shall be of 50 mm thickness & made of rubber material.

17.4.29 UPS Panel, material and coating shall be such that they can withstand the local environmental condition for 25 years without any damage. All Indoor UPS panels and UPSDBs shall be pre-treated as per IS 6005 before being factory-painted with epoxy-based paint shade of paint shall be RAL 7037. Corrosivity grade C5-M as per ISO 12944 shall be considered for indoor equipment. Painting shall be carried out by approved process. Sufficient quantity of touch-up paint shall be furnished for application at Site.

17.4.30 **Step-down transformer and voltage stabilizer**

a. A three phase to single phase vacuum impregnated dry type class-F insulated transformer along with associated voltage stabilizer shall be furnished with the UPS system.
b. The transformer and stabilizer shall be sized for 100% UPS load (+10% design margin) and shall coordinate with the largest branch circuit protection device for feeder short circuit current without sacrificing voltage regulation.

c. The voltage stabilizer shall employ silicon solid state circuitry and shall maintain the specified output voltage for 0 to 100% load with maximum input voltage variation as allowed. The make and rating shall be subject to Owner approval.

d. AC to DC Converter (Rectifier)

e. AC to DC converter of high MTBF shall be provided in 2x100% configuration of suitable DC output voltage suitable for DC loads of breakers, relays, etc.

f. The convertor shall receive supply from the UPSDB and shall be protected by MCB/MCCB of adequate rating.

g. Failure of one converter shall not interrupt DC supply to the breakers, relays etc.

h. Converter shall be capable to operate without damage at design ambient temperature and design ambient humidity. If the converter is placed inside an enclosure, the converter shall be suitable for the maximum temperature rise inside the enclosure.

i. Following protections shall be provided to the converter:

1. Electronic inrush current limiting Varistors
2. Internal safety fuse
3. Lower voltage than the specified minimum input will not damage the unit.

j. Converter shall be compliant with IEC/IS standards.

17.4.31 **UPS Distribution Boards**

a. The distribution boards shall be indoor, single front, fixed type, of modular design in free standing synthetic neoprene gasketed CRCA sheet steel enclosure conforming to IP43. Sheet steel thickness shall be 2 mm minimum.

b. A full height vertical cable alley shall be provided in each panel to facilitate module wiring. The alley shall be liberally sized and shall have removable cover at the front. Removable back covers shall be provided at the back of the panels.

c. Switches shall be double pole, air brake, heavy duty type, capable of safely making and breaking the full load current of associate circuit.

d. Switch handle shall have position indicator and provision of padlocking in ON & OFF positions. Further it shall be interlocked with access door for safety.

e. UPS DB shall have bottom entry for cables.

f. Cable entry facilities shall be provided with renewable gland plates of suitable thickness. Gland plates shall be pre-drilled. Spare holes shall be kept with grommet.

g. UPS DB shall be mounted on base frames made of ISMC-100 all around and their base shall be bolted with ISMC base frame. Pad between panel & base frame shall be 50mm rubber.

h. UPS DB shall be provided properly. Pre-treatment as per IS-6005 before painting. Surface shall be prepared with sand / shot blasting. Two coats of PU enamel coating system with high build

mastic primer. Epoxy based paint shade shall be RAL 7032. Sufficient quality of touch-up paint shall be furnished for application at Site.

17.4.32 **UPS Cabinets/Enclosures**

a. The UPS system components shall be housed in a CRCA sheet steel free standing IP43 enclosure with all access from the front. Sheet steel thickness shall be 2 mm minimum.

b. The enclosure shall consist of vertical cabinets housing modules in rack type sub-assemblies, connected mechanically and electrically to form a rigid, self-supporting, metal enclosed structure.

c. The modular units shall be mounted in pull out and/or swing trays. Each module shall be capable of being easily removed to provide for the ready inspection of major solid-state devices.

d. Vertical wiring trough shall be provided for the entire height of the UPS cabinet. Cable entry shall be from top & bottom.

e. Adequate ventilating louvers and screens shall be provided. The top of the panel shall be protected by a suitable drip cover to prevent entrance of falling liquid and foreign material.

f. If the equipment supplied requires forced air cooling, the cooling system furnished shall meet the following requirement:

1. Two (2) nos. 100% cooling fans shall be provided for each vertical panel.
    - Completely independent duplicate protection, control and wiring systems shall be provided for the cooling fans for redundancy.
    - The cooling fans shall be powered from the output of the associated inverter. Normally one fan will be running while the other is on stand-by.
    - Each cooling fan shall be equipped with an air flow switch having an alarm contact that closes upon failure of air flow.

17.4.33 **Alarms**

a. Microprocessor audio-visual annunciation system shall be provided for inverters, static transfer switch, battery charger.

b. Alarm facia shall be provided on each charger and inverter panel, complete with proper actuating devices, circuitry and legends.

c. The arrangement shall be such that on occurrence of a fault the corresponding window will light up and stays lighted until the fault is cleared and reset button pressed.

d. Each time a window lights up a master relay will get energized to provide group alarm signals for remote SAS/SCADA alarm system.

e. Alarm contacts shall be rated 0.5 A at 220 V DC and 5A at 240 V A.C.

17.4.34 **Lamp / Space Heaters / Receptacles**

a. The panels shall be provided with:

1. Internal illumination LED lamp with door switch.
2. Space heater with thermostat control.
3. 3-pin 5A receptacle with plug.

17.4.35 **Wiring / Cabling**

a. The panels shall be completely wired up. All wiring shall be done with flexible, 1100V grade, FRLS PVC insulated wires with stranded.

b. 2.5 sq.mm copper conductors and routed through wiring troughs. Each wire shall be ferruled by plastic tube with indelible ink print at both end having terminal block number and terminal number as per approved wiring diagram.

c. Panels shall have removable gland plate for cable entry. All incoming/outgoing cables shall be terminated in suitable terminal block.

d. Control terminal blocks shall be box-clamp type, minimum 20% spare terminals shall be furnished.

17.4.36 **Name plate**

a. Engraved nameplates shall be provided for each panel and for each equipment/device mounted on it.

b. The material shall be anodised aluminium / lamacoid, 3 mm thick, with white letters on black background.

c. Nameplates shall be held by self-tapping screws. The size of nameplates shall be approximately 20 mm x 75 mm for equipment and 40 mm x 150 mm for panels.

d. Nameplates for panels shall be provided both on the front and rear.

e. Control and meter selection switches shall have integral nameplates. Nameplates for all other devices shall be located below the respective devices.

f. Instruments and devices mounted on the face of the panels shall also be identified on the rear with the instrument/device number. The number may be painted on or adjacent to the instrument or device case.

g. Caution notice on suitable metal plate shall be affixed at the back of each panel.

17.4.37 **Grounding**

a. Normally A.C power supply will be grounded at the source. For grounding other than this, isolation transformer shall be furnished with the U.P.S.

b. The inverter D.C. input and A.C. output shall be electrically isolated from each other and from cabinet ground.

c. Panels shall have fully rated ground bus with two ground terminals, one at each end.

d. Each terminal shall comprise two-bolt drilling M10 G.I. bolts and nuts to receive Owners' ground connection of Cu flat of appropriate size.

e. Separate electronic grounding shall be provided for UPS system.

**17.5 Painting-UPS**

17.5.1 The panels shall be finished in RAL-7032 with two coats of dry powder coated paint. The panels shall have a matt finish to prevent any glare from surface due to illumination.

**17.6 Tests-UPS**

17.6.1 All equipment and components thereof shall be subject to shop tests as per relevant IEC/BIS Standards. The tests shall include, but shall not be limited to

a. Tests on Battery

1. Following type tests on two cells of the Battery, even if type test certificates ofthese tests are submitted by the Bidder for Owner's approval:
    - Test for capacity - test for voltage during discharge
    - Ampere hour & watt hour efficiency test
    - Endurance test.

b. Tests on UPS System

1. Type & routine test for various components.
2. Burning test on PCBS - Assembled PCBS shall be tested at 70 °C for 72 hours in loaded condition.
3. Rapid temperature cycling test at 70 °C and 0 °C for 30 minutes at each temperature - 5 such cycles.
4. Functional tests to demonstrate compliance with all specified requirements and published. Specifications such as frequency, regulation, voltage regulation, current limiting, fuse clearing capability of inverters, demonstration of phase and frequency control of inverter for synchronization with range of adjustments transfer and retransfer of static switches under influence of under voltage and over current, tests on chargers, batteries, and other system component to confirm compliance with specification.

17.6.2 Type test certificates of any equipment shall be furnished, if so desired by the Owner. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

**17.7 Special Tools & Tackles-UPS**

17.7.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

17.7.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended for selecting Battery capacity.

a. Short circuit release
b. ON/OFF and Trip position indicators.
c. On / Off and Trip position potential free contacts to be integrated to HMI (Controller) & SAS
d. Test trip push button
e. Suitable voltage rating for DC

**17.8 Warranty**

17.8.1 The warranty period of the UPS shall minimum five (05) year and batteries shall be warranted for a minimum of 2 (two) years against all material/ manufacturing defects from the date of Commissioning of Facility.

**17.9 Tests-UPS**

17.9.1 The equipment offered shall be type tested and proven type. Type test certificates shall be furnished for approval. All routine and acceptance tests in accordance with the latest version of applicable standard shall be conducted.

17.9.2 Copies of certified reports of all type tests carried out on similar type and rating shall be furnished. In absence of such type tests certificates or in case such certificates are not found to be meeting the relevant standard requirements, Bidder shall conduct all such tests according to relevant standards free of charge to Owner and reports shall be submitted to Owner for approval.

17.9.3 Sampling scheme and criteria for acceptance shall be as per IS.

17.9.4 Bidder shall carryout the following Site tests:

a. Light Load Test
b. AC input failure test
c. AC input return test
d. Auto changeover test
e. Full load test
f. Rated stored energy time (battery test)
g. Rated restored energy time.

17.9.5 Test reports shall be submitted for approval before the dispatch of batteries.

17.9.6 Acceptance test shall be conducted at Site on completion of installation and commissioning and immediately prior to putting the battery in service.

### 17.10 Drawings, Data and Manual-UPS

17.10.1 To Be Submitted After Award of Contract.

a. Technical data sheet
b. Dimensional general arrangement (GA) drawings for battery, battery chargers, DCDBs if any etc.
c. Schematic and wiring diagram for chargers & DCDBs
d. Sizing calculation for battery and charger with relevant assumptions and characteristic curves
e. Sizing calculation for heat loss and ventilation requirement
f. Dimensional GA drawing for battery, MCCB box and discharge resistor
g. Drawings for battery rack & fixing arrangement
h. Foundation plan and loading details.
i. Quality Plan
j. Test certificates
k. O&M manual

### 17.11 Special Tools and Tackle-UPS

17.11.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

17.11.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended for selecting Battery capacity.

17.11.3 Bidder shall provide the list with expenses for the special tools & tackles for Aux system alone with bid.

### 17.12 Part B - DC Charger

17.12.1 DC Charger Introduction

This section covers requirement of 220V DC system complete with DC batteries and chargers. The DC battery charger shall be used to power critical and non-critical loads during presence and absence of AC power supply from auxiliary transformer. Suitable DC-AC converters shall be provided by the bidder if the loads are AC system.

17.12.2 Codes and Standards

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC / IEEE standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below.

| Codes and Standard | Description |
|---|---|
| IEEE: 485 | Recommended practice for sizing for large lead storage batteries for generating stations and substations. |
| IS: 14782 | Code of practice for maintenance and testing of large lead- acid batteries for generating systems and substations |
| IS: 266 | Specification for sulphuric acid. |
| IS: 1146 | Specification for rubber & plastic containers for lead acid storage batteries |
| IS: 1651 | Specification for stationery cells & batteries, lead acid type with tubular positive plates. |
| IS: 3116 | 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. |

### 17.13 General Requirements - DC Charger

17.13.1 For each DC system, 2x100% batteries, 2x100% float cum boost chargers (FCBCs) and one no. of DC distribution board (DCDB) shall be provided as per the Owner's technical specification.

17.13.2 The maximum voltage variation allowed at the load end shall be +10% to -15% at all operating conditions for both DC systems.

17.13.3 The 220V DC system shall be unearthed. A DC earth monitoring system shall be provided for the DC systems and alarm shall be given on the occurrence of an earth fault.

17.13.4 The chargers shall be supplied power from auxiliary transformer's AC Distribution Board/Box.

17.13.5 Battery stand rack shall be free standing. Suitable porcelain / plastic insulators shall be provided between the stand and the battery room.

17.13.6 Manual discharge resistance bank suitable for each type of battery bank of Battery Charger has to be provided by bidder.

### 17.14 DC Charger

17.14.1 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 minimise harmonics. The charger should be capable to fully charge the required batteries as well as supply the full rated load.

17.14.2 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%. Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle or Boost charging. 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. dSoft 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. 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. 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. 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. 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. 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. 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.

17.14.3 Digital Outputs shall be configured for connection to the SCADA for realtime charger status updation. Outputs like charger output current, output voltage, float/boost mode, etc. may be configured to provide the update to SCADA.

17.14.4 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.

17.14.5 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. The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective Charger. Digital or analog indicating instruments shall indicate DC current, DC voltage & AC voltage.

17.14.6 The Chargers shall be indoor, floor mounted, self-supporting sheet metal enclosed cubicle type. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The Charger shall be fabricated using cold rolled sheet steel shall not be less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied by the Contractor. The Charger shall be tropicalized and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The Chargers shall have hinged double leaf doors provided on front and/or backside for adequate access to the Charger internals. All the Charger cubicle doors shall be properly earthed. 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. All acceptance and routine tests as per the manufacture recommendations and relevant standards shall be carried out. The cabinets shall be IP-42 protection class for indoor application and IP65 for outdoor application. 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 Owner and mutually agreed between the Contractor and the Owner.

### 17.15 DC Distribution Board (DCDB)

17.15.1 For feeding the 220 V DC loads, one (01) number of DC switchboard with bus coupler shall be provided.

17.15.2 The DCDB shall be provided with suitably rated incomers, required quantity and type of outgoing feeders for the auxiliaries, control supplies to various panels/systems in accordance with the number of 220 V DC supplies. In addition, the following feeders shall be provided in each DCDB. 10% or minimum of two nos. feeders of each type whichever is higher shall be provided as spare in each bus section and rating. No. of feeders (Incomer & outgoing) shall be as per the SLD enclosed.

17.15.3 The continuous current rating of the bus bars, incomers, ties for 220 V DCDB shall be the maximum DC load (excluding the momentary load) on the bus due to any operating condition, when unit system additionally feeds station system or vice-versa plus 20% margin rounded off to the next higher standard rating.

17.15.4 MCCB shall be double pole type for incoming and tie feeders. It shall be quick make, quick break, independent manual type with trip free feature. All MCCB shall have the following:

a) Short circuit release
b) ON/OFF and Trip position indicators.
c) On / Off and Trip position potential free contacts to be integrated to HMI (Controller) & SAS
d) Test trip push button
e) Suitable voltage rating for DC

17.15.5 DCDB shall be provided with +ve and -ve bus bars.

17.15.6 DC Distribution boards (220V) shall be metal enclosed, fixed type, double front, compartmentalized construction. The distribution board frame shall be fabricated using CRCA sheet steel of thickness not less than 2.0mm. The frames shall be enclosed by CRCA sheet steel of thickness not less than 1.6mm.

17.15.7 Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP55 for indoor installation.

17.15.8 DBs shall have bottom entry for cables. Cable entry facilities shall be provided with removable gland plates (pre-drilled) of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

17.15.9 The incomer modules shall be MCCB controlled. Each incomer shall be provided with:

i. Incoming Double Pole MCCB
ii. Battery Double pole MCCB
iii. 0.5 accuracy class Digital multifunction meter (144X144 sq. mm bezel, 94mm behind bezel, Aux supply – 80 to 300V AC/DC, RMS 4 digit, Integral 8 digit, Casing-ABS IP54 for front display, Communication

through RS485 port) on incomer with communication facility for interfacing with SAS.

iv. Earth fault relay.

v. Under voltage relay with time

vi. Indicating lamps for ON, OFF, EARTH FAULT, UNDER VOLTAGE conditions.

vii. Current and voltage transducers for remote indication.

viii. Necessary hardware and circuitry for fault alarm, lamp test and alarm rest

17.15.10 Outgoing feeders:

i. These feeders shall be provided with suitably rated DP MCB and status & fault indicating lamps.

ii. The feeders rated 200 Amps and above shall be provided with a shunt and ammeter.

17.15.11 Following indications/alarms shall be available in the SCADA:

i. Incomer, bus coupler, ties - ON & OFF

ii. Incomer current

iii. Incomer alarm supply fail

iv. Bus under voltage

v. Bus earth fault

vi. Bus voltage

17.15.12 All Indoor equipment, panels and cabinets DCDBs shall be pre-treated as per IS 6005 before being factory-painted with epoxy based paint shade of paint shall be RAL 7035. Corrosivity grade as per ISO 12944 shall be considered for indoor equipment. Painting shall be carried out by approved process. Sufficient quantity of touch-up paint shall be furnished for application at Site.

**17.16 Ancillaries - DC charger**

17.16.1 Battery is connected with charger by adequate capacity MCCB. Also, Battery Discharge test MCCB is provided in same enclosure. Panel/Enclosure with above two MCCB's shall be placed in battery room.

17.16.2 Panel/Enclosure shall be wall mounted with wall clamps. Cable entry shall be from bottom. Removable gland plates (pre-drilled) of suitable thickness shall be provided. Panel/Enclosure frame shall be fabricated using CRCA sheet steel of thickness not less than 2.0mm. The frames shall be enclosed by CRCA sheet steel of thickness not less than 1.6mm. Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP55 for indoor installation. Panel shall be pre-treated as per IS 6005 before being factory-painted with epoxy-based

paint shade of paint shall be RAL 7035. Corrosivity grade as per ISO 12944 shall be considered for indoor equipment. Painting shall be carried out by approved process.

17.16.3 MCCB shall be double pole type for battery outgoing and discharge test feeders. It shall be quick make, quick break, and independent manual type with trip free feature. All MCCB shall have the following:

i. Short circuit release
ii. ON/OFF and Trip position indicators.
iii. On / Off and Trip position potential free contacts to be integrated to HMI (Controller) & SAS
iv. Test trip push button
v. Suitable voltage rating for DC

**17.17 Tests - DC charger**

17.17.1 The equipment offered shall be type tested and proven type. Type test certificates shall be furnished for approval. All routine and acceptance tests in accordance with the latest version of applicable standard shall be conducted.

17.17.2 Copies of certified reports of all type tests carried out on similar type and rating shall be furnished. In absence of such type tests certificates or in case such certificates are not found to be meeting the relevant standard requirements, Bidder shall conduct all such tests according to relevant standards free of charge to Owner and reports shall be submitted to Owner for approval.

17.17.3 Sampling scheme and criteria for acceptance shall be as per IS.

17.17.4 Bidder shall carryout the following Site tests:

a) Light Load Test
b) AC input failure test
c) AC input return test
d) Auto changeover test
e) Full load test
f) Rated stored energy time (battery test)
g) Rated restored energy time

17.17.5 Test reports shall be submitted for approval before the dispatch of batteries.

17.17.6 Acceptance test shall be conducted at Site on completion of installation and commissioning and immediately prior to putting the battery in service.

### 17.18 Warranty

17.18.1 The warranty period of the DC charger shall minimum five (02) year and batteries shall be warranted for a minimum of 2 (two) years against all material/ manufacturing defects from the date of Commissioning of Facility.

### 17.19 Special Tools and Tackle - DC charger

17.19.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

17.19.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended for selecting Battery capacity.

17.19.3 Bidder shall provide the list with expense for the special tools & tackles for DC system alone with bid.

### 17.20 Battery

17.20.1 **General**

1. The batteries shall be sealed maintenance free valve regulated lead acid (SMF-VRLA) types.
2. The equipment shall comply with the requirement of latest revision of following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

| Codes and standards | Description |
|---|---|
| IEEE: 1189 | IEEE guide for selection of VRLA Batteries for Stationary Applications. |
| IEEE: 485 | Recommended practice for sizing for large lead storage batteries for generating stations and substations |

17.20.2 **Technical Requirement**

1. Battery sizing and cell selection shall be based on IEEE: 1189 & IEEE 485.
2. The battery shall be sized for a discharge rate with end cell voltage not less than 1.75 V. Suitable electrolyte temperature correction factors shall also be considered for the Site ambient temperature (10˚C higher than outside ambient air temperature). Minimum system voltage for DC shall not be lower than 85% and maximum system voltage shall not be more than 110%.
    i. Design Margin : 20%
    ii. Ageing Factor : 25%
3. The duty cycle imposed on the battery shall include the following. All momentary loads shall be treated as one-minute loads:

- Continuous loads due to indicating lights, continuously energized coils, Control Panels, Relays.
- Momentary loads due to switchgear operation.

4. Batteries shall be rated for the suitable discharge rate as per manufacturer data.
5. 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 fail. Batteries shall be suitable for a long life under continuous float operations and occasional discharges.
6. Containers shall be made of fire-retardant polypropylene. Containers shall be clear, robust, heat resistance, shock absorbing, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc.
7. Batteries shall have thick Positive plates & negative Plates with low Corrosion, low self-discharge rates & maintenance free characteristics.
8. Battery terminals shall be specially designed for sustained high current discharges.
9. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely.
10. The positive and negative terminals shall be clearly marked.
11. The following items shall be provided for the Battery.
    - Long/Short connectors with insulated cover (if applicable)
    - Inter row connectors with insulated cover (if applicable)
    - Fasteners
    - Cell number plates
12. Lead coated copper connectors shall be used for connectors. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. The cell terminals posts shall be provided with connector bolts and nuts, effectively coated with lead to prevent corrosion.
13. End take off connections from positive, negative and tap cell terminals of the battery shall be suitable for single core cables having XLPE insulated stranded aluminium conductors. Necessary supports for termination of these cables on the batteries shall be provided by the Bidder.
14. All the inter cell, inter row and interbank connectors supplied along with the battery shall be capable of continuously carrying the maximum discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared.
15. Lead-coated bent copper plate, tubular copper lugs, wooden clamp, bolts, nuts, washers, etc. shall be furnished for connection of outgoing copper conductor cables.

16. Battery Racks shall be free standing insulated steel stand type. Numbering tags for each cell shall be attached on to the racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled conditions, suitable match markings shall be provided to facilitate easy assembly.
17. The following information shall be legibly and durably marked on each cell/battery:
    - Manufacturers' name and trademark
    - Country & year of manufacture
    - Manufacturers' type designation
    - AH capacity at (***) hour discharge rate
    - Serial Number
    - Polarity marking
    - Nominal voltage of cell
    - Upper and lower electrolyte levels

# 18. AC Distribution Boards (ACDB)

## 18.1 Introduction

18.1.1 Alternating Current Distribution Board (ACDB) is used to facilitate the Auxiliary power supply from Auxiliary transformer of Plant to essential and non-essential electrical loads. The system shall be used to supply 415V/240V AC main/auxiliary power for normal operation, control & protection of the Plant.

## 18.2 Codes and Standards

18.2.1 The AC Distribution Board to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC/ IEEE standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| IS 13032 | Miniature circuit breaker boards for voltages not exceeding 1000V |
| IS 6005 | Code of practice for phosphate of iron and steel |
| IEC/IS 60947 | Low voltage switchgear and control gear part I |
| IEC 61641 | Testing of assemblies |
| IS 2705 | Steel scaffoldings |
| IS 6297 | Electrical test methods for low voltage energy cables. |
| IS 8623 | Low voltage switchgear and control gear assembly |
| IS 1893 | Seismic design of structure |

## 18.3 General Requirements

18.3.1 Duty involves supply of auxiliary power to control and protection system, lighting and space heating, motor drives of various Substation equipment, etc.

18.3.2 The equipment will be located in a hot, humid, and tropical atmosphere, heavily polluted at places.

18.3.3 Bus bars of DBs/MCCB Boards shall be sized to carry continuously the total connected load of the DBs/ MCCB Boards (including anticipated future load, wherever applicable) plus a 20% margin.

18.3.4 In-cubicle ratings of incomer and bus-section breakers/switches shall be identical to the associated busbar rating. Incomers shall be provided with MCCB. Above 800 A, all breakers shall be Air circuit breaker with control and monitoring.

18.3.5 For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and/or this specification.

18.3.6 All equipment and components thereof shall be capable of withstanding the appropriate mechanical forces and thermal stresses of the short circuit current without any damage or deterioration of material.

18.3.7 Circuit breakers shall not produce any harmful over voltage during switching off of induction motors. If required, surge protective devices shall be used to limit over voltages.

18.3.8 Design and selection of all components shall be made liberally with a design margin of safety factors, and these shall be subject to Owner's approval.

18.3.9 Derating factors employed for each component along with their basis shall be clearly stated in the bid.

18.3.10 The distribution of single/three phase shall be arranged through MCBs to various load points.

18.3.11 For ACDB, only two out of the two incomers & bus coupler can be closed at a time. Mechanical / key interlock shall be provided so as to ensure that only two of them can be closed at a time.

18.3.12 The system shall be in outdoor condition.

**18.4 Specific Requirements**

18.4.1 Construction

a. DBs shall be Outdoor/indoor, air insulated, and metal-clad type. The design construction shall be such as to permit extension at either end. DBs shall be fixed type.

b. DBs shall be suitable for floor-mounting and shall be of single-front construction.

c. In control room, DB enclosures shall conform to the degree of protection IP 65 for Outdoor. Minimum thickness of sheet metal used shall be 2 mm.

d. The design shall be such that the specified degree of protection is achieved even after a breaker control module has been taken out of the panel.

e. DB assemblies shall comprise of a continuous line-up of dead-front, free-standing vertical sections, housing the control modules in multi-tier formation.

f. DBs shall be front-wired and front-connected.

g. DBs shall be fully compartmentalized with metal/ insulating partitions between compartments. Working height shall be limited between 450mm and 1800mm from floor level.

h. For ACDB each breaker/control module shall be housed in a separate cubicle complete with an individual front access door having sufficient opening with concealed type hinges.

i. Each vertical section shall have a removable back cover. All doors and covers shall be gasketed.

j. For DBs modules, all push-buttons, lamps, and indicating instruments shall be flush/semi-flush mounted on respective module compartment.

k. For single-front assemblies, a full-height vertical cable alley with cable supports shall be provided in each section to facilitate unit wiring.

l. The alley shall be liberally sized to accommodate all cables as per cable schedule and shall have removable cover at the front for access. The minimum width of cable alley shall be 300 mm.

m. A horizontal wire way extending the entire length of the assembly shall be provided of the top for inter-panel wiring.

n. Incomers shall be provided at the ends of an assembly and bus section, wherever required, shall be provided at the middle of the assembly.

o. Four (4) nos. lifting lugs shall be for each section, two (2) nos. on either end of the section.

p. DBs shall be supplied with base frames made out of structural steel sections along with all necessary mounting hardware required for bolting/welding the base frames to the foundation.

q. After isolation of power and control circuit connections, it shall be possible safely carry out maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose over the cable terminations located in cable alley.

r. The minimum clearance in air between phases and between phases and earth for the entire run of horizontal and vertical busbars shall be 25 mm. For all other components, the clearance between two live parts, a live part and an earthed part, and isolating distance shall be at least 10mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by barriers. However, for horizontal and vertical busbars, the clearances mentioned above should be maintained even when these are sleeved or insulated. All connections from busbars upto MCCB/ACB shall be fully shrouded to minimize the risk of phase to phase and phase to earth shorts.

18.4.2 Moulded Case Circuit Breaker

a. Moulded Case Circuit Breaker shall be quick acting, preferably with a total arc extinction time of less than 24 milli-seconds, trip free and should be able to operate satisfactorily under overload and short circuit conditions.

b. Moulded case circuit breakers shall have current limiting design. The outgoing MCCB, where provided, shall have LSIG (Long time - short time - Instantaneous - Ground) as inbuilt function.

c. Moulded Case Circuit breakers of identical rating shall be physically and electrically interchangeable.

d. Moulded case circuit breakers shall be provided with 2 NO and 2 NC electrically separate auxiliary contacts.

e. MCCB shall comply with IEC 60947, IEC 60947-2 & IEC 60947-3 and IEC 60947-6-1 standards.

18.4.3 Miniature Circuit Breaker

a. MCB shall be suitable for manual closing and opening and also automatic trip on overload and short circuit.

18.4.4 Bus and Bus Taps

a. ACDBs shall be provided with three phase busbars and neutral busbar.
b. All busbar compartments shall be completely enclosed.
c. Horizontal and vertical busbars and bus connections shall be of high conductivity copper alloy. The maximum temperature of busbars and bus connections shall be limited to 85˚C i.e. 35˚C rise over 50˚C ambient. No diversity factor shall be allowed for temperature rise.
d. Vertical busbars shall be designed for a minimum current rating of 200 A.
e. All bus connections shall be provided with anti-oxide grease. Adequate contact pressure shall be ensured by means of two-bolt connection with plain and spring washers and locknuts.
f. Bimetallic connectors shall be provided for connections between dissimilar metals.
g. All busbars and bus connections shall be fully insulated for working voltage. Insulating heat shrinkable sleeves shall be provided for all busbars. All joints and tap-off points shall be shrouded.
h. Bus insulators shall be non-hygroscopic, flame retardant, track resistant, high strength, sheet molded compound or equivalent polyester fibre glass molded type. Separate supports shall be provided for each phase and neutral busbar.
i. Cross-section of the busbars shall be uniform throughout the length of the assembly. All busbars and bus connections shall be supported and braced to withstand the stresses due to maximum short circuit current and also to take care of any thermal expansion.
j. Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left-to-right, top- to-bottom, or front to rear when viewed from the front of the assembly.
k. Bolted disconnecting links shall be provided for all incoming and outgoing feeders for isolation of neutral, if necessary.
l. Cu Busbar shall be provided on the top for AC/DC control supply, PT supply, space heater supply and other auxiliary supply.

18.4.5 DB Modules

a. Modules shall have self-aligning power/control disconnects. All disconnects shall be silver plated to ensure good contacts.
b. Modules of same size and type shall be physically and electrically interchangeable.
c. Various module sizes should be multiples of one basic unit to facilitate modifications at Site. Suitable provision for this purpose should also be incorporated in the vertical busbars.

d. Modules shall house the control components for a circuit such as switch, MCB/MPCB contactors, relays, push-buttons, lamps, meters, etc. only the push-button actuators, lens' of indicating lamps, and transparent windows for meters shall be mounted on module door such that when the module is withdrawn, the cubicle door shall provide specified IP-54 degree of protection when the module door is closed.

e. Breaker operated incomers, bus sections and outgoing feeder shall be provided with one (1) TEST-NORMAL selector switch.

f. Contactor operated motor feeder modules shall be provide with one (1) no. LOCAL-REMOTE selector switch.

g. These selector switches shall be lockable type and shall be mounted on front door of panel.

h. The equipment layout shall provide sufficient working space in between the components.

18.4.6 MCB/ MCCB

a. All isolation points within the electrical system shall utilize MCBs or MCCBs instead of fuses.

b. The ACDB incomer circuit breaker shall be an MCCB only.

c. The specific type of MCB or MCCB (e.g., frame size, number of poles, tripping characteristics) shall be determined based on the circuit's voltage, current rating, and fault level.

d. All circuit breakers shall be compliant with relevant IEC standards for safety and performance.

e. A clear labelling system shall be implemented to identify the function and purpose of each circuit breaker.

18.4.7 Control and Indication

a. Detailed requirements of individual circuits shall be developed by the Bidder.

b. Push buttons shall be heavy duty, oil tight and push to actuate type with integral escutcheon plate marked with its function.

c. Each push button shall have minimum two (2) NO and two (2) NC contacts rated 10A at 240 V A.C.

d. Selectors switches shall be stay-put, rotary type with escutcheon plates marked to indicate the function and positions and shall be lockable in each position. Selector switch contacts shall be rated for 10A at 240 V A.C.

e. Selector switches shall be provided with minimum three (3) contact blocks of 1 NO + 1 NC each.

f. The exact requirements contacts shall be decided by the Bidder considering the scheme requirement and spares.

g. Lamps shall be LED type. The body shall be made of Poly Carbonate Unbreakable Lens. LED shall be protected by inbuilt fuse with surge suppressor or leakage voltage glow protection.

LED circuit shall be PCB mounted. Intensity shall be greater than 200 mcd. All Push Button lamp shall be as per LED indicating lamp.

h. For control supply, two (2) nos. adequately rated 415/240V ±5% epoxy moulded class-B insulated control transformers with necessary taps shall be provided. Auxiliary bus bars shall be used to distribute 415/240V AC control supply. The control supply of different modules shall be tapped individually from the auxiliary bus bars. Transformer ratings shall be so selected to facilitate 100% standby arrangement with adequate spare capacity.

18.4.8 Meters and Meter Selector Switches

a. AC Distribution Boards shall have the following meters:

1. 0.5 class MFM, 3 phase, 4 wire, 3 elements, with RS485 port –. MFM's are to be integrated with SAS.

b. All MFM's shall be of HT type only with CT/PT input. MFM shall be of 0.5 class for general metering, with RS-485 communication port, and CT/PT shall be of 0.5 class.

c. All MFM shall have facility of Real time clock and will be connected with SCADA. SCADA shall have provision to generate 15 minutes data for each MFM.

d. MFM shall have record following parameters.

1. Phase to Neutral voltage
2. Average Phase to neutral voltage
3. Phase to Phase voltage
4. Average Phase to Phase voltage.
5. Line current (L1, L2, L3 and Average)
6. Active / Reactive Current
7. Frequency
8. Power factor
9. Average Power factor
10. Active Power
11. Total Active Power
12. Reactive Power
13. Total Reactive Power
14. Apparent Power
15. Total Apparent Power
16. Active Total Import / Export Energy
17. Reactive (Q1, Q2, Q3, Q4) Energy
18. Apparent Import / Export Energy
19. Cumulative MD

20. Phase Angle
21. Power On / Off Hours
22. Load On / Off Hours
23. Feeder Interruptions Count (When Aux is also off)
24. THD Voltage
25. THD Current
26. THD Power
27. RPM with Freq and Voltage unbalance and current unbalance
28. Modbus on RS 485

18.4.9 Current Transformer

a. Current Transformers shall be epoxy cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection will be made. Insulation class of C.T. shall be B type.
b. Other CT particulars like ratio, burden knee-point voltage, excitation current and secondary resistance shall be decided by the Bidder and approved by Owner.
c. CT secondary shall be rated for 1 A for metering.

18.4.10 Secondary Wiring

a. All boards shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and interlocking schemes.
b. MCB shall be provided to permit individual circuit isolation from bus without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired upto terminal blocks.
c. Wiring shall be done with flexible, 1100 V grade, FRLS PVC insulated switchboard wires with stranded copper conductors of 2.5 mm2 for control, current and 1.5 mm2 voltage circuits.
d. Each wire shall be ferruled by plastic tube with indelible ink print at both end having terminal block no., terminal no., destination no. as per approved Drawing. For CT & PT wiring shall be done with RYB colour wire.
e. Wire terminations shall be made with crimping type connectors with solderless insulating sleeves. Wires shall not be spliced between terminals.

18.4.11 Terminal Blocks

a. Terminal blocks shall be 660V grade box-clamp type 10 mm2 minimum with marking strips. Terminals for C.T. secondary leads shall have provision for shorting.
b. Terminals blocks used for interface with SAS via termination cabinet shall be suitably sized to facilitate proper termination of interconnecting cables.

c. Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished.

d. Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

18.4.12 Cable Termination

a. Generally, all assemblies shall be designed for cable entry from the bottom. Sufficient space shall be provided for all the cables as per cable schedule, for ease of termination and connection.

b. All provisions and accessories shall be furnished for termination and connection of cables as per cable schedule, including removable gland plates, cable support, and crimp type tinned copper/aluminium lugs, double compression brass glands with tapered washer (Power cable only) and terminal blocks.

c. Gland plates shall be minimum 3 mm thick. The gland plate and supporting arrangement for 1/C power cables shall be non-magnetic type to minimise the flow of eddy current.

18.4.13 Ground Bus

a. A ground bus, rated to carry maximum fault current, shall be provided which shall extend the full length of the assembly. Minimum size of ground bus shall be 60 x 10 mm Cu.

b. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end and shall be suitable to receive 25 x 3 mm Cu. flat.

c. All stationary units shall be directly connected to the ground bus for effective grounding.

d. The frames of all circuit breaker units shall be grounded through heavy multiple contracts at all times except when the primary disconnecting devices are separated by a safe distance.

e. The frames of all other draw out modules shall be grounded at all times except when the power disconnects are separated by a safe distance.

f. Wherever the schematic diagrams indicate a definite ground at the switchgear; a single wire for each circuit thus grounded shall be run independently to the ground bus and connected thereto.

g. C.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others.

h. All hinged doors shall be earthed by flexible copper braid.

18.4.14 Nameplates

a. Nameplates of approved design shall be provided on each cubicle, at the top of the assembly and on each instrument & device mounted on or inside the cubicle.

b. The material shall be lamacoid or approved equal. 3 mm thick with white letters on black background.

c. The name plates shall be held by self-tapping screws. Name plate size shall be minimum 20 x 75 mm for instrument/devices & 40 x 50 mm for panels.

d. Caution notice on suitable metal plate shall be affixed both at the front and back of each vertical panel.

18.4.15 Space Heaters and Plug Sockets

a. Each vertical section shall be provided with thermostat-controlled space heater and 5A, 3 pin plug socket.

b. Cubicle heater and Plug-socket circuit shall have individual switch fuse units.

18.4.16 A.C. Power Supplies

a. Necessary 415V AC power supplies as required for control and service, shall be arranged by the Bidder.

18.4.17 Painting

a. All assemblies shall be finished in RAL-7032 with two coats of dry powder coated paint. Painting process shall be of powder coating type.

**18.5 Tests**

18.5.1 The ACDB shall be completely assembled, wired, adjusted, and tested at the factory as per the relevant standards.

18.5.2 Routine Tests

a. The tests shall include but not necessarily limited to the followings:

1. Operation under simulated service condition to ensure accuracy of wiring, correctness of control scheme & proper functioning of the equipment.
2. All wiring and current carrying parts shall be subjected to appropriate High Voltage Test.
3. Primary current & voltage shall be applied to all instrument transformers.
4. Routine test shall be carried out on all equipment such as circuit breakers, instrument transformers, relays, meters, contactors, switch-fuses, etc.

b. Type test certificates of any equipment shall be furnished if so desired by the Owner. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design. Type tests performed before five (5) years are not acceptable.

**18.6 Special Tools & Tackles**

18.6.1 A set of special tools & tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

18.6.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

# 19. Earthing System

## 19.1 Introduction

19.1.1 This specification is intended to outline the requirement of earthing (grounding) for the BESS 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.

19.1.2 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.

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

## 19.2 Codes and Standards

19.2.1 The Earthing System to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC/ IEEE standards including amendments, if any, except where modified and /or supplemented by this specification. Some of the applicable standards are listed below:

| Standard | Description |
|---|---|
| ANSI/IEEE: 80 | Guide for safety in AC Substation Grounding |
| IS 3043 | Code of practice for Earthing. |
| IEC 62561-7 | Requirements for earthing enhancing compounds |
| IEEE: 837 | Standard for qualifying permanent connections used in substation grounding |
| UL-467 | Grounding and Bonding Equipment |
| CBIP Publication: 223 | Design of Earthing Mat for High Voltage substation |
| CEA regulations for electrical safety | |
| Indian Electricity Rules/ Indian Electricity Act. | |

## 19.3 General Requirements

19.3.1 Design and installation of the earth mat and other associated system shall confirm IS: 3043.

19.3.2 The earth resistance should be less than 1 Ohm. Suitable number of earthing pit shall be provided at the BESS field.

19.3.3 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 handrails 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. Every alternate post of the Plant 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/IDT/ICOG/Switchgear panel shall be earthed with two distinct connections at minimum two columns. The entire wall cladding section shall be earthed at minimum two locations with flexible copper cable of not less than 50 sq. mm.

19.3.4 Each continuous laid lengths of cable tray shall be earthed at minimum two places by earth strip to earthing system, the distance between earthing points shall not exceed 30 meters. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.

19.3.5 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.

19.3.6 The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.

19.3.7 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.

19.3.8 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.

19.3.9 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.

19.3.10 Earthing conductors buried in ground shall be laid minimum 600 mm below grade level. 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.

19.3.11 Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

19.3.12 Minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipelines, 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.

19.3.13 Earth pit shall be constructed as per IS: 3043. Electrodes shall be embedded preferably below permanent moisture level.

19.3.14 Earth pits shall be treated with earth enhancement compound weight if resistivity is more than 20-ohm meter. In addition, and if necessary, more numbers of earth pits and conductors shall be provided to achieve earthing resistance less than 1 Ohm. For each earth pit, necessary Test Point shall have to be provided.

19.3.15 The complete earthing system shall be mechanically & electrically connected to provide independent return to earth.

19.3.16 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 in the presence of the representative of Owner/Owner. All equipment required for testing shall be furnished by bidder.

19.3.17 The earthing system shall be connected to the following.

a. Containerized Battery Storage System or BESS containers, racks, DC combiner panel and any metallic objects.
b. The neutral point of each system/equipment
c. Equipment framework and other non-current carrying parts.
d. Frames of panels & cubicles, Inverter room
e. Metallic structures of switchgear, cable racks, casing of cable boxes
f. Equipment supporting Steel structures.
g. All extraneous metallic framework not associated with equipment.
h. The earth points of lightning arrestors; voltage transformers and lightning conductors through their permanent independent earth electrodes.
i. Fence

### 19.4 Technical Details for AC Earthing System

19.4.1 This section outlines the requirements of protective and functional earthing system to discharge AC fault current to earth and provide equipotential bonding for Inverter Duty Transformer (IDT), HT ICOG Panel and other similar electrical equipment, Inverter Duty Transformer neutral and shield.

19.4.2 The bidder shall furnish the detailed design and calculations as per IEEE 80/IS 3043 for Owner's approval.

19.4.3 Bidder shall ensure there at least two earth pits each dedicated for earthing of Inverter duty Transformer (IDT), HT ICOG panel, IDT neutral, Lighting Distribution Panel (LDB), 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.

19.4.4 Earthing system of different equipment such as control building, Inverter Duty Transformer, ICOG panel shall be interconnected in single network of earthing with buried conductor of the MS Flat laid at a depth to achieve equipotential grounding of the electrical equipment. Bidder shall submit the calculation based on the system of earth conductor and electrode connected in single network during detail engineering.

19.4.5 For Earthing of electronic equipment such as PCS, UPS, Battery chargers, Inverter etc. bidder shall follow the OEM's recommendation to provide dedicated earth pit/s near the equipment as applicable.

19.4.6 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 flat.

19.4.7 The Grid substation earthing shall be same as existing philosophy of substation/better solution. During detail engineering, bidder shall submit the calculation for approval and Owner's decision shall be final.

**19.5 Technical Details for BESS Earthing System**

19.5.1 International standards for specific BESS shall be recommended by bidder, (if available). Though the acceptance of standard shall be Owner's decision.

19.5.2 Every equipment shall be effectively earthed by two separate and distinct connections to earthing system. Earthing system shall consist of interconnected earth pits electrodes connected by GS flat or Copper Clad Steel (CCS) earthing. DC-AC earthing shall be connected through test link wherever it is required.

19.5.3 Minimum size of riser conductor to connect the structures to buried earthing conductor and structure to structure in the BESS farm shall be GS Flat or CCS of Min. 80 x 6 Sq.mm size.

19.5.4 Periphery fencing wherever provided shall be earthed at every 100-meter interval with GS flat connected with DC or AC side nearest buried earthing conductor.

19.5.5 The Bidder shall furnish the detailed design and calculations for Owner approval as per IEEE 80 to determine the number of earth pit and size of earth conductor.

19.5.6 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 Plant 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 Plant.

19.5.7 Connection of DC earthing system and AC earthing system with location and manner of connection shall be approved during detail engineering. Bidder shall submit the design calculation of earthing system of AC and DC side as standalone (no interconnection) system.

19.5.8 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.

19.5.9 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.

19.5.10 Each Containerized Battery Storage System shall be earthed in accordance with battery manufacturer guidelines.

19.5.11 Inverter functional earthing (Negative earthing, Anti PID Earthing) shall be carried out as per guideline of OEM. Bidder shall submit complete detail of such earthing from OEM and implement the earthing accordingly.

**19.6 Drawings and Documents**

19.6.1 During Detailed Engineering the following particulars of the "Earthing System" shall be submitted for approval by Owner.

a. Detailed specification of all the items
b. Soil resistivity measurement data
c. DC Earthing for BESS field - Design calculation with Touch & Step potential Verification and GA Layout.
d. AC Earthing - Design calculation with Touch & Step potential Verification and GA Layout.

19.6.2 The successful bidder required to produce schematic diagram of the earthing system and the proposed locations for earth mat as per relevant standard with the Detailed Design Report.

19.6.3 All drawings and calculations submitted by the bidder will be subjected to approval of the Owner.

# 20. Lightning Protection System

## 20.1 Introduction

20.1.1 This specification is intended to outline the requirement of external lightning protection (ELP/Lightning protection) for BESS Project.

## 20.2 Codes and Standards

20.2.1 The lightning protection system to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/IEC standards including amendments, if any, except where modified and / or supplemented by this specification. The applicable standard is given below.

| Standard | Description |
|---|---|
| IS 2633 | Methods for testing uniformity of coating of zinc coated articles. |
| IS 4759 | Hot-dip zinc coatings on structural steel and other allied products |
| IS 3043 / IEEE80 | Code of practice for earthing |
| IEC 62561-7 | Lightning protection system components (LPSC) |
| IS/ IEC 62305 | Protection against lightning |
| IEEE: 837 | Standard for qualifying permanent connections used in substation grounding |

## 20.3 General Requirements

20.3.1 The BESS Power Plant shall be provided with Lightning Protection System (LPS) covering Containerized Battery Storage System, Inverter station, control room and Balance of Plant.

20.3.2 The lightning protection system must be completed prior to start-up of commissioning activities of the project.

20.3.3 The main aim of Lightning Protection System is to protect BESS components, Outdoor Electrical Equipment and buildings from any over voltage surge before it reaches the above equipment.

20.3.4 The minimum level of protection shall be Level IV; however, bidder shall design as per protection level based on Risk assessment.

20.3.5 Hot dip galvanization thickness of the materials which are applicable shall have *minimum 80* microns thickness as average.

20.3.6 The mounting pole and supports shall be securely fixed with the brackets and PVC insulated metallic guy wires to withstand the maximum wind velocity of that area.

20.3.7 Lightning Protection of BESS Yard

a. The BESS Yard and the other sub-system components shall be protected against lightning using Lightning arrestor and shall be as per IEC standards.

b. The lightning system shall include lightning terminal, lightning mast, a Supporting pipe and separate Earthing arrangement with down conductor, test links and Earth pits etc.

c. Each of the Down Conductor shall be connected to the respective Earth Electrodes in the Earth Pit. Both Earth Electrodes shall be interconnected to achieve Earth Resistance not more than 10 Ω.

d. The structures of mounting support shall be designed considering the design wind speed, seismic zone, and maintenance requirement at Site.

**20.4 Specific Requirements**

20.4.1 Down Conductor

a. Down conductor shall be straight and follow a direct path to the earth electrode. Length of the conductor shall be minimized. Any joints to the down conductor shall be welded type only.

b. The Down conductor shall be of copper in accordance with latest IS 2633 & IS 4759 standards and of minimum size 25 X 3 mm.

c. Test link shall be provided to the down conductor at a height of one meter above the ground and there shall not be any other connection below the test link except connection to the earth electrode.

d. 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.

e. All joints in the down conductors shall be welded type.

f. 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.

g. 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.

h. All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.

i. Lightning conductors shall not pass through or run inside GI Conduits. Testing link shall be made of galvanized steel of size 25x 6mm.

j. Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earth's oxide layer or foreign material.

20.4.2 Lightning event counter

a. The lightning event counter shall be connected in series to the down conductor which uses the current induced in a secondary circuit to activate the electromechanical counter.

b. The lightning event counter shall be of non-electronic and non-resettable (Not require any external power supply) type lightning event counter to count the lightning stroke.

c. The lightning event counter having display with IP67 enclosure including all accessories and connection (6/7 digits).

20.4.3 Earth Pit

a. Each earth pit shall be provided with an earth electrode of 3m length copper bonded steel rod of diameter not less than 14 mm including accessories and masonry enclosure with cover plate as per IS 3043.

b. The pit around the electrode shall be treated with carbon-based earth enhancement compound as required as per provisions of IS 3043.

c. Requirements for earthing enhancing compounds shall conform to IEC 62561-7. The minimum quantity of earth enhancement compound to be used with each earth-pit shall be 25 Kg.

d. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. For each earth pit, necessary Test Point shall be provided. The distance between earth pits shall be more than 3 meters.

**20.5 Tests**

20.5.1 Type Test

a. The equipment offered shall be of type tested and proven type. Type test report of latest versions shall be submitted for review.

20.5.2 Routine Test

a. The lightning protection system and its components shall be subjected to routine test in accordance with IEC standard.

20.5.3 Test Witness

a. Tests shall be performed in presence of Owner representative if so desired. The Bidder shall give at least seven (07) days' advance notice of the date when the tests are to be carried out.

20.5.4 Test Certificates

a. Certified reports of all the tests carried out at the works shall be furnished in four (4) copies for approval of the Owner.

b. The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

c. Type test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

### 20.6 Packing and Delivery

20.6.1 The Bidder shall arrange transportation of all equipment from the point of manufacture to Owner Site. The arrangements shall include, but not be limited to, hiring adequate capacity of space, determination of routes, determination of required permits, payment of required taxes and duties, and notification to Owner.

### 20.7 Warranty

20.7.1 All the equipment included in the scope shall satisfy the warranty of 12 months from the date of Commissioning of Facility, or 18 months from the delivery at Site whichever later.

### 20.8 Quality Control

20.8.1 Bidder shall submit the MQAP & FAT for the Air Terminal, Lightning mast, Down Conductor, Lightning Event Counter, Support Pipe, Earthing Strips, Structures and other accessories for Lightning Protection System.

# 21. Fire Detection and Protection System (FDPS)

## 21.1 Introduction

21.1.1 The Fire Detection and Protection System (FDPS) shall provide instantaneous audio alarm and quench (applicable area) when the fire is detected, in order to prevent loss of life, property and valuables etc. by warning inhabitants in the affected premises immediately and quench the fire as soon as possible (applicable area*). FDPS shall be able to evacuate the inhabitants in the affected area so as to obtain necessary help from Fire Fighting and Salvage staff.

## 21.2 Codes and Standards

21.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/International standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards and guidelines are listed below:

| Standard | Description |
|---|---|
| TAC Manual | Manual of Tariff Advisory Committee of Insurance Cos. Of (India) |
| NFPA Codes | National Fire Protection Association Codes |
| IS 2189:2008 | Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System Code of Practice. |
| CEA regulation | Measures relating to Safety and Electricity Supply Regulations, 2010, 2015, 2019 and 2018, Draft 2021 |
| IS 694:1990 | Installation & maintenance of power cable |
| IS 2175:1988 | Specification for heat sensitive detector |
| IS 11360:1985 | Specification for photo smoke detector |
| IS 9779:1981 | Specification of sound level |

21.2.2 Fire Detection & Alarm system components shall be UL/FM approved.

## 21.3 General Requirements

21.3.1 Containerized Battery Storage System area shall adhere to NFPA 855 standard.

21.3.2 The FDPS shall be activated by automatic detection devices and or by manual operation.

21.3.3 The FDPS performs the function of monitoring the areas from fire continuously and giving an Audible alarm in case of sensing "Fire". Also, protecting it from spread of fire (applicable area*).

21.3.4 The sensing of the Fire is accomplished through various types of detectors.

21.3.5 The areas mentioned below shall be providing with the adequate number of detectors for continuous monitoring.

a. Main Control Room
b. Inverter station (if applicable)
c. Other Area/ Outdoor

21.3.6 Suitable Fire Detection System (FDS) using optical beam type smoke detectors and/or heat detectors shall be provided for entire control Building in BESS area and other areas/outdoor.

21.3.7 The FDPS shall be intelligent, Analogue addressable Microprocessor type. The system shall consist of addressable 3D Multi Sensor and Photoelectric Detector to detect any abnormal change in smoke, heat level and provide signal to the fire alarm panel to actuate the corresponding output devices (Hooters, Relays and Quencher) as programmed to take appropriate alarming and quenching measures.

21.3.8 The system shall consist of addressable 3D Multi-sensor Detector & addressable manual call points. All the detectors and detection devices shall be connected with the Fire Alarm Panel (FAP).

21.3.9 The FAP shall be connected to Control and Monitoring System (SCADA) via RTU's in Main control room.

21.3.10 Redundant power supply as well as communication shall be provided for whole system.

21.3.11 It shall be possible to change the sensitivity of each addressable detector to required value from the control room. It shall be possible to set the sensitivity for each detector from the Main Control Room.

21.3.12 The spacing of Detectors shall be as per IS: 2189 in each protected area, considering the construction features.

21.3.13 Response Indicators shall be provided for above false ceiling detectors.

21.3.14 Manual Pull stations shall be provided near exit points.

21.3.15 Electronic Hooters shall be provided in each protected area.

21.3.16 Fire Detection and Protection - Control Room

a. The FDPS for control room shall cover the following areas:
    1. HT Panel Room
    2. Battery Room
    3. Auxiliary Room
    4. Storeroom
b. The Fire Alarm Panel shall be kept at SCADA room to provide the fire detection and protection function for all the above-mentioned protected area.

c. Smoke detectors shall be provided in all the above-mentioned protected area.

d. Heat detectors shall be provided in Battery room and HT panel room. The heat detectors shall be as per NFPA 72.

e. The Photoelectric Smoke detector and Air sampling smoke detector shall be provided in HT panel room.

f. HT panel room shall have Clean Agent Fire Extinguish System to suppress/quench the fire that existed inside the area. (Applicable only for Air-conditioned rooms)

g. The Clean Agent Fire Extinguish System shall be as per NFPA 2001.

h. Dry Chemical Powder (DCP) type fire extinguishers shall be provided as one per 15m inside the control building.

21.3.17 Fire fighting – Other Areas/ Outdoor

a. For Outdoor, Sand buckets and Fire extinguishers shall be provided at applicable locations in the Plant given below:

1. Inverter Duty Transformer Area
2. HT Switchgear Area
3. Auxiliary Transformer Area
4. Control Building outside area

**21.4 Specific Requirements**

21.4.1 Fire Detection System

a. The fire Detection system consists of following components:

1. Optical Beam type Smoke Sensor
2. Heat Sensor
3. Air Sampling Smoke Detector
4. Accessories to mount

b. The fire detection system shall detect any abnormal change in smoke, heat level and provide the signal to fire alarm panel to actuate corresponding devices.

21.4.2 Fire Alarm Panel

a. The Fire Alarm Panel shall consist of necessary indication and control push buttons and other accessories required for operation of the system. When any of the detectors detects any fire inside the protected premises through any type of detector, then the Fire Alarm Panel shall display the corresponding location on the LCD/LED Screen/ Station & the Fire LED of the panel shall start glowing.

b. The audio-visual alarm comes ON in Panel indicating that the fire condition has been detected. Also, "EVACUATION" display unit (Hooter) located at strategic location shall start sounding.

c. The cables shall be 1.5mm2 (Cu) FRLS, PVC insulated, unarmoured for indoor and armoured for outdoor installation complying with IS: 1554.

d. Fire Alarm Panel shall have the capability to receive signal from smoke detector/fire alarm and relay the signal to all the doors with access control to "OPEN/UNLOCK" without access card or biometric.

e. Fire alarm system shall be fully programmable and user friendly. The system shall have reliability, flexibility, and ease of installation, commissioning, and maintenance. Robust power supply, large display option, fast response keypad.

f. Fire alarm system control panel shall function both as stand-alone system as well as interference between the Central Processing Unit and Fire Detectors and their accessories and control device.

g. Hooters shall have frequency between 500 Hz to 1000 Hz. Hooter sound level should not exceed 120 dB.

h. Addressable detector/ manual call point & required devices in various areas shall be connected to FAS by Class A wiring to detector interface unit. No of detector in a single loop shall be more than 99. FAS shall support 5 loops.

i. FAP shall consists of the following:

1. Intelligent, Analogue Addressable type Microprocessor based Fire Alarm Panels at suitable locations as per requirement.
2. Intelligent, Microprocessor based Repeater Panel in the Security room.
3. Intelligent Detectors of 3D Multi-sensor & Photoelectric type.
4. Intelligent Manual Call Point (MCP).
5. Intelligent Monitor Module (Interface Unit), Control Relay Module & Output Module.

j. The FAP shall be equipped with battery backup using Lead Acid battery with float cum boost charger unit.

k. The FAP shall be kept in Control building. The FAP shall be provided with all the necessary accessories.

l. All addressable devices shall be interrogated in order from FAS.

m. FAP shall have individually controlled, monitored alarm output for external hooters, lamps, etc.

n. FAP shall support repeater panel.

o. Redundant power supply for the whole system shall be provided.

p. Redundant communication among all FAS panels shall be provided.

q. It shall be possible to change the sensitivity of each addressable detector to required value from the control room. It shall be possible reads sensitivity for each detector from the control room.

r. FAS shall have the facility to set date and time.

s. FAS shall have the facility to disable/isolate detector, Zone interference unit from the control panel for maintenance purpose and restore the same whenever required.

t. FAS shall check for each detector, zone interface unit for alarm, pre-warning, fault disabling/isolating shall be possible from control room panel.

u. FAS shall store more than 250 events.

v. Software changes shall be possible from FAS without re-burning of Erasable Programmable Read-Only Memory (EPROM).

w. Software database shall be maintained in non-volatile memory. It shall be possible to reprogram the software by authorized person only.

x. All equipment supplied under FAS shall conform to TAC norms.

21.4.3 Fire Protection System (FPS)

a. HT switchgear room shall be provided with Clean Agent System of Novec 1230 / FM200.

b. Adequate numbers of portable / trolley mounted fire extinguishers shall be provided in various rooms control building and outdoor areas.

c. Portable Fire extinguishers shall be as following types:

1. Carbon Dioxide type fire extinguishers, 4.5 kg Capacity (SS-304 body).
2. Water mist-cum-compressed air foam (CAP) gun type trolley mounted of 50 litre capacity.
3. (M) Foam Type Fire Extinguisher, 9kg Capacity
4. Clean Agent NOVEC 1230/ FM200, 4kg Capacity

d. All the Fire extinguishers offered by bidders shall be of reputed make and shall be ISI marked.

e. All the portable extinguishers shall be of freestanding type and shall be capable of discharging freely and completely in upright position.

f. Each extinguisher shall have the instructions for operating the extinguishers on its body itself.

g. All extinguishers shall be supplied with initial charge and accessories as required.

h. Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns.

i. Dry chemical powder type portable extinguisher shall conform to IS: 15683 / NFPA 10.

j. Carbon Dioxide type portable extinguisher shall conform to IS: 15683 / NFPA 10.

k. Wheel/Trolley mounted Mechanical foam type fire extinguishers (SS-304 body) of 9kg capacity, conforming to IS: 16018 / NFPA 10, shall be provided, one number for each Inverter duty Transformer.

l. One (01) number of water mist-cum-compressed air foam (CAP) gun type trolley mounted of 50 litre capacity shall be provided MV yard portion.

m. Also, adequate number of trolley mounted CO2 type fire extinguisher of 6.5 kg capacity shall be provided.

**21.5 Tests**

21.5.1 All type test report as per the above-mentioned standards shall be submitted.

21.5.2 Test Witness

a. Tests shall be performed in presence of Owner representative if so desired. The Bidder shall give at least seven (07) days' advance notice of the date when the tests are to be carried out.

21.5.3 Test Certificates

a. Certified reports of all the tests carried out at the works shall be furnished in four (4) copies for approval of the Owner.

b. The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

c. Type test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise, the equipment shall have to be type tested, free of charge, to prove the design.

21.5.4 Maintenance responsibility during Guaranteed Availability Period

a. During Guaranteed Availability Period, Supplier shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

**21.6 Special Tools and Tackles**

21.6.1 A set of special tools and tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

21.6.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

**21.7 Guaranteed Particulars**

21.7.1 Electrical and mechanical characteristics shall be guaranteed by the bidder. In case of failure of materials to meet the guarantee, M/s Owner shall have right to reject the material. Guaranteed Technical particulars are to be submitted by the successful bidder during detailed engineering along with submitted drawings / documents.

**21.8 Training at Site**

21.8.1 Training shall be provided to Owner for programming of Fire Alarm System at free of charge by the system provider / Bidder.

### 21.9 Quality Control

21.9.1 Bidder shall submit the MQAP, FAT and FQP for the Fire Detection and Protection system, structures, and other accessories to mount FDPS.

### 21.10 Warranty

21.10.1 All the equipment included in the scope shall satisfy the warranty for minimum of12 months from the date of Commissioning of Facility, or 18 months from the delivery at Site whichever later.

# 22. Illumination System

## 22.1 Introduction

22.1.1 A comprehensive illumination system shall be provided for the entire Plant. All control buildings / sheds shall be provided with adequate light fixtures, luminaires 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.

## 22.2 Codes and Standards

22.2.1 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.

| Standard | Description |
|---|---|
| 16101:2012 | General Lighting. LEDs and LED modules<br>Terms and definitions |
| 16102(Part 1):2012 | Self-Ballasted LED Lamps for General Lighting Services.<br>Part-1 Safety Requirements. |
| 16102(Part 2):2012 | Self-Ballasted LED Lamps for General lighting Services.<br>Part-2 Performance Requirements. |
| 16103(Part 1):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 | Luminaire Performance. |
| 16108 :2012 | Photobiological safety of Lamps and Lamp Systems. |
| IS 513 | Cold rolled low carbon steel sheets and strips. |
| IS 12063 | Classification of degree of protection provided by enclosures. |
| IS 14700 | Part-3 Sec. 2: Electromagnetic compatibility (EMC) – Limits for Harmonic |

| Standard | Description |
|---|---|
| | current 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<br>(Part 2/Sec. 13)<br>IS 16004 – 1 and 2) | Lamp control gear: particular requirements for<br>DC or AC supplied electronic control gear 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 TM 21/ IS 16105<br>TM 21/ IS 16105 | Lumen Depreciation and Rated life of LED chip. |
| IES-LM 79 / IS 16106 | Luminaire optics and colour parameter and electrical parameter. |

### 22.3 Lighting System Description for Control Room:

22.3.1 **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 ACDB.

22.3.2 **Emergency AC Lightning System**: The emergency lighting system consisting of 20% of the lights shall be fed from emergency DB as per scheme adopted by the EPC bidder. Load of the same has to be considered for UPS sizing. Bidder shall provide indoor and outdoor emergency lighting at control room and other areas.

### 22.4 Lighting Fixture, Lamps & Accessories

22.4.1 All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at Site.

22.4.2 AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50Hz 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 & 240V.

22.4.3 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 up to 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.

22.4.4 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.

22.4.5 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.

22.4.6 The reflectors shall be manufactured from CRCA sheet steel or aluminium as specified. The aluminium reflector shall made of high purity aluminium sheet, polished electrochemically brightened and anodized or proven alternate arrangement of anodizing.

22.4.7 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.

22.4.8 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.

22.4.9 LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified along with finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere.

### 22.5 Junction Boxes, Conduits, Fitting & Accessories

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

22.5.2 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.

22.5.3 All switches and receptacles up to 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox.

22.5.4 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.

22.5.5 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 weatherproof type suitable for IP55 degree of protection and those used indoor shall be suitable for IP52 degrees of protection.

**22.6 Lighting Poles**

22.6.1 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 BESS panels. The poles shall be hot dip galvanized as per relevant IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall be min. **80* 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.

22.6.2 The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated residual current circuit breaker with overcurrent protection (RCBO).

22.6.3 Hot dipped Galvanized with 80 mm thickness hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable. If JB is outdoor, it shall be IP67.

**22.7 Lighting Wires**

22.7.1 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 and 4 sq.mm. for aluminium.

**22.8 Earthing**

22.8.1 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.

22.8.2 Alternately Bidder may offer technically superior and proven product subject to approval of Owner.

### 22.9 Average Illumination Level

| Location | Average Illumination Level (Lux) | Type of Fixture |
|---|---|---|
| HT Breaker Room | 200 | LED Luminaries |
| Control Room | 300 | LED Luminaries |
| Inverter/Transformer Yard/Outdoor area of Inverter Station | 50 | LED Luminaries (Flood Lighting) |
| Street lighting-Roads | 15 | LED Luminaries |
| Other indoor areas including auxiliary battery room | 150(general) 200(On Strategic Equipment) | LED Luminaries |

### 22.10 Special Tools and Tackles

22.10.1 A set of special tools and tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

22.10.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

### 22.11 Quality Control

22.11.1 Bidder shall submit the MQAP, FAT and FQP for the illumination system.

### 22.12 Warranty

22.12.1 All the equipment included in the scope shall satisfy the warranty of minimum 12 months from the date of Commissioning of Facility, or 18 months from the delivery at Site whichever later.

# SECTION - 3 DETAILED TECHNICAL SPECIFICATIONS (DTS) - CONTROL AND INSTRUMENTATION

# 1. Energy Management System (EMS) and Supervisory Control and Data Acquisition System (SCADA)

## 1.1 Introduction

1.1.1 The Bidder shall provide complete Energy Management System (EMS) and SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient, and reliable operation of entire Plant and its auxiliary systems.

1.1.2 For Substation controls, bidder shall provide separate SAS or same shall be integrated with SCADA. The proposed solution shall be fully equipped with latest hardware and software.

1.1.3 Energy Management System (EMS) shall be a computerized system for real time monitoring, operation, control, reliable & efficient operation and optimization of performance of the BESS. SCADA system shall be part of EMS system. EMS shall be able to acquire real time data of various equipment of BESS and have in-built logic/programming to monitor, control and optimize the performance of BESS as per specification.

1.1.4 Bidder shall include in it's 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 these specifications.

1.1.5 The SCADA and EMS shall have redundant controllers, and each shall be connected in separate ethernet switches. Both the controllers are online (additional hot standby shall be provided for both) during Plant Operating and Non-operating period. All the inverter substations shall be connected in ring topology through fibre optic communication.

1.1.6 The control system design shall provide for local manual operation and remote operation or dispatch from a remotely located computer and the system shall be designed to provide for automatic, unattended operations. Also, all parameters/algorithms/set points shall be adjustable at Site. The power supply shall be fed from auxiliary power supply system. Redundant power supply shall be available for all the SCADA equipment.

1.1.7 Each PCS/BESS/Auxiliary equipment at inverter station and Main control room shall be connected to main SCADA. RTU shall be provided at inverter station level with ring topology.

1.1.8 Licenses for Remote Monitoring of EMS/SCADA: 2 Nos with provision of Concurrent viewing for all users.

## 1.2 Codes and standards

1.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/IEC standards including amendments, if any, except where modified and / or supplemented by this specification.

1.2.2 Some of the applicable standards and guidelines are listed below:

| Standard | Description |
|---|---|
| IEC61850 | Communication protocols for intelligent electronic devices at electrical substations |
| IEC60529 | Rate and grade the resistance of enclosures of electric and electronic devices against the intrusion of dust and liquids. |
| IEC61446 | Minimum requirement for system documentation, commissioning tests and inspection |
| IEC61724 | Guideline for measurement, data exchange and analysis |
| IEC60204-1 | Requirements and recommendations related to the electrical equipment of machinery |
| IEC61439 | Low Voltage Switchgear and Control Gear Assemblies |
| IEC60870-5-104 | Tele control, tele protection, and other tele-communication functions for electric power systems |
| IEC60870-5-101 | Power system monitoring, control & associated communications For tele control, tele protection, and associated tele-communications For electric power systems |
| IEC62056 | Electricity Metering Data Exchange |
| IEC62682 | Management of Alarm Systems for the Process Industries |
| IEC62443 | Industrial Cyber Security Services |
| EN61000 | Electromagnetic Compatibility (EMC) for Power Supplies |

## 1.3 General Requirements

1.3.1 The scope of supply shall include but not limited to the following:

1. Energy management system EMS, Supervisory Control and Data Acquisition (SCADA) for the BESS Field and Substation, including all the necessary software licenses.
2. SCADA Human Machine Interface (HMI) with one (1) no. of Operator Workstation (OWS), one no. Historian station and one (1) Operator cum Engineering Workstation to supervise all system from the Control Room.

3. One portable Laptop (EWS based)
4. SCADA server with minimum RAID 5 (Redundant Arrays of Inexpensive Disks) configuration.
5. EMS Server with minimum RAID 5 (Redundant Arrays of Inexpensive Disks) configuration.
6. Network Switches
7. Large Video Screen (Laser) with digital controller
8. Protocol Converters
9. Gateways and Firewalls
10. Copper to FO – Converter, if required
11. GPS Based Clock system
12. Required Operating System and SCADA application Software
13. Interface with Fire Alarm System.
14. Field Test Equipment
15. Remote Terminal Unit for each inverter station
16. One (1) number of high speed A3/A4 network colour laser printer for report printing from any workstation.
17. All control and communication cables from SCADA to respective equipment.
18. High speed broadband internet connection including the necessary auxiliary equipment, hardware, etc., connection with the service provider.
19. Training on the complete SCADA system for the Owner's management, operation and maintenance staff. The training shall cover hardware and software of SCADA components, etc.
20. Assistance and close cooperation for end-to-end test for data and signal transferred from Plant to Load Dispatch Centre (if applicable), which shall include data point tests, data communication and exchange tests.
21. 20% spare ports shall be provided in each type of switches.

1.3.2 Bidder shall also consider in it's scope the submission of following documents:

1. Technical manuals & brochures
2. Commissioning documents
3. As built drawings including set points, interfaces, etc.
4. Complete hardware and software documentation (including licenses and certificates.

1.3.3 IP addressing for each equipment but not limited to EMS, Numerical relays, Multifunction meters, Energy meters, Power quality meter, PCS, CCTV system, Auxiliary equipment UPS, DC Chargers, etc., of entire Plant shall be provided by bidder.

1.3.4 SCADA System shall have the provision to perform the following functions:

1. Remote control of all the HT Breakers either in hard or soft signal.

2. Remote control of PCS active and reactive power as per requirement mentioned in respective chapter.
3. 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
b) Incomer and bus coupler breaker of LT Panel.
c) Power conditioning system (PCS)
d) Battery system
e) UPS and Battery charger as per requirement mentioned in respective chapter.
f) TVM/ABT/MFM meter, numerical relay, fire alarm panel, GPS time synchronization unit and transformer.
g) EMS and SCADA Hardware, Accessories and Communication link
h) Any other equipment required as per specification.

1.3.5 Display of status for major equipment in Single Line/Mimic Diagram. Mimic Diagram colour shall comply to IS 11954: Guide for colour coding of electrical mimic diagrams.

1.3.6 Display and storage of derived/calculated/integrated values.

1.3.7 Generate, store and retrieve user configurable periodic reports. SCADA shall have facility to generate report in MS Excel file type.

1.3.8 Remote monitoring of essential parameters of Plant on the web using popular web browser without requirement of additional software. Same shall be authorized with user id and password using standard modem. User ID and password for remote view can only be changed by SCADA Administrator. Internet connection for transferring data to web shall be taken by Bidder in the name of Owner Site for O & M period.

1.3.9 Performing self-monitoring and diagnostic functions

1.3.10 The Bidder shall provide at least one GPS clock, which shall be synchronized with the EMS and SCADA system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with EMS-SCADA shall be synchronized with GPS Clock through EMS-SCADA or directly with GPS Clock. The technical details of GPS have been specified elsewhere in the specification.

1.3.11 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.

1.3.12 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.

1.3.13 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 Bidder during Factory Accepted Test (FAT) in the presence of Owner Representative.

1.3.14 Bidder shall provide a Package/Split AC of suitable capacity decided by load requirement in EMS-SCADA control room. All the power supply module, Ethernet switches and network accessories for non-air-conditioned area shall be suitable for operating in ambient temperature of 50 deg.C minimum.

**1.4 Design Requirements**

1.4.1 A consistent instrumentation and control philosophy shall apply throughout the Plant and shall be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture. The objective shall be to standardize all measurement and control equipment throughout the Plant in order to rationalize operation, maintenance and reduce spares holding.

1.4.2 The instrumentation and control equipment shall have high electro-magnetic and radio frequency interference immunity and shall not be affected by portable radio transmitters operated in the vicinity of the equipment. Any limitations shall be stated.

1.4.3 All I&C equipment shall have enclosure classification not less than IP 55 according to IEC 60529 when 'mounted in an enclosed building and IP 65 for mounting outdoors.

1.4.4 Control cubicles installed in air-conditioned rooms shall be at least IP 5X. The cubicles which are outdoor wall/Ground mounted, the bidder/vendor shall provide recommendation for sunshades or canopy for all cubicles located outdoor. These sunshades or canopy shall be installed by bidder.

1.4.5 Due to the requirements of availability, reliability and function, the control and monitoring tasks of main Plant processes shall be performed by a state-of-the-art control system.

1.4.6 The control system shall achieve all functions of:

1. Real time data acquisition and display of data, status, alarms, and trends (Realtime/Historical)
2. Control
3. Serial and/or hardwired communication to PCS and other systems.
4. Human machine interface
5. Alarm signalling.
6. Sequential event recording

7. Historical data archive
8. Management reporting

1.4.7 To obtain a high availability and reliability of the Plant, the control system also requires a high availability. This shall be achieved by using single fault tolerant design for the centralized components, important sensors, which might affect the Plant availability in case of malfunction or used for protection, shall be provided in a redundant configuration.

1.4.8 System configuration shall be simple, scalable and flexible with respect to re-configuration of loop connection and, display formats to suit changes in operational requirements. System software security, including data base configuration, controller loop tuning parameters shall be accessible by password.

1.4.9 The SCADA system shall be composed of an integrated operator human machine interface (HMI), input/output (I/O), controller modules, communication modules complete hardware & software.

1.4.10 The bidder shall provide the configuration of the proposed SCADA system along with supervisory station, which refer to the server and software responsible for communicating with the field equipment, and then to the HMI software running on workstations in the control room, or elsewhere.

1.4.11 All systems shall require minimum maintenance, and shall have comprehensive self-checking and self-diagnostic capabilities including self-test failure alarms etc. Mode of signal transmission shall be serial using standard protocols matching with SCADA, e.g. MODBUS, etc.

1.4.12 All the PCS, Ring Main Units (RMU's), switchgear and utility metering (if applicable) shall be integrated with SCADA system.

1.4.13 Remote Terminal Unit (RTU)/Controllers shall be used to collect data from, the PCS, meters, ICOG panels, UPS system and the transformers to transfer data to the SCADA server which will carry out key control and monitoring functions of the Plant.

1.4.14 Alarm contacts (WTI, OTI, BUCHOLZ, PRV) from transformers and status of Load Break Switch from HT switchgear shall be wired to SCADA system through integrated RTU DI cards.

1.4.15 The SCADA system shall include all the required hardware, software, all types cabling and cable mounting system for complete installation and commissioning of system.

1.4.16 All Emergency signals (Minimum twenty No's) from Plant level shall be wired to SCADA system in Control Room through Integrated Remote Terminal Unit (RTU) from Inverter station. List of Emergency signals wired to SCADA system in Control Room shall be finalized during Detailed Engineering.

1.4.17 The data acquisition shall be through a Server of latest configuration. The bidder shall provide external communications link to access all data acquisition and real time performance monitoring. Bidder shall provide all necessary hardware as required for entire setup.

1.4.18 The recorded data shall be sequential right from inverter to metering. The data shall be compatible and transferable to MS Office excel. The report format shall be as per operational requirements and approved format from Owner.

1.4.19 The SCADA system shall be provided with GPS Time Master with Antenna to provide time synchronization signal to all servers, controllers, relays, meters, trackers etc., on NTP.

1.4.20 The SCADA shall be Windows/Linux based Server System in redundant configuration. The Servers shall be time synchronized from GPS based time Servers on NTP.

1.4.21 The SCADA shall process and synthesis the data collected and provide for the Display Manager, Event Manager, Trend Manager and other utilities residing in the Server. The SCADA shall facilitate OWS/EWS to display SLD, Trend, Alarm/Event, Report page. The Historian shall be managed by the SCADA to store and retrieve data of the Plant.

1.4.22 The SCADA system shall be provided with screen refresh rate of 1 sec, report generation time of 2 sec on call and 1 sec for trend call updation.

1.4.23 Source of power for SCADA system and all related hardware shall be taken from UPS DB.

1.4.24 In addition to conventional parameters (V, I, kW, kVA, kVAr etc.) below is the non- exhaustive list of monitoring and recording parameters.

1.4.25 BESS parameters

1. Battery string current
2. Power at interconnection
3. Daily power charging and discharging in kWh
4. Monthly power charging and discharging in kWh
5. Annual power charging and discharging in kWh
6. State of charge of battery
7. State of Health of battery
8. No of cycles of battery
9. Round trip efficiency for each charging and discharging cycle
10. Charging and discharging power from the date of Commissioning of Facility
11. AC active power in kW both import and export
12. AC Reactive power (kVAR) and (kVA) both import and export
13. Power factor for both import and export.
14. Individual PCS availability
15. Auxiliary consumption during standby and operation mode.
16. Daily, Monthly, Annual Plant Load Factor (PLF)

1.4.26 Bidder shall submit hardware, Bill of materials, Architecture wiring and field cabling. Wiring schedules shall be in the document submission.

1.4.27 Wherever suitable panels are not available for mounting, especially at the Inverter station, the Ethernet/IEC 61850 switches, the bidder shall provide suitable panels or wall mount enclosures to

accommodate the switches. Owner will identify suitable location for mounting these panels/ enclosures in the Plant.

1.4.28 The BMS shall be designed to provide for automatic, unattended operation of the Containerized Battery Storage System.

1.4.29 The BMS shall provide the necessary monitoring and control to protect the battery cells/module/string from out of tolerance ambient or unsafe operating conditions.

1.4.30 BMS shall ensure safe operation and mitigate fire risk.

1.4.31 The BMS shall automatically balance the battery cells/module to optimize energy storage and range, monitor cell/module heath and provide critical safeguards to protect the batteries from damage.

1.4.32 BMS shall have the following feature. However, Bidder to supply the BMS system as per battery OEM recommendation and requirement and shall be in line with the application requirements.

1. Cell/module Protection: - Protecting the battery from out of tolerance operating conditions and BMS must provide full cell/module protection to cover almost any eventuality.
2. SOC Determination: - BMS shall automatically determine the State of Charge (SOC) of the individual cell/module.
3. SOH Determination: - BMS shall automatically determine the State of Health (SOH) of the individual cell/module.
4. Cell Balancing: - BMS shall automatically balance between cells/modules to optimize energy consumption, range and protecting the battery.
5. History - (Logbook Function):- Monitoring the battery's parameters and communicating the same to SCADA.
6. Alarm and fault generation and communicating the same to SCADA.
7. Isolating the battery in cases of emergency.

## 1.5 Specific Requirements

**SCADA and EMS controller system:**

1.5.1 Separate hot redundant controllers shall be provided for EMS and SCADA system.

1.5.2 Energy management system (EMS) 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 EMS processor, there shall be an appropriate alarm and simultaneously the hot standby EMS 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 EMS processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. EMS shall be able to perform the functional requirement as required. The controller 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.

1.5.3 The SCADA shall be of PLC/RTU/DCS based as per specification given hereunder.

1.5.4 SCADA shall have the following feature:

a. Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.

b. 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.

c. The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in non-volatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.

d. 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.

**Data Communication System (DCS)**

1.5.5 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.

1.5.6 The DCS shall have the following minimum features:

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

1.5.8 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.

1.5.9 If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility

1.5.10 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.

1.5.11 The design and installation of the system bus shall take care of the environmental conditions as applicable.

1.5.12 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

1.5.13 Cat 6 UTP or fiber optic cables shall be employed.

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

1.5.15 Bidder shall setup Gigabit Ethernet based Plant Local Area Network (LAN) for EMS and SCADA system to connect to different communication nodes at Battery/PCS /Switchgear location etc. with redundant backbone using ring or better topology. Each Modbus cable shall be provided with Surge protection device at EMS and SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.

1.5.16 The following Network shall be built separately to manage the Data Transmission without any loss of packets.

| | |
|---|---|
| SCADA Network-Operation Highway | 1000 mbps |
| SCADA Network-Data Highway | 100 mbps |
| Time Sync Network | 100 mbps |
| Ethernet Network | 100 mbps |
| Relay Communication Network | 10/100 mbps |
| Modbus on TCP/IP | 10 mbps |
| Modbus on RS485 | 9600-19200 Baud |

**Time Synchronization:**

1.5.17 All the systems and equipment in the Plant shall be Time Synchronized with GPS time using NTP Time Signal. Redundant Time Server shall be provided with GPS Antenna. The Time Server shall be locked with GPS.

**SOFTWARE REQUIREMENT**

1.5.18 All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirements shall be provided. The programs shall include

high level languages as far as possible. The Bidder shall provide sufficient documentation and program listing so that it is possible for the Owner to carry out modification at a later date.

1.5.19 The Bidder shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.

1.5.20 Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry.

1.5.21 EMS and SCADA system shall include the following standard protocols as a minimum:

1.5.22 Modbus (TCP/IP, RTU, ASCII).

1.5.23 Sub Station Protocol (IEC-61850 and IEC 60870 -5-101/104).

1.5.24 Any other protocol on which the offered equipment (by Bidder) will communicate with EMS and SCADA

1.5.25 The system shall have user friendly programming language & graphic user interface.

1.5.26 All system related software including Real Time Operating System, File management software, screen editor, database management software, Online 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.

1.5.27 All application software for EMS and 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.

1.5.28 The Bidder shall provide software locks and passwords to Owner's engineers at Site for all operating & application software so that Owner's engineers can take backup of these software and are able to do modifications at Site.

1.5.29 The Bidder shall provide software license for all software being used in Bidder 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 Owner to seek a new license/renew license due to up gradation/change of hardware/machine in Bidder's System at Site. All licenses shall be valid for the continuous service life of the Plant.

1.5.30 All the EMS and SCADA Software with license Key shall be handed over to Owner on the DVD/CD media. All the hardware and software shall be licensed to Owner.

**Parametric requirements**

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

a) 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).

b) Adjustment Command: - 0.5 to 1 second.

c) On screen Updating and All Control related displays: - 1 second.

d) Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays: - 1 to 2 seconds.

1.5.32 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.

**Input/output modules**

1.5.33 The EMS and SCADA system should be designed according to the location of the input/output cabinets as specified.

1.5.34 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 Bidder.

1.5.35 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.

1.5.36 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.

1.5.37 Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator.

1.5.38 The I/O Module shall have the following features:

a) Power supply monitoring.

b) Contact bounces filtering.

c) Optical isolation between input and output signals with the internal circuits

d) In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be finalized during detailed engineering.

e) 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.

f) 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.

g) Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) and Modbus link at PCS and control room shall be calculated based on the Input/output signal list to be submitted by the Bidder for approval during detail engineering.

**System spare capacity**

1.5.39 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:

1.5.40 10 % spare channels in input/output modules fully wired up to cabinets TB.

1.5.41 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.

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

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

1.5.44 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.

1.5.45 The Data communication system shall have the capacity to handle the additions mentioned above.

1.5.46 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.

1.5.47 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.

**Historical Storage and Retrieval System (HSRS)**

1.5.48 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 the hard disk is certain percentage full.

1.5.49 The data to be stored in the above system shall include alarm and event list, periodic Plant data, selected logs/reports.

1.5.50 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.

1.5.51 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 drives of 2TB each.

1.5.52 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.

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

| Sl.No | Parameter | Time Interval |
|---|---|---|
| 1. | MFM, Energy meter, PQM and Numerical Relay data | 1 (One) Minute |
| 2. | Important parameter of BESS for evaluation of BESS Application requirement. | 1 (One) Minute |
| 3. | BESS estimated SOC at Plant output and PCS level. | 1 (One) Minute |
| 4. | Power Conditioning Systems (PCSs) data | 1 (One) Minute |
| 5. | BESS Battery Voltage, current and SOC (upto Module and String level) and other Important Battery and BMS data. | 1 (One) Minute |
| 6. | Parameter for BESS smoothing function: BESS feeders power, BESS power, reference target power (EMS controller), etc. | 1 (One) second |
| 7. | Scheduled power of Plant | 1 (One) Minute |
| 8. | Any other parameter as per Owner requirement. | |

**EMS and SCADA PANEL/cabinet/control desk/furniture**

1.5.54 The SCADA and EMS cabinets shall be IP22 protection class.

1.5.55 The Bidder 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 Bidder 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 soundproof 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.

1.5.56 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 control room.

1.5.57 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 Owner and shall be furnished by the Bidder during detailed engineering. Wall mounted cabinet is acceptable for PCS room/sub-pooling switchgear.

1.5.58 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.

1.5.59 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 colours for exterior and interior surfaces shall conform to following shades:

a) Exterior: - As per RAL 9002 (End panel sides RAL 5012),
b) Interior: - Same as above
c) Paint films which show sags, checks or other imperfections shall not be acceptable.
d) As an alternative, single coat of anodic dip coat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable

1.5.60 The control desk shall be free standing tabletop 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.

1.5.61 The Bidder 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 remains 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.

1.5.62 The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.

1.5.63 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 polyurethane and twin wheel castor of glass filled nylon.

1.5.64 One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.

1.5.65 All the furniture shall be of reputed make.

## 1.6 Scope of work interface with Existing Kurkurmara substation

1.6.1 Data shall be transferred from MCR at Plant to the existing Kurkurmara substation through fiber optic cable.

1.6.2 Remote Input/Output Control Panels (RIO) / RTU shall be kept at the existing Kurkurmara substation and all the control outputs from proposed Bay feeder shall be hardwired. Additional I/O cards if required shall be included in the RTU of the existing substation SAS.

1.6.3 Bidder scope also include energy meters/ transducers (0.2 class or better) as applicable for EMS controller use and shall be mounted in BESS feeder. Measurement of load for feeder shall be directly from panel mounted MFM meter (over Modbus protocol) or numerical relay (with IEC61850 port). Supply of control & communication cable and associated cabling work (including termination etc.) shall be in the Bidder scope.

1.6.4 All necessary software's and hardware's including laying of Communication/Fiber optic cable as required for communication with SCADA shall be provided by the Bidder.

**Auxiliary Power Supply:**

1.6.5 Auxiliary power shall be provided to Servers, Network Switches, OWS, EWS, PPC, Gateway, Firewall, Time Server, and Weather Monitoring Station.

1.6.6 Single UPS Power supply 230 VAC shall be provided at one location in the Inverter room. Bidder shall distribute the power to the various systems in the room.

1.6.7 The SCADA shall contain the following main functional parts:

1. Redundant Servers
2. Ethernet switches
3. One number operator workstation.
4. One number engineering workstation
5. One number operator-cum engineering workstation
6. One no. historian station
7. One number colour laser jet printer (A4paper)

8. Dual redundant communication link & gateway for SLDC/ NERLDC (if applicable)
9. Dual redundant communication link for Field systems
10. Communication link for interfacing Weather monitoring station and Satellite meteor station
11. GPS
12. Any other equipment as necessary

1.6.8 The data exchange among various levels take place via the dual redundant bus configuration or ring configuration according to IEC 61850-8-1 standard for Numerical Relays.

1.6.9 The communication infrastructure shall consist of a fibre optic, managed, switched Ethernet LAN in a dual fault tolerant ring configuration.

1.6.10 Server main and standby servers as well as workstation servers shall be of state of the art. The server shall be capable of performing all functions of the entire Plant and shall be scalable for future requirements. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. The capacity of hard disk shall be selected such that the following requirements will occupy less than 50% of disk space:

1.6.11 The user interface shall be based on WINDOWS concepts with graphics and facility for panning, scrolling, zooming, decluttering etc. Operation shall be by a user-friendly function keyboard and optical mouse.

1.6.12 The SCADA system shall be provided with 1 Historian, 1 no. operator workstation (24" screen) with 1 no. laser printer and 1 no Engineering workstation with laser printer, GPS with 1 time master and NTP time server.

1.6.13 The SCADA shall be provided with the 1 no. gateway with firewall, which shall be connected with the ISP (internet service provider).

1.6.14 The SCADA shall be provided with the 1 no. gateway with firewall, which shall be connected with the WEB client.

1.6.15 The SCADA for system shall have the following features:

1. The SCADA system shall fulfil and demands emanating from the domains of:
    a. Automation
    b. Monitoring
    c. Process control
    d. Management
    e. Engineering
2. Uniform operator machine interface.
3. Reliable user guidance.
4. Comprehensive redundancy concept.
5. Modern object-oriented software structure.

6. Shall be able to communicate with external system and intelligent field equipment.
7. Simple central project planning and configuration aids.
8. Integrated documentation system.
9. Integrated diagnosis and service.
10. Commissioning support.

1.6.16 The Control System shall have on-line simulation & testing facility.

1.6.17 The system shall have the flexibility to easily reconfigure any controller at any time without requiring additional hardware or system wiring changes and without disabling other devices from their normal operation mode. Modifications shall not require switching off power to any part of the system.

**Human Machine Interface System (HMIS)**

1.6.18 HMIS configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.

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

1.6.20 For communicating the generation data of Plant in Owner place, the SCADA system shall be interfaced/ connected with PI server of Owner on OPC Protocol. The details of Owner PI server shall be furnished during the detailed engineering.

1.6.21 Graphical Interface Unit (GIU) / Operator workstation (OWS) shall perform control, monitoring and operation (as applicable) for Plant equipment's connected with SCADA system.

1.6.22 Engineering workstation (EWS) shall work as a programming station for controller and SCADA. It shall be possible to use same EWS as programming station and the Human Machine Interface System.

1.6.23 SCADA System shall be provided with redundant OWS. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure in the HMIS.

1.6.24 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.

1.6.25 The mimic shall be configured on the HMI, and it shall be possible to control, monitor and operate the Plant from the same.

1.6.26 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.

1.6.27 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.

1.6.28 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.

1.6.29 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.

1.6.30 The system security shall contain various user levels with specific rights as finalized by the Owner during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

1.6.31 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.

1.6.32 In addition to GUI Display, one 50 Inch LED display shall be provided at SCADA Room.

1.6.33 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.

1.6.34 SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.

1.6.35 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.

1.6.36 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.

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

**Fault Diagnosis**

1.6.38 Complete software for control system including the communication software between systems etc., shall be supplied and implemented. The software shall be also included for equipment performance test, life evaluation, equipment capability curve and alarm analysis, etc.

**Control system basic system and features**

1.6.39 SCADA equipment shall employ modern microprocessor-based technology, as required to comply with the project specification and the SCADA system should not be more than 2-year-old. A truly integrated SCADA is envisaged with all the self-sustaining subsystems communicating with each other over the bus network and thus ensuring that the system has a truly global data base.

1.6.40 The fundamental functions of control, alarm, monitoring and protection shall be functionally and physically segregated to greatest practicable extent so that failure of a function does not result in the failure of other functions. Special attention should always be given to the independence of the protection function so that safety of Plant personnel and equipment is preserved.

1.6.41 The active control system including the Plant protection system is the heart of the SCADA system and therefore most stringent safety, availability and reliability requirements have to be fulfilled by this subsystem. The bidder must bring out very clearly in it's proposal how he intends to satisfy these requirements.

1.6.42 A functional group control hierarchy shall be devised for the Plant equipment and their auxiliaries to allow operator to select a lower level of certain system or equipment.

1.6.43 In case of redundant Analogue and Binary Signals, these will be connected to different input modules.

1.6.44 Control system shall comply with following general failure criteria :

1. No single fault can cause the complete failure of the control system.
2. The grouping of control functions into system blocks shall be arranged such that failure of any one block will only partly degrade the control of the overall system. Such degradation shall always be manageable by operator intervention.
3. No single random fault in the entire automation and control system will cause a load loss, forced outage.
4. No two simultaneous faults shall lead to or potentially cause damage to Plant.
5. Safety related instrumentation and control shall be designed with a fail-safe mode.
6. No single fault shall jeopardize the functioning of the entire system.
7. The control and automation system and other items as well as its support systems, power supplies and data networks shall be immune to the electromagnetic interference and shall conform to the internationally accepted standards.
8. To meet the operational and safety requirements, the control system hardware and software shall conform to a modular, hierarchical architecture.

1.6.45 To meet the above failure criteria the system shall incorporate self-checking facilities so that internal faults can be detected within the system itself prior to any resulting disturbance to the process. In addition, the protection and safety systems shall incorporate channel redundancy or diversity of

measurement as well as self-checking and adequate test facilities. For some important systems, "online" test shall be employed with no effect to the proper functioning of the protection system.

1.6.46 To meet the stringent failure and self-checking requirements for I&C system, measurement redundancy shall be provided for all such parameters which can cause a direct system trip.

1.6.47 To make sure that the SCADA is an extremely user-friendly system, a centralized engineering subsystem is envisaged. An integrated subsystem shall be provided which takes over the complete task of planning, I/O allocation, generation of function schemes and wiring documentation (in design stage) and finally the automatic linking and loading of the planned functions in the target hardware.

1.6.48 Potential free contacts as per power transformer requirement shall be connected to integrated RTU of SCADA system. SCADA shall have provision for the same.

1.6.49 The complete engineering of all the automation and data acquisition functions should be possible from this central tool. This shall include all modulating and sequence control functions as far as the automation is concerned, generation of overall Plant graphics, logs and other MMI functions. In addition, the central engineering system must support all service, maintenance, and commissioning assistance functions.

1.6.50 Individual control elements shall be equipped with permissive to prevent the inappropriate operation of the item and "active interlocks" to trip the item in case of dangerous operation conditions.

1.6.51 Alarms shall be provided for all abnormal conditions over which the operator has control in the control room, plus those abnormal conditions which are of interest to the operator because they may affect Plant operation or security. Alarm shall be descriptive, it shall be incorporated in the alarm/event list database of SCADA, in discussion with Owner.

1.6.52 AC power from UPS supply for control cubicles of each control and monitoring system shall be derived from two independent sources shall be furnished to guard against the total loss of power supply. The arrangements of power supplies shall be such that no single fault could interrupt both supplies and no control system malfunction shall occur due to supply changeover.

1.6.53 The functions of SCADA System are achieved through bus communication units, bus interfaces, process controllers, I/O modules, and computers. The system shall be versatile and provide the user, the flexibility to freely choose configuration and redundancy. The system shall ensure very high reliability and safety through complete distribution and decentralization which goes right down to the individual level.

1.6.54 Interposing relays with suitable contact rating shall be provided in case the status of the field equipment is not captured through numerical relays., between SCADA and Panel/SWGR in Interposing relay panels for giving command signals ON/OFF or OPEN/CLOSE. Interposing relays shall have minimum 2 NO and 2 NC contacts.

1.6.55 Also, the system shall have the flexibility to easily reconfigure any equipment at any time, without requiring additional hardware or system wiring changes and without disabling the devices from their normal operating mode.

1.6.56 The system shall execute all control functions with the help of a set of pre-programmed functions resident in control System. The offered system shall have provision for open system architecture to establish communication to any other system using open system standards such as UNIX, WINDOWS, TCP/IP, OSF, MOTIF, SQL Access etc.

1.6.57 The system shall provide inherent safe operation under all Plant disturbances and component failures so that under no circumstance safety of the Plant personnel or equipment is jeopardized.

1.6.58 All process input/output cards shall have built in galvanic/optical/electronic isolation for each input and output channel.

1.6.59 The failure of controller module and each I/O module shall be indicated on control cubicles and all operator stations.

**Light Interface Unit (LIU)**

1.6.60 LIU are generally used in interconnecting, cross-connecting or splicing applications in LANs at a location.

1.6.61 The LIU is Optical Fibre interconnecting unit.

1.6.62 The Housing shall be of Aluminium and is easy to mount. The number of ports expected shall be 6, 12 or 24-port as per the locational requirement. It shall be capable of storing up to 3 meters of 900µm buffered fibre per adapter. It is easy to change the adapter panels for patching of various connectors.

1.6.63 LIU shall help in efficient fibre management for maintenance. Also, LC connector patch cords shall be used on either end of the fibre cables.

1.6.64 The LIU shall be as following:

| Sl. No | Description | Data |
|---|---|---|
| 1 | Material | Aluminium |
| 2 | Front and rear covers | Removable |
| 3 | Cable Plug | 28 mm Dia, Rubber |
| 4 | Adapter panel | Maximum 48LC, 24SC, 24ST, or 24FC terminations |

**Plant Automation system**

1.6.65 The Bidder will be required to do the complete sequencing for start-up, raising the load to full load operations, emergency shutdowns etc. under various conditions. The system shall be capable of three (3) modes of operation:

1. Automated control mode requiring no operator intervention except at the start. In this mode, operator will be informed of various steps being performed. In case any missing criteria occur, this will be informed to the operator.
2. System guided modes in which extensive operator guides will be provided by the system. The operator will start/stop the major sequences based on the operator guides. The major sequences will, however, be programmed into the system.
3. Manual step by step mode in which the operator can directly intervene at the drive level. Detailed operator guides shall be provided by the system under such mode also.

**Plant shutdown**

1.6.66 The system shall be capable of orderly Plant shut down as and when required in case of Exigencies. The operator guides and check listing will be displayed via. the operator OS on the Control Panel.

1.6.67 All operating stations connected on redundant data highway shall be interchangeable and operation of the Plant shall be possible from Engineering Station after security check. All operator stations shall have full access to the entire Plant data base and shall have identical functionalities. The system shall have full data base redundancy. The data base shall be independent and shall reside separate from the operator stations.

1.6.68 The system shall have built in redundancies for all system functions both at the processor and device level. No failure of any single device or processor shall lead to any system function being lost. It shall have redundant data highway on a “master less” principle.

1.6.69 Redundant equipment wherever provided shall be powered from redundant power supply units to improve system availability and reliability.

1.6.70 The SCADA shall be fully capable to operate Plant in all regimes of Plant operating conditions, including emergency operation/trip conditions, black out conditions etc. without resorting to manual control. The SCADA shall be capable of bringing the Plant to safety state automatically without operator interventions.

**Main Power Plant controller**

1.6.71 If the offered System requires Controller to achieve the functionalities the following shall be adhered.

1.6.72 Each controller envisaged for this project shall have following features as minimum:

1. Processing word length of 32/64 bit (Preferably 64 bits)
2. 16 Mbytes RAM
3. Redundant power supplies
4. Power fail/auto start feature

i. Watchdog timer (WDT)
ii. Memory protection
iii. Direct Memory Access feature
iv. Self-monitoring & diagnostic feature
v. Easy modification of control functions
vi. RISC/CISC based.
vii. Real time data controller, Computer/PC based soft controller are not acceptable.

1.6.73 The system 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.

1.6.74 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.

1.6.75 The standby processor shall be updated in line with the changes made in working processor. The system shall have redundant power supply.

1.6.76 The standby processor shall be updated in line with the changes made in working processor. The system shall have redundant power supply.

**Established reliability**

1.6.77 All components and systems offered by the Bidder shall be of established reliability. The minimum target reliability of each component shall be established by the Bidder, considering its failure rate/ meantime between failures (MTBF) & meantime to repair (MTTR), such that the availability of the complete system is assured for 8700 hours / year (99.3%) or better.

1.6.78 To ensure the target reliability, the bidder shall perform necessary availability tests and burn in tests for major systems. Surge protection for electronic control systems, annunciation system and other solid-state systems conforming to SWC test per ANSI C 37.90a (IEEE standard 472) and selection of proper materials, manufacturing processes, quality-controlled components and parts, adequate rating of electronic components and parts shall be ensured by the Bidder to meet the reliability and life expectancy goals.

1.6.79 Continuous self-checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.

1.6.80 In general, failure of equipment used for alarm purpose will cause switching to the alarm state.

**Specifications for operator station, engineering workstations**

1.6.81 Workstations shall be based on latest state of art technology. The workstation employed shall be redundant based on industry standard hardware and software which will ensure easy connectivity with other systems and portability with third party software.

1.6.82 Redundant communication between workstation and redundant communication bus 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.

1.6.83 The LAN to be provided shall support TCP/IP protocol (Ethernet connectivity) for interface with other systems and shall have data communication speed of minimum 100MBPS.

1.6.84 All network components of LAN and Workstation shall be compatible to the LAN, without degrading its performance. Each operating station & Engineering workstations and any other workstations/PC envisaged in Plant shall meet following minimum requirements and as per latest trends at the time of supply:

1. Onboard Intel: 64-bit server grade Xeon octa core, 3.46 GHz processor with 1066 MHz bus with Hyperthreading or higher.
2. 16 core CPU, dual socket, dual processor (8+8)
3. 32GB DDR3 RAM (min.) and upgradable up to 24 GB minimum
4. SAS-3 x 2 TB IDE Hard Disk Drive of 10k RPM or higher in RAID5 configuration
5. 1024 MB Graphic Accelerator
6. System chipset: Intel
7. 2 x RS232/485ports
8. 1 x parallel port
9. 4 nos. USB ports (2nos.onfrontside)
10. 1 x 52X CD R/W Drive &16 X DVD Drive
11. 4 x Ethernet (100/1000MB) cards (Industrial Grade)
12. UXGA graphics and monitor 1920X1080, 256 colours with MRPII compliant, viewing angle 178°, vertical and horizontal and fastest response time.
13. Latest and proven version of Windows OS with Multimedia
14. Ethernet adapter
15. Third party operating system, graphical users' interface (GUI) and software, if required.
16. Optical mouse
17. Soundcard
18. Internal speakers
19. Wireless internet & Bluetooth Interface
20. Redundant power supply (In-built)

21. General MS Windows latest, MS-Office Professional, Adobe
22. Acrobat, anti-virus McAfee or equivalent, AutoCAD, Network Security etc.
23. Application engineering & HMI software – to suit project specific requirement.
24. All OWS shall be interchangeable.
25. Rugged series server rack mountable 1U including key feature: dust filter, harsh operating temperature of 40 degrees and above (Make shall be HP or DELL).

1.6.85 The system shall be provided with two (servers) 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.

1.6.86 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.

1.6.87 The standby processor shall be updated in line with the changes made in working processor. The system shall have redundant power supply.

**Full flat monitors with led back lighting**

1.6.88 The bidder shall furnish OWS / EWS / Servers / PC with coloured full flat monitors with LED back lighting. OWS/EWS/Servers/PC with Monitors shall have a fast cursor control device like a track ball/optical mouse.

1.6.89 All Monitors shall be of high-resolution colour graphics type and with not less than 32 colours.

1.6.90 The picture frequency shall not exceed 85 Hz. The resolution required is 1920 X 1080 pixel or better. The picture shall be stable and completely free of any flickering. The screen illumination shall be enough to give good readability.

1.6.91 The screen dimensions shall not be less than 24" screen diagonal.

1.6.92 Antiglare hard coating shall be provided. High reliability and long life 24" (Industrial type) or better size monitors shall be supplied by the bidder. Monitors shall be equipped with all adjusting elements accessible on the front plate. Monitors with 3D capabilities for graphics shall be provided by bidder.

1.6.93 Monitors along with keyboard& optical mouse shall be mounted on supervisory control console specified elsewhere in the specification.

**Broadband connectivity**

1.6.94 It should be three tier architecture with Core, Edge, and Access layers.

1.6.95 It shall transport multiple signals at a wide range of frequencies.

1.6.96 It shall have a high-speed Internet access that is always on and faster than dial-up access.

1.6.97 Network shall be scalable to 500 Gbps in Core.

1.6.98 Layer-2 & Layer-3 VPN technologies shall serve all type of connectivity requirements and different class of services.

1.6.99 It shall be scalable from present capacity of Gigabit to Terabit.

1.6.100 The Backbone network reliability shall be of 99.5%.

1.6.101 It shall have physically segregated internet network for security of VPN network.

**System grounding**

1.6.102 The automatic control system shall be designed for grounding to the station ground mat at a single connection point. Insulated ground bus from this point shall be furnished to the control logic cabinets and shall be connected to an insulated copper grounding strap in each cabinet. The control panel and local instrument cabinets shall be grounded to the station ground mat.

1.6.103 Shields on electronic cables shall be grounded as required. When shielding terminations are required in cabinets furnished under this specification, suitable terminals and supports shall be furnished.

1.6.104 The control logic cabinets shall be equipped to accept the single point system ground, which at this point will be isolated from the building ground. Any internal component grounds or commons shall be connected at the system ground, which shall be kept isolated from the building ground.

1.6.105 Any required electrical ground or common from components not mounted in the control logic cabinets shall be brought to a terminal block connected within the component. This terminal block connection shall be located with the other terminals and shall be available from connection through the shield of the field wiring to the system ground specified within the logic cabinet. Isolation from building ground and case ground shall be inherent in the component design.

1.6.106 Earth connection of communication equipment (indoor and outdoor) shall be done in accordance with the norms of the Institute of Electrical and Electronics Engineers (IEEE)-80 or the Bureau of Indian Standards (BIS):3043, as per the applicability.

1.6.107 Protection against lightning and electric surge shall be provided as per International Electro-Technical Commission (IEC) 61000-4-5 and compliant to relevant parts of IS/IEC 62305, as per the applicability.

**Keyboard**

1.6.108 Functional keyboards for Plant operator station shall be of special type adopted to operation tasks and monitor functions. It shall contain all keys necessary for Plant operation arranged in an ergonomically manner. Multi-function keys shall be provided with automatic display for modified functions. Freely programmable keys (Minimum 101) shall be available for special user application.

1.6.109 Keyboard shall be integrated into supervisors control console's horizontal part.

1.6.110 Provision of functional keyboard shall be in addition to facility for operator control through mouse/trackball.

**Fibre Optic Cables**

1.6.111 Fibre optic cable cores shall be single mode type (OS2, G.652D), made of high-grade silica doped with Germanium and individually coated with a composite layer of acrylate, UV cured. The primary coating shall be removable with chemical solution or by mechanical accurate tool, for splicing purpose.

1.6.112 Fibre optic cables shall be circular in cross section and free from pinholes, joints, repairs and other defects. Materials used in the construction of the cable shall not affect the physical or optical properties of the fibres and shall be compatible with each other.

1.6.113 The fibre optic cables shall meet, but not limited to, the following requirements:

1. Mechanical resistance to impacts- minimum 10 impacts of 1 N/m.
2. Crush resistance - minimum 100 N/cm.
3. Maximum operating pulling force- minimum 600 N.
4. Maximum pulling force- minimum 2000 N.
5. Operating temperature range: -10°C to +60°C.
6. Ingress protection Class 66

**PRINTERS**

Coloured Laser Jet printer

| | |
|---|---|
| Printing Speed | 20 ppm (minimum) |
| Resolution | 1200X600 dpi; Memory 128MB (minimum) |
| External Port | 1 no. USB 2.0 port, and TCP/IP 10/100 Ethernet, Bluetooth interface |
| Duty Cycle | 40,000 pages per month |
| Pages size | A3, A4 and Transparency; With automatic duplex printing facility. |

## 1.7 Tests

1.7.1 The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC.

1.7.2 Type Tests

1.7.3 Controlled and Communication Equipment

1. Power Input
   a. Auxiliary Voltage
   b. Current Circuits

c. Voltage Circuits
d. Indications

2. Accuracy tests
   a. Operational measured Values
   b. Currents
   c. Voltages
   d. Time resolution

3. Insulation Tests
   a. Dielectric Tests

4. Influencing Quantities
   a. Limits of operation
   b. Permissible ripples
   c. Interruption of input voltage

5. Electromagnetic Compatibility Test
   a. 1 MHZ. burst disturbance test
   b. Electrostatic Discharge Test
   c. Radiated Electromagnetic Field Disturbance Test
   d. Electrical Fast transient Disturbance Test
   e. Conducted Disturbances Tests induced by Radio Frequency Field
   f. Magnetic Field Test
   g. Emission (Radio interference level) Test.
   h. Conducted Interference Test

6. Function Tests:
   a. Indication
   b. Commands
   c. Measured value Acquisition
   d. Display Indications

7. Environmental Tests:
   a. Cold Temperature
   b. Dry Heat
   c. Wet heat
   d. Humidity (Damp heat Cycle)
   e. Vibration
   f. Bump
   g. Shock

**Factory Acceptance Tests**

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

1.7.5 The manufacturing phase of the SCADA shall be concluded by the factory acceptance tests (FAT). The purpose is to ensure that the Bidder has interpreted the specific requirements correctly and that the FAT includes checking to the degree required by the Owner. The general philosophy shall be to deliver as system to Site only after it has been thoroughly tested and its specified performance has been verified, as far as Site conditions can be simulated in a test lab. If the FAT comprises only a certain portion of the system for practical reason, it shall be assured that this test configuration contains at least one unit of each, and every type of equipment incorporated in the delivered system.

1.7.6 If the complete system consists of parts from various Bidders or some parts are already installed on Site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed onsite together with the Site Acceptance Test (SAT).

1.7.7 Integrated Testing-The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:

1. Redundant Servers, Operator workstation, DR, along with all IEDs for the one bay and printers.
2. All other switches for complete sub-station as detailed in section project shall be simulated as needed.

1.7.8 Hardware Integration Test-The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory.

1.7.9 The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software.

## 1.8 Drawings, data and manual

1.8.1 The minimum requirements of data, drawings and instruction manuals for this package as listed below, in addition to the requirements of various clauses of Technical Specification, and other applicable Sections to be submitted in multiple copies to the Owner. All communications in the drawings, documentations, technical literatures, and manuals will be in English language.

1.8.2 The Bidder shall prepare an exhaustive Master Deliverable List (MDL)of all drawings/ documents/ manuals to be submitted during detailed engineering stage (including those from sub-Bidders). The MDL shall contain drawing/ document no., rev.no, title, scheduled date of submission, actual date of submission and approval status (Category & date). The exact format shall be as approved by Owner.

1.8.3 The Bidder shall furnish the MDL to Owner before Notification of Award (NOA). This shall be discussed and finalized during pre-award discussions. The MDL will be modified by Bidder periodically to take care of detailed engineering requirements.

1.8.4 The MDL shall be submitted by Bidder for Owner's information, every month with latest status.

1. Time schedule
2. An exhaustive Master Deliverable List (MDL) for drawing& documents
3. Technical data sheet of individual components
4. List of deliverable items &packing list.
5. Bill of quantity
6. Documents as listed in various sections.
7. Detailed erection and commissioning procedure
8. Test procedures which include Factory Acceptance Test (FAT)/Site Acceptance Test (SAT)/PG Test as per relevant IS/IEC standard
9. Type test certificates for all equipment
10. Manufacturing quality plan
11. Field quality plan
12. O&M manual
13. As-built drawings
14. Hardware/Software Bill of Quantities with model no./part no., Volume, weight, and dimensional details (including spares)
15. Hardware Specification
16. Functional design document
17. Block Diagram
18. Guaranteed technical parameters, Functional design specification and guaranteed availability and reliability.
19. Calculation of power supply dimensioning
20. Complete documentation of implemented protocols between various elements.
21. System Configuration Diagram with interfacing details.
22. G.A. (General Arrangement) and Internal Arrangement drawings of all Control Panels / Cabinets / Consoles with all dimensional details, wiring diagrams and terminal details.
23. Control loop configurations with write-ups and logical diagram
24. I/O assignment system including nest loading, spare capacity, and other engineering details.
25. Special tools/instruments for maintenance
26. Certificate from statutory body
27. As built drawings.

28. Installation, Operation & Maintenance manuals
29. Operating, programming, reference, and other manuals for software
30. Spare parts list for 5 years
31. Maximum bus utilization under worst loading condition calculation details shall be furnished.
32. Datasheets of each item
33. Hardware & software design manual (covering exhaustive details of complete system)
34. List of software included.
35. Confirmation certificate for the latest version of software and hardware offered.
36. Final documentation, Master clock system, as per the as-built status of the system
37. Sub-vendor list
38. Recommended Spares List
39. Any other drawings/ documents listed in respective equipment sections.

### 1.9 Special tools and tackles

1.9.1 A set of special tools and tackle which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied.

1.9.2 The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which they are intended.

### 1.10 Packing and delivery

1.10.1 The Bidder shall arrange transportation of all equipment from the point of manufacture to the Site. The arrangements shall include, but not be limited to, hiring adequate capacity of Wagon, determining the routes, determination of required permits, payment of required taxes and duties, and notification to the Owner.

### 1.11 Painting

1.11.1 All steel surfaces shall be sand blasted to remove all rust, scale, and foreign adhering matters. The steel surfaces shall be then chemically cleaned, rinsed, phosphate, rinsed and dried.

1.11.2 Immediately after phosphating, the surfaces shall be given two coats of high-quality primer and stoved after each coating.

1.11.3 The panels shall be finished with two coats of synthetic enamel paints unless otherwise specified, white inside and approved shade of paint outside. The panels shall be stoved after spraying of each of the finish coatings. Base frame shall be painted black. Alternatively, powder coating can be adopted.

1.11.4 The panels shall have a smooth and uniform matt finish, free from scratches, dents and any other imperfections. Sufficient quantity of touch-up paints shall be furnished for application at Site.

1.11.5 The Bidders are requested to furnish the details process adopted by them for pre-treatment and painting of sheet metal for the control boards.

## 1.12 Warranty

1.12.1 All the equipment included in the scope shall satisfy the warranty of minimum 12 months from the date of Commissioning of Facility, or 18 months from the delivery at Site which ever later.

# 2. Instrumentation and Communication Cables

## 2.1 Introduction

2.1.1 Instrumentation cables shall be used to internal wiring for control, metering, and auxiliary circuits. The communication cables shall be used to communicate with other system internally and externally.

## 2.2 Codes and Standards

2.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

| Standard | Description |
|---|---|
| IS: 3975 | Mild steel wires formed wires and tapes for armouring of cables. |
| IS: 4905 | Methods for random sampling. |
| IS: 5831 | PVC insulation and sheath of electric cables. |
| IS: 1554 Part-1 | PVC insulated heavy duty electric cables |
| IS: 8130 | Conductors for insulated electric cables and flexible cords. |
| IS: 10418 | Drums for electric cables. |
| IS: 10810 | Methods of tests for cables. |
| IEC 60502-1 | Cables for rated voltages of 1 kV ((Um = 1,2 kV) |
| BS EN:50288-7 | Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for instrumentation and control cables |
| IEC 60331, BS 6387, SS 299 | Fire Resistance Test |
| IEC 60332, BS 4066, IEEE 383 | Flame Retardant test |
| IEC 61034, BS 7622, EN 50268 | Smoke Emission Test |
| IEC 60754, BS 6425 | Halogen Content Test |
| ASTM D 2863 | Oxygen Index Test |
| Indian Electricity Act and rules framed there-under. | |
| Regulations laid by the office of the Chief Electrical Inspector to Government (CEIG). | |
| Regulations laid by CEA of India. | |

## 2.3 Technical Requirements - Instrumentation Cables

2.3.1 Cables shall be capable of operating satisfactorily under the power supply and frequency variations, high ambient, high humid tropical climatic conditions as specified in project information.

2.3.2 The control power cables shall be multicore with copper conductor, PVC insulation and aluminium/steel armoured. The common core covering shall consist of non-hygroscopic filler.

2.3.3 The PVC outer sheath shall be oil resistant and treated in order to prevent the cables from spreading fire and shall be black coloured for all control cables. The sheath shall contain the manufacturer's name, the voltage levels, and the cable type.

2.3.4 The cable sheaths, these shall be resistant to the following:

a. Saline ground water
b. Flame retardant.
c. BESS radiation
d. Bacterial action
e. Attack by insects and rodents.
f. Action of sea water.

2.3.5 Cables are proposed to be laid in multi-tier overhead cable racks, in duct banks, in concrete cable trenches, directly buried in soil.

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

2.3.7 PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg C. The insulation material shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.

2.3.8 Colour coding shall provide core identification of multicore cables of up to 5 cores. For more than 5 core, cores shall be identified by numbering.

2.3.9 Cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath, except single core cables.

2.3.10 For multicore armoured cables, armouring shall be of galvanised steel.

2.3.11 To minimize the damage that can be caused by a fire, conductors installed in electrical cable tray systems shall have jackets which have low smoke, non-propagating, and self-extinguishing characteristics. Outer sheath shall be of PVC black in colour. These cables shall meet the following test requirements. Test methods shall be as per IS 10810 or other international standards listed under clause 2.0.0

a. Oxygen index of minimum 29 when tested.
b. Temperature index of minimum 250˚C when tested.

c. Acid gas emission of maximum 20% when tested Average light transmission of 40% minimum when tested (average smoke density is maximum 60%).

d. Flame test requirements as per relevant IEC/IS

e. Flame retardant test requirements.

2.3.12 All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added into the PVC compound of the outer sheath. The sheath shall be resistant to water, UV radiation, fungus, etc.

2.3.13 In Plant repair of cable shall not be acceptable. Damaged cable shall be removed from the Site. Both ends of cables shall be sealed with heat shrink PVC/rubber caps.

2.3.14 Multicore 1.1kV earthed grade control cables shall constitute the following:

a. Multi stranded annealed copper conductor.

b. Extruded PVC insulation.

c. Extruded PVC inner sheath.

d. Galvanised steel formed wire/strip.

e. Extruded FRLS PVC outer sheath.

2.3.15 Multi pair 1.1kV kV earthed grade, overall screened signal cables shall constitute the following as per BS EN 50288-7:

a. Multi stranded annealed copper conductor.

b. Extruded PVC insulation.

c. Twisted pair.

d. Overall polyester taped, Al-mylar screened with ATC drain wire.

e. Extruded PVC inner sheath.

f. Galvanised steel formed wire/strip.

g. Extruded FRLS PVC outer sheath.

2.3.16 Multi pair 1.1kV kV earthed grade, individual and overall screened signal cables shall constitute the following as per BS EN 50288-7:

a. Multi stranded annealed copper conductor.

b. Extruded PVC insulation.

c. Twisted pair.

d. Individual polyester taped, Al-mylar screened with ATC drain wire.

e. Overall polyester taped, Al-mylar screened with ATC drain wire.

f. Extruded PVC inner sheath.

g. Galvanised steel formed wire/strip.

h. Extruded FRLS PVC outer sheath.

## 2.4 Technical Requirements - Communication Cables

2.4.1 Optical Fibre Cable

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

b. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. Steel central number, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly etc.

c. 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.

d. The operating temperature shall be -20 deg. C to 70 deg. C. All testing of the optic fiber cable being supplied shall be as per the relevant IEC, EIA and other international standards. Bidder to ensure that minimum 50% (but not less 4) cores are kept as spare in all types of optical fiber cables.

e. Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation. Spliced/ Repaired cables are not acceptable.

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

2.4.2 Ethernet

a. Ethernet cable shall be CAT6A SFTP

b. RS485 cable shall have individual & overall shielded.

c. Ethernet Cable Minimum Specification as per ANSI/TIA-568C.2, ETL Verified, UL Listed & Verified for CAT 6, TIA/EIA-568-C.2

| | |
|---|---|
| Type | : CAT 6 |
| Conductor | : 23 AWG bare solid copper |
| Insulation | : High density Polyethylene |
| Inner Jacket | : PVC – GREY |
| Thickness of inner jacket | : 0.65 to 0.70mm |
| Armouring | : Aluminium Wire |
| Size of Wire | : 0.80mm |

| | |
|---|---|
| Sequential Marking | : At Every Meter |
| Temperature Rating | : -20° to + 70°c |
| Outer Jacket | : Fire Retardant PVC – Black |
| Outer Jacket Thickness | : 0.85mm |
| Colour of Jacket | : Black |
| Filler | : HDPE |
| Conductor Resistance (DC) | : 93.5 Ohm /1000 mtr @20°C Max |
| Resistance Unbalance | : 5% Max |
| Mutual Capacitance | : < 5.6 nF/100 mtr |
| Capacitance Unbalance Pair/Ground | : 330pF/100M Max |
| Propagation Delay Skew | : 536 nS/100M |
| Worst Case cable skew | : 45nS/100M |
| Characteristic Impedance | : 100±15% |

**2.5 Cable identification system**

2.5.1 In addition to manufacturer's identification on cables as per IEC, following marking shall also be embossed/printed on the outer sheath at an interval of one metre throughout the length of cables.

- Manufacturer's name and or trade name.
- Year of manufacture
- Cable code
- Type of cable and voltage class.
- Nominal cross section area of conductor and no. of cores.
- Progressive sequential length making.

2.5.2 Cables shall be marked as having FRLS outer sheath at every 5 meters.

2.5.3 The embossing / printing shall be progressive, automatic, in line and marking shall be legible and indelible.

2.5.4 Multi-core cable colour coding shall be as follows:

- Red, yellow, blue, black and grey for five core cables
- Outer sheath shall be of black in colour.
- For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.
- For multi pair cables, each pair shall be coloured and numbered.

**2.6 Cable drums**

2.6.1 Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. All ferrous parts shall be treated with suitable rust protective finish or coating to avoid rusting during transit and storage. All wooden parts shall be manufactured from durable quality wood duly seasoned and treated with copper naphthenates or zinc naphthenates for preserving the wood. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. 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. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with BS8512.

2.6.2 Each drum shall carry manufacturer's name, Owner's name, address and contract number item number and type, voltage grade, number of cores, size and length of cable and net and gross weight and drum number stencilled on both side 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. The standard drum length shall be 1000 M.

2.6.3 Cable overall diameter tolerance shall be less than ±2.0 mm. Eccentricity of the cable core shall not exceed 20 percent and the ellipticity of the cable core (insulated aluminium conductor) shall not exceed 10 percent.

2.6.4 The cable drums should carry the following details in printed form:

a. Manufacturer's name or trade make.
b. BIS Mark
c. Type of cable & voltage grade
d. Year of manufacture
e. Type of insulation e.g. HR85 for HRPVC
f. No. of core and size of cables
g. Cable code
h. Length of cable on drum
i. No. of length on drum, if more than one
j. Direction of rotation, by arrow
k. Approx. gross mass.
l. Owner Name

**2.7 Tests**

2.7.1 Cables offered shall be type tested and proven type. Type tests and special tests shall be carried out for each voltage grade and for one type of single core cable and one type of multicore cable.

Acceptance tests shall be carried out on each lot as per applicable IEC. Sampling plan shall be as per IS. Routine tests shall be carried out on each drum as per applicable IEC. Tests on cables shall constitute the following:

2.7.2 Type Test

a. Tests on conductor
   1. Annealing test
   2. Resistance test

b. Tests for armour wires/strips

b. Tests for thickness of insulation and sheath

c. Physical tests for insulation
   1. Tensile strength and elongation at break
   2. Ageing in air oven
   3. Shrinkage test
   4. Hot deformation
   5. Heat shock test
   6. Loss of mass test in air oven
   7. Thermal heat stability test

d. Physical test for outer sheath
   1. Tensile strength and elongation at break
   2. Ageing in air oven
   3. Shrinkage test
   4. Hot deformation
   5. Heat shock test
   6. Loss of mass test in air oven
   7. Thermal heat stability test
   8. Anti termite and anti-rodent test (on outer sheath).
   9. Insulation resistance (volume resistivity) test
   10. High voltage test
   11. Flammability test
   12. Cold impact test

2.7.3 Acceptance Test

a. Annealing test

b. Conductor resistance test

c. Test for thickness of insulation and sheath

d. Tensile strength and elongation at break test for insulation and outer sheath

e. High voltage test

f. Insulation resistance (volume resistivity) test

2.7.4 Routine Test

a. Conductor resistance test

b. High voltage test

2.7.5 Special Test

a. Oxygen index test as per

b. Temperature index test

c. Acid gas generation test

d. Smoke generation test

e. Flammability test

f. Flame retardant test

2.7.6 All cables shall be suitable for high ambient, high humid tropical climatic conditions. Cables shall be designed to withstand the

**2.8 Drawings & Documents**

2.8.1 The following drawings and documents shall be submitted for approval during detail engineering stage.

a. Technical data sheet.

b. Cable cross-sectional drawing.

c. Short circuit withstands calculation of metallic screen and conductor.

d. Component list & Bill of Quantities.

e. Erection and commissioning procedures along with de-rating factors.

f. Catalogues / drawings / leaflets for all items.

g. General Instruction for Operation and maintenance manual.

h. Test reports along with type test reports.

i. Sub-vendor list – Source of raw material.

j. Manufacturing quality plan.

k. Conformity Certificates to be submitted (from NABL accredited lab)

# 3. Fibre Optic Terminal Equipment (FOTE)

## 3.1 Intent of Specification

3.1.1 This specification is intended to cover the Design, Engineering, Manufacture, Assembly, Inspection, Erection, Testing and Commissioning of the Fibre Optic Terminal Equipment.

3.1.2 The Bidder shall submit the detailed design calculations, GTP and drawings, bill of materials and their specifications / standards to the Owner for approval before manufacturing commencement.

3.1.3 All design calculations, GTP and drawings shall be submitted to the Owner for approval before execution.

## 3.2 Codes and Standards

3.2.1 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards, CEA metering regulations and CBIP publications including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards and publications are listed below:

| Standards | Description |
|---|---|
| IEC 61000-6-2 (1999-01) | Electromagnetic compatibility (EMC) – Part 6-2:<br>Generic standards – Immunity for industrial environments. |
| IEC 61000-6-5 (2001-07) | Electromagnetic Compatibility (EMC) - Part 6-5:<br>Generic standards – Immunity for power station and substation environments.<br>Test: 1.2, 1.3, 2.3 and 2.5 |
| IEEE C37.1 (1994) | Definition, Specification and Analysis of Systems<br>Used for Supervisory Control, Data Acquisition, and Automatic Control - 6.6 Electromagnetic Interference (EMI) and electromagnetic Compatibility (EMC) |
| IEEE C37.90.2 (1995) | Withstand Capability of Relay Systems to Radiated<br>Electromagnetic Interference from Transceivers. |
| IEEE C37.94 | IEEE Standard for 64kbit/s Optical Fiber Interfaces Between Line Differential relay and Multiplexer Equipment |
| EN 55022 | Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement |
| ITU-T G.664 | Optical safety procedures and requirements for optical transport systems |
| ITU-T G.702 | General aspects of digital transmission systems -Terminal equipment - Digital hierarchy bit rates |
| ITU-T G.703 | Digital transmission systems – Terminal equipment – |

| Standards | Description |
|---|---|
| | General Physical/electrical characteristics of hierarchical digital interfaces |
| ITU-T G.704 | Digital transmission systems – Terminal equipment – General Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736kbit/s hierarchical levels |
| ITU-T G.706 | General aspects of digital transmission systems-Terminal equipment - Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in recommendation G.704 |
| ITU-T G.707 | Network node interface for the synchronous digital Hierarchy |
| ITU-T G.711 | Pulse code modulation (PCM) of voice frequencies |
| ITU-T G.712 | Transmission performance characteristics of pulse code modulation channels |
| ITU-T G.732 | General aspects of digital transmission systems – Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048kbit/s |
| ITU-T G.735 | Characteristics of primary multiplex equipment operating at 2048kbit/s and offering synchronous digital access at 384kbit/s and/or 64kbit/s |
| ITU-T G.736 | General aspects of digital transmission – Characteristics of a synchronous digital multiplex equipment operating at 2048kbit/s |
| ITU-T G.737 | characteristics of external access equipment operating at 2048kbit/s and offering synchronous digital access at 384kbit/s and/or 64kbit/s |
| ITU-T G.783 | Characteristics of synchronous digital hierarchy (SDH): equipment functional blocks |
| ITU-T G.785 | Characteristics of a flexible multiplexer in a synchronous digital hierarchy environment |
| ITU-T G.803 | Architecture of transport networks based on the synchronous digital hierarchy (SDH) |
| ITU-T G.805 | Generic functional architecture of transport networks |
| ITU-T G.813 | Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC) |
| ITU-T G.823 | The control of jitter and wander within digital networks, which are based on the 2048kbit/s hierarchy |
| ITU-T G.825 | Control of Jitter and Wander within Digital Networks which are based on Digital Synchronous Hierarchies (SDH) |

| Standards | Description |
|---|---|
| ITU-T G.826 | Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate |
| ITU-T G.841 | Types and characteristics of synchronous digital hierarchy (SDH) network protection architectures |
| ITU-T G.957 | Optical interfaces for equipment and systems relating to the synchronous digital hierarchy |
| ITU-T G.958 | Digital line systems based on the synchronous digital hierarchy for use on optical fiber cables |
| ITU-T G.991.2 | Single-pair high-speed digital subscriber line (SHDSL) transceivers |
| ITU-T G.7041 | Generic framing procedure (GFP) |
| ITU-T G.7042 | Link Capacity Adjustment Scheme (LCAS) for virtually concatenated signals |
| ITU-T G.8032/ Y.1344 | Ethernet ring protection switching |
| ITU-T G.8113.2 (11/2012) | Operations, administration and maintenance mechanisms for MPLS-TP networks using the tools defined for MPLS |
| ITU-T G.8261 | Timing and Synchronization Aspects in Packet Networks |
| ITU-T K20 | Resistibility of telecommunication equipment installed in a telecommunications centre to over voltages and over currents |
| ITU-T K.21 | Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents |
| ITU-T K.45 | Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents |
| ITU-T M.2101.1 | Performance limits for bringing into service and maintenance of international SDH paths and multiplex section |
| ITU-T Q.552 | Transmission characteristics at 2-wire analogue interfaces of digital exchanges |
| ITU-T Q.553 | Transmission characteristics at 4-wire analogue interfaces of digital exchanges |
| ITU-T T.50 | International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange |
| ITU-T M.2101.1 | Performance limits for bringing into service and maintenance of international SDH paths and multiplex section |
| ITU-T T.50 | International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange |
| ITU-T G.813 | Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC) |

| Standards | Description |
|---|---|
| IEEE 802.1D | Media Access Control Bridges |
| IEEE 802.1Q | Virtual bridged local area network |
| IEEE 802.1p | Traffic class expediting and dynamic multicast Filtering |
| IEEE 802.1t | MAC bridges amendment 1 |
| IEEE 802.1w | MAC bridges amendment 2: rapid reconfiguration |
| IEEE 802.3 | Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications |
| IEEE 802.3z | Gigabit Ethernet |
| IEEE C37.94 | IEEE Standard for Nx 64kbit/s Optical Fiber interfaces between Teleprotection and Multiplexer Equipment |
| IEEE 1588 2008 (v2) | IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems |
| IEEE 1613 | IEEE Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations |
| CEA Regulations | Technical Standards for Communication System inPower System Operations, dated 27th February 2020 AND Cyber security in Power Sector Guidelines 7th July 2021<br>Draft Central Electricity Authority Technical Standards For Construction of Electrical Plants Electric Lines Regulations 2021-1. |

### 3.3 General requirements

3.3.1 The Contractor shall be responsible for complete design, engineering, manufacture, factory inspection including approved tests, supply, delivery, installation and integration of the Fiber Optic Terminal Equipment with the SAS, CRP and other associated equipment.

3.3.2 SDH equipment along with suitable optical line interfaces & tributary cards, Network Management System (NMS), all cabling wiring, digital distribution frame patch facilities, interconnection to supplied equipment's, etc. All interface data and communication cables are covered under scope of this specification.

3.3.3 The digital fiber optic communication backbone shall be based on the SDH technology and network architecture. The proposed FOTE system shall be capable of supporting both SDH & Teleprotection (Distance & Differential Protection) interfaces required for the project.

3.3.4 The FOTE system shall be designed for digital transmission using single mode optical fiber and shall conform to ITU-Y recommendations G.703, G.704, G.707, G.783 and G.957.

3.3.5 The multiplexing structure of the proposed FOTE system shall allow existing PDH signals to be carried over the synchronous network and shall permit the extraction of individual circuits from high capacity systems without having to demultiplex the whole system.

3.3.6 The proposed fiber optic communication network shall support the voice, Teleprotection (both distance protection commands operation & line differential protection) & data communication requirements of RTUs and the EMS system. The communication system shall provide data & voice connectivity of RTUs with NERLDC. The RTUs shall communicate using IEC 870-5-101 or IEC 870-5-104 Protocol. The proposed communication system shall also support Ethernet interface for RTUs over TCP/IP protocol and serial interface.

3.3.7 The fiber optic network shall be based on the lowest bit rate of the Synchronous Digital Hierarchy (SDH) i.e. STM-16 or, better by optical (Laser) SFP. The Contractor shall propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement.

3.3.8 FOTE shall be of reputed vendor (same shall be as per grid substation requirement) with all required hardware, software, accessories, etc. inbuilt in the panel for full operational of FOTE requirement shall be in the scope of bidder.

3.3.9 FOTE software License shall be perpetual and FOTE software shall be loaded in Laptop provided by Owner. Owner Laptop will have one ethernet port, any additional Converter, special cables, hardware and software required for programming, configuration, fault diagnostic etc. of FOTE from Owner Laptop shall be in scope of bidder. Bidder shall demonstrate programming, configuration etc. from Owner Laptop by connecting it to FOTE panel. Bidder shall give training to Owner engineer for Programming configuring, fault diagnostic etc. of FOTE system.

3.3.10 Periodic Testing of the Communication system

a) All users that have provided the communication systems shall facilitate for periodic testing of the communication system in accordance with procedure for maintenance and testing to be prepared by CTU within 60 days of notification of Regulations and approved by Commission.

b) Testing process for communication network security should also be included even for third party system if exists in accordance with procedure for maintenance and testing to be prepared by CTU and approved by Commission.

**3.4 Technical Requirements**

3.4.1 The digital multiplex equipment shall be designed to operate in 132kV networks and suitable for installations in pooling substations with harsh environment and high electromagnetic interference. It

shall be highly reliable and provide secure communications for real time signals such as voice over Internet Protocol (VoIP), Video Conferencing, Metering, Distance and Differential Teleprotection. The multiplex equipment shall offer the possibility for fan less operation in order to ensure maintenance free operation and comply with the environmental conditions in substation environment. Accordingly, it shall comply with substation relevant standards such as IEEE 1613, IEC61850-3. The offered Hybrid FOTE equipment shall comply simultaneous functionality of SDH and MPLS-TP with the latest ITU-T and IETF recommendations, ETSI and IEEE standards and be able to communicate over be interconnected with legacy multiplexer. On PACKET TRANSPORT LEVEL interfaces for optical MPLS-TP based transmission up to 10Gbit/s shall be available. Enhanced traffic engineering using MPLS-TP technology as per relevant IETF standards shall be supported by providing VPWS, VPLS and Tree services using the MPLS-TP infrastructure. The FOTE shall support SDH and MPLS-TP functionality with same 19" rack equipment.

3.4.2 The Hybrid FOTE communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

3.4.3 The wide band network shall be designed in a manner to ensure absolute channel delay less than 25 milliseconds and channel delay asymmetry less than 0.1 milliseconds required for protection applications.

3.4.4 New node when added to the existing network, the terminal equipment shall be compatible to the existing one and shall be possible to integrate with existing respective network management system either at State level or at Central level for complete monitoring, reconfiguration and control.

3.4.5 The terminal equipment shall be designed with the required numbers of directions considering the route redundancy and future expansion.

3.4.6 FOTE system shall have provision for supporting minimum 06 nos. of VOIP telephone.

3.4.7 On SDH/TDM Transport Level interfaces for optical transmission on STM-16 (2.5Gbit/s) shall be available. Additionally, 2Mbit/s DSL interfaces shall be available for connection to copper cables. For connection to higher order transport equipment also N x 2Mbit/s (E1) and STM-1/16 electrical interfaces shall be available.

3.4.8 MPLS-TP and SDH simultaneous functionality shall be natively integrated with legacy application.

3.4.9 Static configuration of bidirectional and co-routed communication channels shall be supported using the NMS. Dynamic routing shall be prohibited for all critical data channels. End to end channel supervision should be supported. The equipment shall be software controlled, of modular design and all modules shall form an integrated part of a 19" shelf.

3.4.10 The bidder must be original Equipment manufacturer of proposed FOTE SDH & MPLS-TP, Teleprotection interface/Coupler for Distance, Differential IEEE C37.94 and IEC 61850 goose based teleprotection solution for desired inter-tripping application. The platform shall have means to cross-connect, drop and insert individual channels (64kbit/s time slots), 2Mbit/s framed (G.704) and unframed (G.703) signals. It shall also support termination and cross connection of VC-12 and VC-4. Equipment protection and various

3.4.11 protection schemes shall be supported.

3.4.12 For Pooling Substation with Teleprotection and telecommunication requirements an integrated Teleprotection interface (distance, differential & IEC 61850 GOOSE based protection) shall be offered / supported with SDH and MPLS-TP functionality. For external Teleprotection equipment is only accepted in stations, wherein existing equipment has to be integrated for extending the teleprotection application. With offered external Teleprotection equipment must be offered with Ethernet interface for communication on MPLS-TP and E1 2 Mbps for SDH functionality and it should also comply requirement of Teleprotection as per IEC 60834-1. i.e. security, dependability.1The proposed 19" rack Hybrid FOTE equipment should have minimum 18 slots for application cards. Each network element shall be manageable locally as well as from an operation center.

3.4.13 With Hybrid FOTE equipment with SDH and MPLS-TP functionality / Future upgradability for direct connection to following user signals shall be available on hot pluggable plug-in modules for the equipment:

- Ethernet interface module with 10/100/1000BaseT, electrical, RJ-45 or SFP based or integral part of Control System or TDM interface.
- Ethernet Interface 100BaseFX and 1000BaseLX/SX, optical, SFP based
- Support of L2 switching functions
- Support of L3 routing functions
- Support of Power over Ethernet
- Ethernet interface supporting Ethernet over SDH (EoSDH, GFP ITU-T G.7041 and LCAS ITU-T G.G.7042 functions)
- Alarm collection interface
- Distance Teleprotection integrated interface module with 4 tripping signals common for both SDH and MPLS-TP functionality as per IEC 60834-1
- Differential Teleprotection integrated Optical interface module for up to 4 protection relays common for both SDH and MPLS-TP functionality compliant to IEEE C37.94
- IEC 61850 GOOSE based protection interface
- Binary signal (status and control) interface

- 2 Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704
- Circuit emulation function for E1, serial and telephony interfaces
- n x 2 Mbit/s electrical SHDSL ports for TDM services supporting copper pair bonding

3.4.14 On TRANSPORT LEVEL the equipment shall support / future upgradable to the following connection ports:

- Up to 8 x STM-16 SDH optical ports
- Up to 16 x STM-4 SDH optical ports
- Up to 8 x STM-1 SDH optical / electrical ports
- Up to 8 x MPLS-TP capable transport ports
- Up to 8 x 10 Gbit/s Ethernet (MPLS-TP) ports
- N x 2 Mbit/s electrical E1 ports
- N x 2 Mbit/s SHDSL ports
- Up to 200 x electrical/ optical 1 Gbit/s Ethernet ports

3.4.15 All optical MPLS-TP, SDH and Ethernet ports shall support SFP or SFP + modules (small-factor pluggable unit) for short, medium, long and extra-long optical communication. ALS (Automatic Laser Shutdown) shall be fully supported.

3.4.16 The bidder must supply the FOTE from the Original Equipment Manufacturer (who has service centre in INDIA) of proposed FOTE MPLS-TP, Teleprotection interface/Coupler for Distance, Differential and IEC 61850 goose based teleprotection solution desired for intertripping application. The OEM shall have necessary valid evidence such as Certificate of Registration, ISO, License, previous supply / delivery references in State Power Utilities/ IPPs/ CPPs /CTUIL substations, performance certificate etc. Equipment Life Span: All equipment supplied under this specification shall have a minimum expected life of ten (10) years from the date of operational acceptance by Owner. FOTE and it cards, accessories shall be selected that no items shall be in end of life cycle/phase-out product. O.E.M shall provide certificate/letter for support of spares and services for 10 years from the date of operational acceptance by Owner.

3.4.17 The FOTE shall support minimum functionality, namely: -

- high speed bundled n x E1 support including ethernet, gigabit ethernet (GbE);
- high speed E1 channel support.
- 64 kilobits per second (kbps) and n x 64 kilobits per second (kbps) data and Protection channel support.
- low speed (300 -1200 bits per second) data channel support.
- voice (2 wires, 4 wires) channel support.
- data transport supporting network management channels

- An Institute of Electrical and Electronics Engineers (IEEE)-C37.94 interface card for tele-protection of lines.
- The relevant standards and code of practice as specified in the Bureau of Indian Standards (BIS), the International Telecommunications Union Telecommunication (ITU-T) and the IEC shall be followed.

## 3.5 Multiservice Platform Requirements

**General Requirements**

3.5.1 The equipment shall be capable of operating as a Label Edge Router (LER) and Label Switch Router (LSR) in MPLS-TP networks. It shall support packet switched point-to-point, point-to-multipoint and multipoint-to-multipoint topologies. The proposed FOTE equipment shall as well support hybrid operation where MPLS-TP and SDH is operational at the same time.

3.5.2 Ethernet over SDH as well as circuit emulation functionality shall be provided to link the TDM with the PSN domain. In SDH networks the equipment shall operate as a terminal, as an add-drop multiplexer and in transit mode as a regenerator/repeater. First order (2 Mbps), low order (VC-12) and high order (VC-4) multiplexing shall be integrated. Conference for voice channels and point-multipoint functions for data signals shall be supported. The equipment shall be of modular design.

**Packet Switched Capacity**

3.5.3 The design of the backplane shall provide wire-speed 10 Gigabit Ethernet (GbE) connectivity between the different slots and the central (redundant) Ethernet switching matrix slots. Between uplink slot positions a backplane capacity of n x 10 GbE shall be available ($n \geq 2$). For future upgrade purposes a 10 GbE backplane connection from the central Ethernet switching matrix to x different slots shall be available ($x \geq 6$). The central switching matrix shall at least support 62 Gbit/s in full duplex wire-speed switching capacity in a lower scale version and at least 146 Gbit/s in a higher scale version. IPv4 routing shall be as an option with a capacity of at least 10 Gbit/s wired speed routing. The combination of MPLS-TP and integrated IP routing interface card shall allow to offer L3 VPN services with fast L2.5 based transport functionality and IP routing at defined locations. This also supports VPWS (Point to Point) & VPLS (Point to Multipoint) services, to send the Ethernet traffic over MPLS-TP Link.

**Circuit Switched Capacity**

3.5.4 The cross-connection functions shall be implemented in such a way that no single point of failure exists. Each SDH interface card shall offer a high-order SDH cross-connect capacity of up to VC-4 and VC-12 in the same SDH interface card with a capacity of up to VC-12. VC-4 & VC-12 SDH cross connect capacity shall be upgradable by adding additional SDH interface units.

**Redundancy Capabilities**

3.5.5 The equipment shall provide enhanced redundancy features in order to ensure highest availability of the communication network. The following redundancy schemes shall be supported:

- Redundant or distributed cross connect
- Redundant power feeding
- Redundant CPU functionality
- HW redundancy of SDH aggregate interfaces
- HW redundancy of 1 Gbit/s and 10 Gbit/s MPLS-TP aggregate interfaces
- HW redundancy of voice and data conferencing
- HW redundancy of central Ethernet switching matrix
- HW redundancy of routing function
- Enhanced TDM traffic protection schemes
- SNCP/ MSP/ VCAT/ LCAS over redundant TDM aggregate modules
- Enhanced PSN traffic protection schemes
    - 1:1 LSP protection switching
    - Hitless redundancy for protection data channels using MPLS-TP
    - xSTP and ERPS loop prevention
    - VRRP for routing function

## 3.6 Traffic Protection Scheme

**1:1 Path protection**

3.6.1 1:1 protection of MPLS LSPs shall be supported. Switching from main to backup path shall be automatic, bidirectional and symmetrical. Configuration options shall exist for reversible or non-reversible operation.

**1+1 Path Protection**

3.6.2 The equipment shall provide means to protect 64kbit/s channels. The protection shall be end to end from one interface (telephone, data, protection signalling) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

3.6.3 If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm. The switching shall be done within the multiplexer without using the Network Management System.

3.6.4 SNCP protection on VC-12 and VC-4 level shall be supported. Switching from main to backup path shall be automatically. Configuration options shall exist for reversible or non-reversible switching. Switchover time shall be less than 50 ms.

3.6.5 For utility critical applications symmetrical switching of TX and RX on VC-12 and 64Kbps level shall be supported.

**1+1 Selection Protection**

3.6.6 The equipment shall provide means to protect SDH STM-n sections (MSP). It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed. MSP shall be configurable as intra- and inter-card feature to provide aggregate interface as well as module protection. The switching shall be done within the multiplexer without using the Network Management System.

3.6.7 Hitless protection for teleprotection data channels

3.6.8 Critical teleprotection data shall not use any LSP 1:1 protection but rather be implemented using a hitless redundancy scheme where critical teleprotection data is duplicated at the teleprotection interface card itself and transmitted via two diverse non-redundant Label Switch Path.

## 3.7 Teleprotection

a) The offered Hybrid FOTE (SDH and MPLS-TP) equipment shall support integrated teleprotection coupler by adding necessary hardware in the same equipment. The communication system has to ensure simple, reliable and secure operation. The module shall support the following features related to the protection commands.
   - Security and Dependability according to IEC 60834-1 shall be fulfilled
   - Accept protection command signals in the range of 40VDC to 250VDC
   - All inputs and outputs shall be isolated and with EMC immunity for harsh environment (see also table of compliance, emission and immunity)
   - Transmit up to 4 protection commands bi-directionally, it shall also be able to drop and insert commands, transfer commands as a transit station and to realize AND- and OR-combinations between commands. The module shall support T-node configurations.

b) The Integrated teleprotection module shall provide
   - An integrated non-volatile event-recorder, which shall be synchronized to either the PTP information available in the MPLS-TP based WAN, to the node local clock or via local connection to the Global Positioning System (GPS) using the IRIG-B inputs
   - IRIG-B time of day outputs to pass on time-of-day information to end devices
   - Robust and fast transmission of teleprotection commands by means of direct packetization of teleprotection signals in case of MPLS-TP WAN shall be supported.

c) The teleprotection module shall further support

- 1+1 path protection. Switching shall be done within less than 4 ms (typical value) for TDM line interfaces and hitless for MPLS-TP networks
- Periodical automatically initiated loop-tests
- Delay measurement and supervision of the Teleprotection channel including a warning if a configured threshold is exceeded
- Input de bouncing functionality shall be provided
- Input/ output command prolongation functionality shall be provided
- Command addressing: this function shall be used to prevent tripping if the signal is wrongly routed through the telecommunication network

3.7.1 Under no circumstances the module shall cause false trip-commands in case of power supply failure or when equipment is put into or taken out of service.

3.7.2 Distance and differential protection functions shall also be made available for MPLS-TP/ TDM based transport (networks) complying with the established, standard TDM/PSN performance parameters.

### 3.8 IEC 61850 GOOSE protection interface

3.8.1 Specific integrated interface for IEC 61850 based protection applications shall be available. The same shall be part of the IEC 61850 configuration of the substation and act as a gateway IED subscribing to the relevant messages for line distance protection. At least the following functionality shall be provided:

- 4 x FE/ GbE interfaces (SFP based) for direct connection with the station bus of IEC 61850 substations
- Representation of remote IED for inter substation IEC 61850 GOOSE signal transmission
- Filtering capabilities for GOOSE messages
- Translation capabilities of GOOSE messages to resolve potential addressing/ naming conflicts between substations
- Redbox functionality for connection to PRP redundant station bus (one card/ two card solution)
- L2 firewall for access restriction from the WAN to the substation station bus
- Hitless redundancy for GOOSE protection communication channels
- Guaranteed data integrity thanks to authentication of data streams
- 6 electrical IRIG-B outputs for synchronization of end devices to GPS Grandmaster clock
- Optical IRIG-B output for synchronization of end devices to GPS Grandmaster clock
- SNTP master functionality for providing time of day information to IEDs
- SNTP client functionality for full IEC 61850 compliance
- MMS status reporting to substation automation system for full IEC 61850 compliance

- Enhanced traffic supervision features providing full visibility of the communication channel performance
- Full integration in network management system
- Providing all optical interconnections from relay to relay through multiplexer without any converter boxes
- Processing time of IEC 61850 GOOSE Gateway shall be less than 200 µs
- It shall be possible to connect to up to 8 different remote ends with 1 interface card (or 1 PRP redundant interface card couple).

### 3.9 Synchronization

3.9.1 It shall be possible to synchronize the equipment using an external clock source, derived from a network or from an internal oscillator. The synchronization shall be configurable, and it shall be possible to distribute the synchronization to other equipment as well. The system shall have the means of switching to select the synchronization source as well as a means of preventing the system from creating synchronization loops. The bidder shall submit the synchronization plan as per standard ITU-T G.811. All sync equipment proposed under this package should meet ITU-T G.811 criterion.

3.9.2 The equipment shall support synchronous Ethernet and a synchronization selection process based on ESMC (Ethernet Synchronization Message Channel).

3.9.3 The precision time protocol (PTP) as defined by IEEE/ IEC shall be supported for frequency and time of day synchronization.

3.9.4 For teleprotection event recording it shall be possible to synchronize the event recorder of teleprotection interfaces to a GPS. The GPS time shall be available for the Network Element time as well.

3.9.5 Configuration support for SyncE and PTP synchronization shall be available e.g. by means of wizards or guided configuration.

3.9.6 For TDM synchronization the equipment shall be capable of selecting the source of synchronization by means of SSM (Synchronization Status Messaging) on 2 Mbit/s PDH or SDH port or by means of a priority-based sequence.

### 3.10 Telephony

3.10.1 The equipment shall support interconnection of telephony subscribers as well as digital solutions shall be supported:

- Digital VoIP subscriber and gateway functionality (SIP)
- Power over Ethernet solutions
- Hotline services

### 3.11 Cyber Security

3.11.1 The equipment shall support integration into a cyber-security architecture enabling cyber secure operation of a communication network. It shall comply to CEA regulation Guidelines_on_Cyber_Security_in_Power_Sector_2021-1 and amendments.

- Authentication, Authorization and Accounting (AAA)
  - Local management port disabling
  - User roles (privilege-levels)
  - Radius based authentication
  - Security relevant local event logging (audit log)
  - Syslog
- Secured management communication
  - SNMPv3
  - IPSec
  - SSH
- Denial of service (DoS) prevention for device functions and user traffic
  - Rate limiters for different traffic types
  - Firewall towards device management
- Traffic authentication and encryption
- Access Control Lists (ACL)

3.11.2 The equipment shall be of robust design and hardening shall be done considering cyber security aspects.

### 3.12 Quality of Service

3.12.1 Hardware support to ensure device internal and user traffic quality of service shall be provided:

- ≥ 8 hardware queues per physical port
- Configurable scheduling profiles
- Priority mapping tables (DSCP, PCP, EXP, PHB, TC)
- Priority configuration for individual protocols (e.g. PSC, MCC, …)
- Port and service based rate limiting (at least single rate two color marker (SR2CM))
- Configurable storm control for unicast, unknown unicast, multicast and broadcast per port.

### 3.13 Aggregation / Transport Interface Requirement

3.13.1 MPLS-TP Functionality

The following MPLS-TP functionality shall be supported:

- Static configuration of MPLS-TP tunnels via configuration tool or network management system
- Bidirectional MPLS-TP tunnels
- Priority handling using L2 or L3 class of service information
- Mission critical services & guaranteed performance parameters for teleprotection applications.
- Port based MPLS assignment
- VLAN based MPLS assignment
- The following topologies shall be supported
    - Point to point virtual private wire services (VPWS)
    - Tree structures
    - Virtual private LAN structures (VPLS)
    - Hierarchical VPLS structures (H-VPLS)
- End to end Operation Administration and Maintenance (OAM) channel with at least the following functionality
    - Continuity check messages (CCM)
    - Remote defect indication (RDI)
    - Route tracing (LSP ping/ trace route)
- 1:1 traffic protection with < 50 ms switchover time
- Management functionality using dedicated MPLS channel
- Circuit emulation of legacy services via MPLS-TP shall be supported.

**SDH functionality**

3.13.2 The interface shall be designed for use on single mode fiber (conforming to ITU-T G.652 or G.655). The interface card shall be based on SFP technology and use LC/PC connectors.

3.13.3 The following main functions shall be supported:

- Prepared for STM-1/4/16 SFP's (small-factor pluggable units) for short, medium, long and extra-long optical communications (1310nm, 1550nm or xWDM)
- Prepared for electrical STM-1 (155Mbit/s) SFPs
- Termination of the OS-, RS-, MS- and VC-4 layer
- Extraction and insertion of the SOH communications information
- Through connections of VC-12, VC-3 and VC-4
- Support of MSP (Multiplex Section Protection)
- Support of SNCP (Subnetwork Connection Protection)
- Ethernet over SDH (EoS) functionality based on GFP / VCAT / LCAS
- 1+1 SETS timing protection
- 1+1 hardware protection

3.13.4 The following maintenance functions shall be supported:

- Status indications
- Loop
- Restart after ALS
- Trail Trace Identifier (TTI) monitoring
- SFP inventory and diagnostics

3.13.5 At least the following amount of ports shall be available per module. Twice the amount shall be available in hardware redundant configuration.

**SHDSL Interface**

3.13.6 The 2 Mbit/s SHDSL interface shall provide means to interconnect the multiplexer over one or two pairs of copper wire up to 10 km using G.SHDSL modulations. At least 8 x SHDSL interfaces shall be available on the module. The ports shall be available for the synchronization source selection process. Clock quality level transmission/ reception shall be supported.

**Access / user Interface**

3.13.7 This Equipment shall be offered with following user application interfaces:

- Voice over IP subscriber media gateway
- Party line Telephone System (Engineering Order Wire)
- Ethernet electrical connection: 10/100/1000BaseT
- Ethernet optical connection: 100Base-FX and 1000Base-LX/-SX/-EX/-ZX
- Circuit Emulation Interface
- Distance Teleprotection integrated interface module with 4 tripping signals common for both SDH and MPLS-TP functionality as per IEC 60834-1
- Differential Teleprotection integrated Optical interface module for up to 4 protection relays common for both SDH and MPLS-TP functionality compliant to IEEE C37.94
- IEC 61850 GOOSE based protection interface

**Alarm Interface**

3.13.8 The module shall provide means to collect at least 12 external alarms, which shall be displayed on the Network Management System. It shall be used to supervise external equipment by the Network Management System. Minimum of 2 Outputs shall be available.

3.13.9 It shall be possible to label an alarm. The label-text shall be read from the interface module and visible on Network Management System as well as on the local craft terminal.

**Optical Teleprotection Interface**

3.13.10 This module shall have at least 4 optical ports each of them allowing direct connection to protection relays with interfaces complying with ANSI/IEEE C37.94. Each interface shall support all 12 time slots (64 kbit/s – 768 kbit/s) in accordance with ANSI/IEEE C37.94.

3.13.11 Symmetry as well as jitter and wander values shall be guaranteed in order to meet application requirements regardless of the transport technology (TDM or MPLS-TP). IRIG-B outputs (optical and electrical) shall be available to pass on time-of-day information to end devices in case WAN supports transmission of accurate Time of Day information.

3.13.12 Redundant communication channels in line with application requirements shall be supported.

**Management Interfaces**

- The equipment shall make provision for an Ethernet port (henceforth called "local management interface") that allows access only to the local management agent (i.e. to the management agent running on the equipment itself but not to management agents running on remote equipment).
- The equipment shall make provision for interface(s) that allow access to the management agent from a remote Site through an IP network (henceforth called "routed management interface(s)").
- The equipment shall make provision for a VLAN dedicated exclusively to the traffic to/from the management agent (out-of-band management). The VLAN identification must be configurable.
- The priority of the traffic flowing through the routed management interfaces shall be configurable (i.e. capability to assign a Class of Service to the management traffic).It shall be possible to enable/disable the local management interface by configuration. It shall be possible to enable/disable the routed management interface(s) by configuration. The IP address of the local management interface shall be configurable. The IP address/addresses of the routed management interface(s) shall be configurable.
- The local management interface shall not participate in dynamic routing protocol (i.e. the local interface and its IP address are not propagated outside the local equipment).It shall be possible for a routed management interface to participate in a dynamic routing protocol. The participation shall be configurable.
- The equipment shall support the following protocols for the communication between the management agent and the network management system (NMS)/craft terminal (CT):
  - **i.** Telnet
  - **ii.** SSH
  - **iii.** IPsec (tunnels between the NMS and the equipment management agent)
  - **iv.** SNMPv3

### 3.14 SYSLOG

3.14.1 The equipment shall support the capability of sending event messages to up to ten different remote syslog servers. Each server is identified by its IPv4 address.

### 3.15 OSPF Authentication

3.15.1 The equipment shall provide the capability to authenticate Open Shortest Path First (OSPF) messages (e.g., MD5). This capability shall be provided for both DCN and user traffic OSPF capable routers.

### 3.16 Encryption

3.16.1 The equipment shall provide the capability to encrypt MPLS-TP traffic (end-to-end tunnel encryption). The encryption shall be provided by a plug-in self-contained unit (henceforth designated as "encryption unit") offering the following features:

- Eight (8x) SFP/SFP+ cages for electrical or optical 1 or 10 Gbit/s Ethernet
- AES-256 GCM encryption
- Four dedicated and independent (i.e. not shared) encryption engines for each one of four pairs of Encrypted/Unencrypted ports (i.e. the 8x ports are grouped into 4x pairs, for each pair one unencrypted port connects to the trusted zone whereas one encrypted port connects to the untrusted zone – henceforth such a port pair will be designated as "E/U ports-pair")
- The 4x E/U ports-pairs shall be in turn grouped into 2x fully independent functional sub-units (2x E/U ports-pairs on each functional unit). Indepedent means that if one of the two functional sub-units is compromised it shall be possible to continue operation on the remaining sub-unitn1 or 10 Gbit/s wire-speed encryption capability for each encryption engine
- Management port dedicated exclusively to the management of the encryption unit
- MPLS outer label dependent encryption
- Up to 1024x keys to encrypt 1024x LSPs to arbitrary endpoints for each one of the four E/U ports-pairs (total 4x E/U ports-pairs X 1024 = 4096 encrypted LSPs)
- Encryption of layer 2 frames (e.g. PTP, ESMC) shall be configurable
- Encryption of OAM message shall be configurable

### 3.17 Power Supply

- The supply voltage to FOTE panel shall be universal power supply i.e. 230V AC and 220 VDC of station battery. The equipment shall work satisfactorily over battery voltage variations of +20% to –15% with at least 10 hours battery backup or extended backup as per depending on requirement of CEA regulation (Technical Standards for Communication System in Power System Operations 2020) requirement.

- The equipment shall support dual power feed (1+1 hardware protection) with 100% redundancy and auto changeover i.e. that two power sources can be connected directly to the equipment (two connection points)..The equipment shall supervise the power source and provide corresponding alarming in case of loss of either power source. The alarm shall be integrated to SAS.
- Power supply modules directly connected to mother board is preferred. However, in event of non-availability directly connected power supply modules to mother board, then rack mounted DC/DC converter of required specifications shall be provided as an integral part of FOTE panel. Make of DC/DC converter shall be that of OEM of FOTE panel with required input and output switchgears and protections. Safety Ambient Conditions

**Storage and transport:**

Temperature range: - 25°C to +70°C

Humidity: max. 95% (no condensation)

3.17.1 **Operation:**

Temperature range: - 25°C to +60°C

in fan less configuration: - 25°C to +55°C

Humidity: max. 95% (no condensation)

Electromagnetic Compatibility (EMC)

The equipment shall comply with the EN 55022 class A, EN 61000-6-2, EN 61850-3, and shall be in conformance with Circuit Emulation (CE).

3.17.2 **Mechanical Construction**

The equipment shall be available as a 19" shelf to be mounted in a 19" rack or 19" cabinet. It shall be of robust design. All modules shall be integrated in the same shelf. All connectors shall be accessible from the front and comply with international specifications.

## 3.18 Network Management System (NMS)

3.18.1 The network management system (NMS) shall have facilities to supervise, monitor, control and configure each equipment and the whole network. It shall have capabilities of fault, configuration, performance and security management. It shall provide various graphical views to the network such as, logical network structure, and hierarchical view. The network management system shall allow to define different user profiles.

3.18.2 The NMS shall support end-to-end service provisioning for MPLS-TP as well as for TDM based services. For MPLS-TP based services, all service types (VPWS, Tree, VPLS) shall be supported by the end-to-end service provisioning functionality. The NMS shall perform channel calculations based on various

parameters such as available bandwidth, number of hops, provisioned bandwidth/services and channel diversity requirements.

3.18.3 A comprehensive alarm management shall show current alarms such, that icons of the network elements change their colors according to the alarm level. The alarms shall be categorized as critical, major, minor alarms and warnings. A summary shall indicate the total number of alarms and warnings in the entire network. An alarm list shall list all alarms of the entire network according to the time of their occurrence. It shall be possible to filter alarms with various filter criteria. Operators shall be able to add comments to the alarms.

**3.19 Drawings, Data and Manual**

3.19.1 To Be Submitted After Award of Contract:

- Technical data sheet
- Bill of Material
- Dimensional general arrangement drawing
- System Layout
- Optical Power Budget Calculation
- Quality plan
- Test certificates
- O&M manual

**3.20 TESTS**

3.20.1 The equipment offered shall be of type tested and proven type. Type test reports shall be submitted for review. The bidder shall submit the type tests reports for the tests conducted on the equipment similar to those to be supplied under this contract and the test(s) should have been conducted at an independent laboratory not earlier than five (5) years prior to date of supply. All routine and acceptance tests in accordance with the latest version of applicable standard shall be conducted. The minimum tests / test reports are mentioned below but not limited to:

3.20.2 Type Test

a. Temperature and Humidity Tests

- Low temperature test – Operation to Specifications and Operation without Damage
- Dry Heat test – Operation to Specifications and Operation without Damage
- Damp Heat test – Temperature and Humidity
- Temperature variation test

3.20.3 All the above tests shall be as per IEC 60068-2

b. Immunity Tests

- Power supply and EMI/EMC tests
    - Voltage Fluctuations
    - Voltage dips and interruptions
- 1.2/50 – 8/20 ms surges Power Supply ports as per IEC 61000-4-5
- 1.2/50 – 8/20 ms surges Signal & Control Lines as per IEC 61000-4-5
- Fast Transient Test
- Damped oscillatory waves
- 10/700 ms surges
- Electrostatic discharge
- Power frequency magnetic field
- Radiated electromagnetic field
- Damped oscillatory magnetic field
- PF voltage on control and signal lines
- DC voltage on control and signal lines

c. Emission Tests

- LF disturbance voltage
- RF disturbance voltages
- RF disturbance currents
- RF radiated field

d. Insulation Withstand Voltages

- Isolation Test
    - DC power supply
    - Control and Signal
    - Telecon Line
- 1.2/50 microseconds impulse voltage
    - DC power supply
    - Control and Signal
    - Telecon Line

e. Mechanical Tests

- Vibration Test – Response and Endurance test
- Free Fall Test

3.20.4 Factory Acceptance Tests, Routine Test, Pre-commissioning and Commissioning Tests

3.20.5 All the Factory Acceptance Tests, Routine Test & Pre-commissioning and Commissioning Tests shall be carried out as per relevant IEEE/IEC/ITU-T/EN guidelines of FOTE. Bidder has to follow specification and Customer approved Manufacturing Quality Plan and FAT/SAT procedures.

3.20.6 Bidder shall provide all necessary information that deems to be necessary to complete the project in all respects.

### 3.21 Equipment Availability

3.21.1 The calculated availability requirements are as follows:

a. The availability of each fiber optic link shall be at least 99.999%.

b. The availability of subscribers (on Ethernet interfaces) shall be at least 99.97%.

3.21.2 The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS.

3.21.3 The bidder shall confirm that the equipment & configuration proposed by the bidders shall be capable of demonstrating the specified availability figures. The Contractor shall submit the availability analysis for the proposed equipment/ sub system. The analysis shall include the meantime- between failure (MTBF) and mean-time-to-repair (MTTR) of all of the components on the link. For this analysis, an MTTR of at least 4 hours shall be assumed.ILost Signal Recovery

3.21.4 At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable. Under NMS Control controlled sequencing of the alarm response and restoration may alter normal switch over/ switchback.

### 3.22 Revision Levels and Modification

3.22.1 All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Owner, prior to the completion of SAT.

3.22.2 All field modifications required to update the hardware, firmware and software to the latest revision level occurring after the above specified tes

3.22.3 ing, shall be fully disclosed, documented and presented to the Owner for their consideration. Satisfaction of this disclosure requirement does not obligate the bidder to implement the changes provided the latest revision date occurs after the above requirements are met. The intent is to provide the Owner with the documentation and opportunity to consider their implementation.

3.22.4 All field modifications of the hardware, firmware and software that is required to meet installation, performance specifications, shall be fully documented as part of the deliverables, both as a separate field modification record and as corrected equipment/configuration documentation.

### 3.23 System Maintainability

3.23.1 Once a failure or degradation of performance is detected in the communications system, its cause shall be promptly isolated and corrected. To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control.

3.23.2 Preventive and problem-oriented maintenance of the communications system shall be performed using diagnostics tools such as NMS and test equipment. They shall support complete maintenance of all system elements and shall permit the diagnosis of any fault without requiring additional test equipment. For all redundant systems, disconnection and repair of any failed device shall not interrupt the operation of the system.

3.23.3 All applications shall be supported by USER accessible HELP commands that shall assist the USER in the performance of its tasks. HELP commands for an application shall be available to the USER from within the active application and shall not interfere with the activities of the application.

# 4. Surveillance System

## 4.1 Introduction

4.1.1 The surveillance system shall have the cameras, layer switches, communication cables, signal convertors, display units, and other accessories. All the control elements of the surveillance system shall be placed in Control Room.

4.1.2 This section of the specification details the requirement of surveillance by the Owner.

## 4.2 Codes and Standards

4.2.1 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.

| Standard | Description |
|---|---|
| IEC 62676-3:2013 | Video surveillance systems for use in security applications-IP interoperability implementation based on Web services |
| IEC 62676-2-2 | Video surveillance systems for use in security applications-IP interoperability implementation based on HTTP and REST services |
| IEC 61000-4 | Electromagnetic compatibility EMC –Testing and measurement techniques-Radiated, radio frequency, electromagnetic field immunity test |
| ISO /IEC 30137-1 | Information technology- Use of Biometric in Video surveillance system specification |
| IS: 13947 | Degree of Protection provided by enclosure for Low voltage appliances |
| IEC 60079 | Electrical apparatus for explosive gas atmospheres |
| EN 55022 | Information technology equipment, ITE for the radio disturbance characteristics for electromagnetic compatibility compliance |
| EN 55024 | Immunity test requirements for information technology equipment in relation to continuous and transient conducted and radiated disturbances |
| IEC 60950 | Information technology equipment – Safety |
| IEEE-802.3z | Standard for Gigabit Ethernet |
| ITU-T G.652 D | Characteristics of a single-mode optical fiber and cable |

| Standard | Description |
|---|---|
| BS-5308 PART I | Specification for Polyethylene insulated cables |
| BS EN 50290-2 | Specific requirements for Crosslinked Polyethylene (XLPE) compounds to be used for the insulation of instrumentation, control, and field bus cables. |

4.2.2 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.

### 4.3 General Requirements

4.3.1 The Bidder shall comply with design requirements of this specification. The expense of refabricating & replacement shall be the responsibility of the Bidder for non-conformance to this specification.

4.3.2 The Bidder shall take special precautions in the selection and protection of cameras against deterioration because of humidity and temperature & dusty atmosphere.

4.3.3 It is the Bidder´s responsibility to determine and select the correct material / protection specified for the environmental and service conditions involved.

4.3.4 Complete CCTV system shall be selected to ensure reliability, high availability, safety and ease of maintenance.

4.3.5 The BESS personnel shall be able to monitor and control from Main Control Building. The operating personnel shall be able to control the CCTV system and Perimeter intruder detection system (PIDS) at Control room building. Control and monitoring system for CCTV and Perimeter intruder detection system shall be placed in Main control room.

4.3.6 The Plant fencing will be secured with a CCTV system utilizing a dedicated fibre optic ring.

4.3.7 All cameras must be equipped with intrusion detection capabilities that function effectively during both day and night conditions. These alarms will be linked to the SCADA system through an NVR using either software or hardwired connections.

4.3.8 The proposed CCTV system must have the provision to be seamlessly integrated with the substation CCTV system for comprehensive security coverage.

4.3.9 High-performance CAT6A SFTP/FTP cables shall be used for the CCTV system.

4.3.10 The Bidder must provide a comprehensive warranty period of 2 years for all equipment and materials related to the CCTV system.

4.3.11 The Bidder must ensure their solution provides full coverage for all inverter station devices and perimeter fencing. The camera quantity must be adjusted to achieve this objective.

### 4.4 Specific Requirements

4.4.1 IP Camera

a. All camera images shall be continuously recorded. Facility for transferring camera images to separate recorders/ data storage devices and play back facility of the same shall be provided.

b. Camera image monitoring and viewing facility shall be provided at Main Control Room.

c. Alarm & Display monitors shall be provided in the operator stations of CCTV at Main control room and Grid Substation control room building.

d. PTZ (Pan, Tilt, Zoom) Cameras shall have:

1. The cameras shall be rugged high speed PTZ dome cameras with inbuilt PTZ driver unit & RS 485 receiver unit, 1/4-inch image format fully performance colour CCD dome cameras. These cameras should provide high resolution and high sensitivity suitable for operation, both in natural and artificial sighted areas.

| Sl. No. | Description | Type of camera |
|---|---|---|
| 1 | Outdoor area such as Peripheral Road/boundary wall, Approach Road area within Plant premises. It is intended to cover Detection of an event and identification of a person's face; object Features within a predefined range. Capture the human movement. | IR IP HD Fixed Dome/ Bullet Type camera (Day & Night) all accessories with adequate coverage and all latest features. Coverage of the cameras shall be 100-meter IR Illuminator |
| 2 | Outdoor area such as Security building / Main Gate peripheral area it is intended to cover Detection of an identification of a human / Vehicle movement. Features within a predefined range. | Fixed Full HD Doom type Day/Night IP PTZ cameras with all accessories with adequate coverage and all latest features. Coverage of the cameras shall be 40-meter IR Illuminator |
| 3 | Outdoor area of BESS Transformer, maximum coverage of BESS area Monitoring the system and premises of Inverter Substation | High speed Doom type Day/Night IP PTZ cameras with all accessories with adequate coverage and all latest features. Coverage of the cameras shall be 40-meter IR Illuminator |
| 4 | Indoor area for ISS building area It is intended to cover Allows you to monitor | Fixed IR Doom type cameras with all accessories with adequate coverage |

| | | |
|---|---|---|
| | unusual behaviour in and around your environment and acts as evidence in the case of theft. | and all latest features. |

e. All cameras shall be minimum of 2MP with associated recorder, servers, consoles, panels, hardware, cables/wires & software's etc. as required for completion of CCTV surveillance system for the ISS area and integrated up to Main Control Room, Security Room, Main Gate, BESS yard and other areas as mentioned in the above table.

f. The detailed specifications of the above-mentioned cameras shall be as per below table.

| **Sl. No.** | **Items** | **Technical description, specifications and standards** |
|---|---|---|
| 1 | IR IP HD 30X PTZ Camera with all accessories | **Type**: PTZ<br>**PAN & Tilt Angle**: PAN:360deg: Tilt:0-90 deg, Auto Flip<br>**ONVIF**: Profile S Compliant<br>Signal to Notice Ratio: ≥50 dB<br>Certification: CE, UL, FCC<br>**Onboard Storage:** Minimum 128GB with class6 or higher from day one (during downtime of the connectivity to server, captured data should be stored locally and the same should automatically upload into the server after restoring of connectivity)<br>**Image Sensor:** 1/3" Progressive Scan CMOS or **Videor Resolution:** 1920x1080<br>**Frame rate:** Up to 30/25fps<br>**VIDEO Compression:** H.264 or superior, MJPEG **WDR:** 120db or better<br>**Streaming:** Dual Stream<br>O/p Network Port: RJ45 10/100<br>**Base T Protocol:** IPv4/v6, TCP/IP, UDP, RTP, RTSP, RTCP, HTTP, HTTPS, SSL, ICMP,<br>FTP, SMTP, DHCP, PPPoE, UPnP, IGMP, SNMP v2c/v3, Bonjour, DNS, DDNS, QoS, NTP, NFS **Administration:** Remote configuration, motorized zoom adjustments and |

| Sl. No. | Items | Technical description, specifications and standards |
|---|---|---|
| | | auto focus through web<br>client or from the NVR<br>**Tool Lens:** 6.0-180 mm, F1.6-F4.8, 30x optical zoom lens with 360° continuous rotation for the flexibility to clearly view the target area with desired.<br>width and depth.<br>Focal length: for 30x Optical zoom Focus: Both Auto and Manual Face<br>Detection Illumination / Sensitivity: Colour: 0.5 lux; Mono: 0.05 lux.<br>**IR Distance:** 50Mtrs or better<br>Day and Night: YES<br>**Audio Compression:** G.711 or better Two way **Audio:** Required Input / Output : 1in and 1out **Protection :** Ik10 & IP66 enclosure<br>Operating Temperature: 0° - 50° C |
| 2 | IR HD Outdoor Bullet Camera with all accessories | **Camera Type**: Fixed box/ Bullet<br>**ONVIF**: Profile S<br>Compliant Certification: CE, UL, FCC<br>**Onboard Storage:** Minimum 128GB class-6 or higher from day one (during downtime of the connectivity to server, captured data should be stored locally and the same should automatically upload into the server after restoring of connectivity)<br>**Image Sensor:** 1/3" Progressive Scan CMOS or **Better**<br>**Resolution:** 1920x1080 at 30/25fps or higher<br>**Compression:** H.264 or superior, MJPEG<br>**WDR:** 120 dB or better<br>**Streaming:** Dual Stream<br>**Network Port:** TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP, SMTP, SNMP, IGMP, 802.1x, QoS, IPv6, Bonjour |

| Sl. No. | Items | Technical description, specifications and standards |
|---|---|---|
| | | **Remote Administration:** Remote configuration and status using web-based tool.<br>**Lens:** 2-10mm<br>**Focus:** Both Auto and Manual Dynamic<br>**Color:** 0.7 lux<br>**IR Distance**: 100 m Peripheral/40Mtrs Approach Road or better<br>**White Balance**: Yes, Wide Dynamic<br>**Range**: 120 dB or higher<br>**Day and Night**: Auto/schedule<br>**Input / Output**: 1in and 1out<br>**Protection**: IP66 enclosure<br>Operating Temperature: 0° - 50° C<br>**PoE:** 12V, 24V IEEE 802.3af Class 3 |
| 3 | Fixed Focus High Resolution IP Camera | **Type**: Fixed focus, 1.3 mega pixel indoor IP camera or better<br>**Video Signal**: Color, CCIR Standards<br>Signal to Notice Ratio :>_ 40 dB or better.<br>Certification: CE, UL, FCC<br>**Onboard Storage:** Minimum 128GB with class6 or higher from day one (during downtime of the connectivity to server, captured data should be stored locally and the same should automatically upload into the server after restoring of connectivity)<br>**Image Sensor:** 1/3" Progressive Scan CMOS or **Video Resolution:** 1920x1080<br>**Frame rate:** Up to 30/25fps<br>**VIDEO Compression:** H.264 or superior, MJPEG **WDR:** 120 dB or better<br>**Streaming:** Dual Stream<br>**O/p Network Port:** RJ45 10/100, Ethernet connection<br>**Base T Protocol:** IPv4/v6, TCP/IP, UDP, RTP, RTSP, RTCP, |

| Sl. No. | Items | Technical description, specifications and standards |
|---|---|---|
| | | HTTP, HTTPS, SSL, ICMP,<br>FTP, SMTP, DHCP, PPPoE, UPnP, IGMP, SNMP v2c/v3,<br>Bonjour, DNS, DDNS, QoS, NTP, NFS **Administration:**<br>Remote configuration,<br>Detection Illumination / Sensitivity: Colour: 0.5 lux; Mono: 0.05 lux.<br>**IR Distance:** 40 m or better<br>Day and Night: YES<br>**Audio Compression:** G.711 or better Two-way **Audio:**<br>Required Input / Output: 1in and 1out **Protection:** Ik10 & IP66 enclosure<br>Operating Temperature: 0° - 50° C |
| 3 | IP 55 Enclosure/Rack with Accessories | Should be IP 55 Rated Floor Mount and Vandal Proof Design device.<br>Should be constructed based on nine-fold CRCA metal profile with a front sheet steel door with 3point locking system to ensure the security of the cabinet. Side and wall panels should be double wall constructed with fixed bolts internal to the cabinet.<br>Should have integrated Splice tray to manage the different Security device connectivity and cable manager.<br>Base/Plinth including two screw-fastened gland plates for cable entry will be inherent in the overall cabinet design.<br>Cabinet should have minimum 2 fans with Front door have Air inlet.<br>Painting: Electro-phoretic dip coat priming to 20 Microns and then powder coated to RAL 7035 textured pure polyester (PP) to 80 to 120 Microns.<br>The bidder has to provide suitable size metallic Junction box for all the Sites (where cameras will be installed) for UPS Battery switch and any other peripherals for |

| Sl. No. | Items | Technical description, specifications and standards |
|---|---|---|
| | | operations of cameras.<br>All the in & out cables must be concealed and laid underground as applicable.<br>Should be ROHS compliant. |
| 5 | Outdoor Armed Shape Pole (if applicable) | Type: Hot dip galvanized after fabrication with silver coating of 86 micron.<br>Height: 3.5 meters or higher, as per requirements for different types of cameras & Site conditions.<br>Diameter: Minimum 100mm diameter pole (Bidders to choose larger diameter for higher height)<br>Bottom base plate: minimum base plate of size: 300mm x 300mm x 15mm.<br>Foundation: Casting of civil foundation with foundation bolts (J Bolt), to ensure vibration free erection (basic aim is to ensure that video feed quality is not impacted due to winds in different climatic conditions and also from vibration caused due to heavy vehicles on road).<br>Supply and fixing of 40mm dia, 2/3mtrs Long single arm bracket with suitable pole sleeves suitable for fixing of cameras including S /F of suitable nuts, bolts, washers etc. as required for camera installation.<br>Protection: Lightning arrestors with proper grounding (if applicable).<br>Sign-Board and Number Plate.<br>The length / design / cantilever of the Pole will be as per location and Site requirement |

4.4.2 Camera Mounting

a. The camera shall be mounted such that a clear, unobstructed view of the scene to be observed is generated. The mounting bracket / pole and accessories shall be designed to ensure a proper, rigid support to the camera. The installation shall be done in a manner that the camera and its components / accessories are easily accessible for maintenance and there is minimal risk of accidental damage.

4.4.3 Camera Enclosure

a. The enclosure shall feature a removable / sliding / hinged type cover to allow easy access to the camera, lens and the camera mounting platform. The camera mounting platform shall be constructed from rigid non-conducting material. It shall be removable and shall allow for adjustment of height. Glands shall be provided for easy installation of the power and video cables. An optically clear and distortion free viewing window shall be provided. The housing shall be suitable for obstruction free viewing. The enclosure shall have a powder coated or epoxy finish. Mounting brackets to suit the location of installation shall be supplied. The protection class of these enclosures shall be IP 65 or better.

b. For outdoor camera enclosures in addition to the requirements detailed above, thermostatically controlled heater, blower with filter and sun shroud shall be provided along with necessary wipers.

c. The camera mount should be of the same make as that of camera and suitable for the model no. offered as specified by the manufacturer and should be an integrated unit.

4.4.4 Operator Workstation

a. The CCTV monitoring shall be carried out from one number of Operator workstation which shall be located in MCR. The operator workstation shall be provided with 55" colour LED dual monitor (Industrial type), keyboard & mouse. Resolution shall be 4k minimum. The operator workstations shall be provided with latest configuration available in the market as on date of supply. All necessary software license as required for the completeness of the system shall be provided.

4.4.5 Network switches

a. Power over Ethernet switches shall be provided which are network switches or hubs that not only transmit network data, but also supply power to connected devices. (PoE stands for Power over Ethernet).

b. IP Cameras that are Power over Ethernet enabled shall be connected to any of the PoE Network Switches to power the cameras and transmit Ethernet data over a CAT6 network cable. This shall allow easy integration of surveillance network cameras to an existing network and connection to an NVR recorder. High quality solid copper CAT5e wire for use with PoE cameras shall be provided to ensure there is no significant power drop. Depending on the power consumption of the cameras, it shall be possible to run up to 328ft from the PoE switch to the camera.

4.4.6 Communication cables

a. Refer suitable Clause of this document for technical specification of Optical fibre cable and Ethernet cable.

4.4.7 Nameplate

a. Each equipment shall have a permanent stainless-steel nameplate. The information shall include input power characteristics (nominal voltage, tolerance of input power voltage, rated current), output characteristics or equipment properties, serial number insulation/explosion-proof class and manufacture's name.
b. The equipment identification number, as provided by client / representatives, shall be stamped on the nameplate, and including year of manufacture.
c. All data stamped on the nameplate shall be in English and French language, according to International System (S.I.)

4.4.8 Inspection And Testing

a. The equipment and its auxiliaries shall be inspected by Owner representative's inspector.
b. Owner's inspector shall witness all specified tests and those which may have been ordered. These tests will be extended or repeated when at client / representative's inspector's judgement the results obtained are doubtful.
c. Supplier shall provide Owner inspector with necessary construction drawings and all measuring instruments and equipment required to conduct this work.
d. Any part rejected by Owner inspector, based upon the inspection and tests carried out, will be considered as definitive.
e. Acceptance of the equipment by Owner shall not relieve the Supplier, Bidders, or engineering firms from all the guarantees related to design, materials construction, and operation of the train.
f. Owner inspector shall not give authorization for shipment until all required certificates corresponding to each test conducted have been provided by Supplier, unless required otherwise by Owner.
g. The Supplier shall provide Owner with a preliminary schedule of the tests to be conducted including test procedures and test limitations. Such schedule shall be provided three months in advance to the expected test dates.

4.4.9 Spares

a. The supplier shall include a list of spare parts for commissioning and start-up.
b. Also, he will include the list of all recommended spares and consumables for 2 years operation and delivery time.

4.4.10 Guarantees

a. The supplier will guarantee compliance of the requirements defined in this specification relative to the following concepts:
b. Equipment is adequate for the purpose of the process as defined in this specification.

c. The materials supplied are appropriate for the service and comply with the requirements indicated in this specification.
d. Alarm and detection limits as per relevant standards.
e. Noise levels.
f. Safety and functional operation in the range of conditions stabilised in this specification.
g. Engineering and good construction of all elements of the installation and the equipment as a whole, including start up spare parts, for a period to be fixed in the Purchase Order.

### 4.5 Drawings, Data and Manual

a. Technical offer with complete BOQ
b. Technical schedules duly filled up and stamped and signed on all the sheets.
c. Catalogs/drawings leaflets for major items
d. Complete Datasheets/Brochures
e. Technical Architecture of proposed system
f. Technical details of Software and Video management
g. Technical details of connectors/switches
h. Diagrams and wiring connections.

# SECTION - 4 DETAILED TECHNICAL SPECIFICATION (DTS) - CIVIL

# 1. Civil, Structural and Architectural Works

## 1.1 Introduction

1.1.1 This chapter covers the technical requirements for BESS and Control Room facility including associated design and preparation of all civil, structural & architectural drawings and execution of all associated civil works. This Chapter deals mainly with technical specifications for design, preparation of general arrangement drawings, construction and fabrication drawings, supply of materials, supervision and construction of complete civil, structural & architectural works under the scope of this contract.

1.1.2 The specifications are intended for general description of work, quality and workmanship. The specifications are not however exhaustive to cover minute details and the work shall be executed according to relevant latest Indian Standards Specifications. In the absence of the above, the work shall be executed according to the best prevailing practices in the trade, recommendations of relevant American or European Standards or to the instructions of the Engineer. The Bidder is expected to get himself clarified on any doubts about the specifications, etc. before bidding, and the discussions recorded in writing with the Owner in respect of interpretation of any portion of this document.

1.1.3 The work to be performed under this specification consists of design, engineering and providing all labour, materials, consumable, equipment, temporary works, temporary storage sheds and staff colony, temporary Site offices, constructional Plant, fuel supply, transportation and all incidental items not shown or specified but reasonably implied or necessary for completion and proper functioning of the facility, all in strict accordance with the specifications and including revisions and amendments thereto as may be required during execution of the work.

## 1.2 Scope of Work

The scope of work shall include the following.

1.2.1 Site related investigations.

1. Topographic survey.
2. Geotechnical investigation.

1.2.2 Site Development works

1. Site Grading including Soil stabilization and slope protection.
2. Green Belt, Landscape development and horticulture including associated water supply system.
3. Compound wall with gates.
4. Internal roads and Box Culverts.
5. Storm water drains and interconnection to outside main drains.

1.2.3 Buildings and Civil Works

1. Control Building.
2. Crushed stone paving and Anti-weed treatment.
3. Transformer foundations with soak pit.
4. Transformer Burnt oil pit.
5. Cable trenches.
6. Containerized Battery Storage System Foundation.
7. Transformer foundation
8. PCS Platform Foundation / Inverter station with canopy
9. Pre- fabricated buildings
10. Pooling Substation structure & foundation
11. High Mast and Street Lighting Foundations
12. Septic tanks and soak pits.
13. Service and Potable Water Supply System

1.2.4 Any other civil and structural works, which is not specifically mentioned in this document but required to complete the total Plant as EPC is also included in the scope of work.

## 1.3 Codes and Standards

1.3.1 The work to be executed under this specification shall be in accordance with the applicable section of the latest version of the relevant IS standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below

| **Standard** | **Description** |
|---|---|
| **Structural Design Loads** | |
| IS: 875 | Code of practice for design loads |
| IS : 1893 | Criteria for earthquake resistant design of structures |
| **Structural Works** | |
| IS : 800 | Code of practice for general construction in steel |
| IS : 802 | Code of practice for use of structural steel in overhead Transmission Line Towers (All Parts) |
| IS:808 | Rolled steel beams, channels and angle sections |
| IS:813 | Scheme of symbols for welding |
| IS:1161 | Steel tubes for structural purposes |
| IS:2062 | Steel for general structural purposes |
| **Civil Works** | |

| | |
|---|---|
| IS : 456 | Codes of Practice for plain and reinforced concrete |
| IS 13920 | Ductile detailing of reinforced concrete structures subjected to seismic forces- Code of Practice (Earthquake) |
| NBC :2016 | Guidelines for regulating the building construction activity |

1.3.2 In case any specification for any particular item of work is not covered, the same shall be executed in accordance with the relevant IS Standards / CPWD Standards, as applicable.

**1.4 General Requirements**

1.4.1 All materials including cement, reinforcement steel and structural steel, etc. shall be provided by the Bidder. The material arranged by the Bidder shall conform to quality standard specified elsewhere in the specification and shall be procured from licensed agencies / sources only with prior approval of Owner.

1.4.2 The work shall be carried out according to the design/ drawings to be developed by the Bidder and approved by the Owner. For all building & structures, foundations, etc., necessary layout and details are to be developed by the Bidder keeping in view statutory & functional requirements and providing enough space & access for operation, use and maintenance.

1.4.3 Certain minimum requirements are indicated in this specification for guidance purpose only. However, the Bidder's offer shall cover the complete functional requirements as per the best prevailing practices and to the complete satisfaction of the Owner.

1.4.4 All the quality standards, tolerances, welding standards and other technical requirements as covered in this specification shall be strictly adhered to by the Bidder.

1.4.5 The Bidder should fully appraise himself of the prevailing conditions at the proposed Site, locations of adjoining facilities/ structures, climatic conditions including monsoon pattern, local conditions and Site-specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications.

1.4.6 The Bidder shall take all necessary precautions to protect all the existing equipment, structures, facilities & buildings, if applicable, etc. from damage.

1.4.7 In case any damage occurs due to the activities of the Bidder on account of negligence, ignorance, accidental or any other reason whatsoever, the damage shall be made good by the Bidder at it's own expense to the satisfaction of the Engineer. The Bidder shall also take all necessary safety measures, at it's own expense, to avoid any harm / injury to it's workers and staff from the equipment & facilities.

1.4.8 The scope of work comprises of but not limited to the following: Construction of Storage yard for Containerized Battery Energy Storage systems cum inverter station, transformer yard with BESS control room development.

1. Internal electrification of Main control room /building.
2. Construction of roads, drainage, fencing, gates for yard.
3. Construction of cable trenches.
4. Providing and laying RCC Hume pipe/trench as per Site requirement.
5. Geotechnical/ soil investigation for foundation system finalization.
6. Any other facility / structure that would be required as per system requirements.
7. Any additional civil works, materials and services, which though not specially mentioned but are required to make the system complete.
8. As built drawing for all structures and layout.

**Construction Facilities:**

1.4.9 The Contractor shall provide all temporary offices, sanitary conveniences, store, compounds, parking areas, etc. necessary for the completion of the works. The setting and layout of these shall be in such a manner as to not interfere with the construction and operation of the Plant when completed and shall be to the general approval of the Owner. The temporary buildings shall be disposed of as directed by the Owner.

1.4.10 All temporary buildings shall be maintained in a clean condition and operated efficiently. All buildings must at all times be open to the inspection of the Owner / Government authorities and, the Contractor shall comply with any instruction given by him for the proper cleaning, disinfection, and general maintenance in a sanitary and hygienic condition of the buildings.

1.4.11 In order to enable the Owner for providing the space, the Contractor shall give a layout and the area requirement. The Contractor shall be fully responsible for mobilization and demobilization of the temporary Site facilities

**Plant levels**

1.4.12 It is Contractor's responsibility to make a reference datum and its accuracy shall be maintained throughout the construction period. All levels shall be referred to this datum. Surveying instruments with high quality and one second accuracy and in appropriate quantities shall be used by the Contractor during Construction. The Contractor is fully responsible for the accuracy of the Site levels. Latest and validated calibration report of respective equipment used for survey work shall be submitted before carrying out survey work as per manufacturer manuals and instruction.

**Methods of Construction**

1.4.13 The Contractor shall submit documents with the details of methodology of construction and the equipment bidder proposes to utilize for all major structures. The Contractor shall also submit it's reports and quality assurance plan to the Owner prior to work and its commencement subjected to Owner approval.

**Coordination at Site**

1.4.14 The Contractor shall at all times maintain accesses, facilities without hindrance to others, carry out it's work in such a way and in close coordination with other agencies working at the Site so that the work proceeds in a systematic and planned way. No stoppage of work due to disputes arising from lack of coordination will be entertained by the Owner.

**Safety**

1.4.15 Contractor shall ensure all safety measures are taken at Site to avoid accident of it's Employees, Owner's employee or it's co-contractors employee as per prevailing safety rules. Contractor shall deploy enough number of safety personnel at project Site. Contractor shall make all necessary rigid and temporary design to support permanent ongoing Construction activities.

**Industrial Sign Boards and Safety Signs**

1.4.16 Contractor shall install and fix industrial sign boards and safety signs as per relevant safety regulations. Safety signs and boards shall be in fluorescent Acrylic Night glow stick on the door, framed on walls, and hang on false ceiling with Solid 8mm GI road and Clamps. Contractor shall submit relevant drawings to Owner for approval.

**Levels**

1.4.17 Finished ground floor level (FFL) for control building shall be minimum 600mm above Finished Ground level (FGL).

**Design Wind Speed**

1.4.18 Basic Wind Speed as per IS 875 Part 3 shall be 50 m/s.

**Seismic Zone**

1.4.19 The proposed Plant is located in Zone V as per IS:1893.

## 1.5 Site Related Investigations

**Topographical survey**

1.5.1 Preliminary topographical survey has been carried out by the Owner and the same is available for information. The Contractor shall carryout detailed additional topographic survey at no additional charge to Owner.

**Geotechnical Investigation**

1.5.2 Preliminary soil investigation has been carried out by the Owner and the same is available for information. Typical data from bore logs and test results are available in the report. The Contractor shall carry out detailed Geotechnical investigation for the project area to finalize the foundation design parameters at no additional expense to Owner.

1.5.3 Credentials of the Geotechnical investigation agency shall be submitted for Owner's review and approval.

1.5.4 Layout and number of boreholes shall be decided based on final approved plot plan and the same shall be submitted for Owner review and approval before start of Soil Investigation work.

1.5.5 Type of foundations – pile, raft or open foundations, shall be decided based on the recommendations of the final Geotechnical Report.

## 1.6 Site Development Works

**Site Grading**

1.6.1 The land is almost flat and will be handed over to the Contractor as it is basis. Average Site grade level is around 64.500m. Final finished grade level shall be 65.500m.

1.6.2 During Topography survey if the Bidder finds out that the FGL needs to be raised above the mentioned grade level, the bidder shall carry out the same at its own expense.

**Landscaping**

1.6.3 Landscaping shall be developed at entry to Control Building.

**Boundary Fencing**

1.6.4 Boundary fence shall be provided along the Plant boundary to demarcate the Plant boundary and to keep away the unauthorized access to the Plant.

1.6.5 Fencing shall comprise of 1.8 m high galvanized chain link fence of minimum 4 gauge with mesh size 100 mm and three numbers of galvanized barbed wire on inclined member to a height of 600 mm above the chain link fencing. 3 lines of 12 gauge high tensile spring steel wire shall be provided for the entire length of fencing. 50 x 6 galvanized MS flats shall be provided at every fifth post sandwiching the fencing with post using GI nuts and bolts.

1.6.6 Fencing post shall be fabricated out of galvanized MS angle section and shall be spaced at a maximum spacing of 2.5 m with struts made up of galvanized MS angle at every fifth fencing post in addition to

these at bends. Expansion joint shall be provided at every 60 m. All fence posts shall be 65 x 65 x 6 MS angles. All straining posts i.e., end posts shall be 65 x 65 x 6 MS angles. All corner posts shall have two stay posts and every tenth post shall have a transverse stay post

1.6.7 Suitable concrete foundations for the angle iron posts and stays shall be provided based on the soil conditions.

**Gates**

1.6.8 Number of gates and wicket gates shall be as per proposed Layout of Plant, which is part of this tender document.

1.6.9 Gates shall be double swing gates of adequate size, 2.2 m height and 6.0 m wide (or maximum width of objects to be brought in plus 1.0 m free space on either side). Wicket gate shall be of 1.5 m wide single leaf. Necessary locking arrangement shall be provided for gates, but gates should not be self-locking.

1.6.10 Gate shall be fabricated out of tubular sections conforming to IS : 1161 and shall be hot dipped galvanized. Outer frame shall be 65 NB (medium) tube and diagonal 50 NB (medium) tube 50 mm sq. Welded mesh with 4 mm Dia. GI wire fabric shall be welded to 25 mm ´ 6 mm thick GI flat which in turn shall be welded to the outer tubular frame.

1.6.11 The gate shall be provided with 20 mm wide ´ 80 mm Dia. flat M.S. roller at the bottom. The gate frame shall be fixed to GI tubular post or RCC post.

**Storm water Drain Network**

1.6.12 Storm water drainage network shall be provided for the entire plot area and the same shall be discharging to the natural drain on the south side of the project Site. Drain shall be of RCC construction. The drawings shall indicate the basic drainage plan from the various units within the plot area. Invert level of drainage network and at outfall point shall be decided in such a way that water can easily be discharged outside the station Boundary. The maximum velocity and non-silting velocity shall be ensured.

**Roads**

1.6.13 Scope of road work consists of the following.

1. Connecting road (60m approximate length) from Plant entry gate to existing road towards Guest House of Substation. Width shall be same as existing road.

2. Road network inside the project area (peripheral road and internal roads). Width of all roads shall be 4.0 m with 1.0 m wide shoulders on both sides.

1.6.14 All roads shall be of RCC construction.

1.6.15 Adequate turning space for vehicles and Crane shall be provided and turning radius shall be set accordingly. Road to the Transformer shall be as short as straight. Crane position for lifting transformer shall be as short as to lift the heavy object / parts / equipments and can load and unload easily for replacement or maintenance any failed unit.

1.6.16 Road network inside the Plant shall originate from the main gate and connect to all the buildings and Inverters and run along the periphery fence as well.

**Walkway / footpath**

1.6.17 Footpath with concrete or light weight paving blocks shall be provided wherever required for access to facilities.

**Car parking**

1.6.18 Aesthetically pleasant car parking shed shall be provided, suitable to park four wheelers and two wheelers at suitable location to be decided during detail Engineering.

**Chain Link Fence**

1.6.19 PVC coated Galvanized Chain link fence shall be provided wherever necessary like transformer, etc.

## 1.7 Substaion Structural Steel Works

1.7.1 The steel structures in the Substation are towers, gantries, girders, etc. They shall be of latticed construction using angle sections. In addition, supporting structures for equipment, such as isolator, lightning arresters, CB, CVT, etc. (as required as per Electrical layout) shall also be provided. These structures may be of tube section or latticed as the case may be.

**Design Requirements**

1.7.2 The loading for the design of Substation structures shall be as per IS: 802 (all parts). Following loads shall be considered:

a) Dead load due to equipment and structure.
b) Wind load on towers, conductors, ground wires and insulator strings calculated as per Cl. 8 and 9 of IS: 802.
c) Temperature effects consisting of effect of temperature variation and sag tension as per Cl. 10 of IS : 802.
d) Climatic loads as per Cl. 11.2 of IS : 802.
e) Anti-cascading loads as per Cl. 11.3.1 of IS : 802.
f) Torsional and longitudinal loads caused by breakage of conductor as per Cl. 11.3.2 and 16 of IS : 802.
g) Construction and maintenance loads
h) Seismic loads as per IS : 1893-2002.

i) Short circuit forces including "snap effect" in the case of bundled conductors.

i) Loads due to conductor tension due to broken wire conditions and shield wire, producing worse effect.

j) Corrosion class as per ISO 14713 C2

1.7.3 All steel structure for the Substation shall be hot double dip galvanized structure with welded / bolted connection at shop and bolted connection at Site. All bolts and nuts shall also be galvanized. Minimum strength of Bolts shall be as per relevant IS code. Fabrication and shop report shall be submitted to Owner for review and approval.

**Dead Loads**

1.7.4 Dead loads consist of the weights of the complete structure and equipment, conductors, insulators strings, bus bars etc. The unit weight of structural steel shall be considered as 78.5 kN / cum for computation of loads. Unit weight given in IS:875 (part-I) shall be made use for other materials.

**Imposed Loads**

1.7.5 Imposed loads in different areas shall include live loads, dust loads, minor equipment loads, cable tray loads, erection loads, operation / maintenance loads etc. The loads considered shall not be less than that specified in IS:875 (Part II). The loads listed hereunder are the minimum loads for the areas involved. The specific minimum floor live loads are listed below

a) Chequered plate / gratings : 5 kN / sqm

b) Walkways : 3 kN / sqm

**Seismic Load**

1.7.6 Seismic forces shall be as per IS:1893. Particular attention is drawn to calculation of the design base shear as per relevant clause of the code while using response spectrum method.

**Equipment Load**

1.7.7 Static loads of major equipment shall be based on the manufacturer's data of the specified equipment and shall be considered in design in addition to the live load. Weight of equipment, ducts, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

**Wind Loads**

1.7.8 Wind load shall be in accordance with IS: 802 (Part 1 / Sec1):1995). For arriving at the design wind loads as per the code, the following values shall be adopted for the different factors,

K1 factor = As per IS: 802 (Part 1 / Sec1):1995). Based on Reliability level 1

K2 factor = Corresponding to Terrain Category 1

1.7.9 The wind pressure on the Towers, Conductor, Ground wire and Insulator strings shall be in line with IS:802 (Part 1 / Sec 1) : 1995.

1.7.10 The wind shall be assumed to blow in any direction and most unfavourable condition shall be considered for design. Wind shall always be assumed to act perpendicular to the Conductor / Rigid bus for structural analysis purposes.

1.7.11 Diagonal wind / inclined wind shall be considered for isolated self-supporting structures like lighting and lightning masts, poles only. Substation structures, which are interconnected either by beams or rigid buses, need not be analyzed for inclined wind loading.

**Temperature and Temperature Variations**

1.7.12 The minimum temperature of conductors shall be taken as 3.9°C and maximum temperatures of current carrying conductors exposed to sun shall be taken as 85°C for AL59 conductor equivalent to Moose where static ground wires are involved the maximum temperature shall be taken as 50°C.

**Other Loads**

a) Short Circuit Forces in combination with seismic forces along with other normal forces shall be considered for the structural analysis of tower / structures. Short circuit forces and wind forces shall not be considered simultaneously

b) Other loads shall be as per IS : 802 (Part 1 / Sec 1) : 1995, broadly classified as,

   1. Climatic Loads
   2. Failure containment loads
   3. Construction and maintenance loads

   These loads shall be computed in line with IS : 802 (Part 1 / Sec 1) : 1995.

c) Anti-Cascading checks, Tension limits, Broken wire condition and Strength Factors related to Quality shall be as per IS - 802 (Part 1 / Sec 1) : 1995.

**Design and Detailing Requirements**

1.7.13 Permissible stresses, slenderness ratios of members, minimum thickness of steel members, net sectional area of tension members and bolting and framing shall be as per IS: 802 (Part 1 / Sec 2): 1992.

1.7.14 All Substation structures shall be designed for the worst combination of dead loads, live loads, wind loads and thermal loads as per IS : 802 (latest), Seismic forces as per IS : 1893 (latest), loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including `Snap' in the case of bundled conductors, forces due to differential settlement and any other loading condition which can occur during the design life of the structure.

1.7.15 Wind & Seismic forces shall not be considered simultaneously in any load combination.

1.7.16 The design of structure shall be based on the condition where stringing is done only on one side i.e. all the three conductors broken on the other side. A factor of safety of 2.0 under normal and broken wire condition and 1.5 under combined short circuit and broken wire conditions shall be adopted for all external loads for design.

1.7.17 In addition to this, in aforesaid both conditions, the design of all structures shall be based on the assumption that stringing is done only on one side. ie .all the three (phase) conductors broken on other side.

1.7.18 Three-dimensional analysis shall be carried out for structures like towers and girders while two-dimensional analysis may be adopted for equipment support structures, using standard software package like STAADPro. Any non-standard software used shall be validated with manual calculations and shall be used only with the approval of Owner.

1.7.19 Vertical load of half the span of conductors / string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with the tools shall be considered as 150 kgs for the design of structures.

1.7.20 Terminal / line take off gantries shall be designed for a minimum conductor tension. The distance between terminal gantry and dead end tower shall be taken as 200 meters. The design of these terminal gantries shall also be checked considering ± 30 deg. deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

1.7.21 The girders shall be connected with lattice columns by bolted joints.

1.7.22 All pipe support used for supporting equipment shall be designed for the worst combination of dead loads, erection loads, wind loads / seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bar as per IS:806. The material specification shall be as per IS:1161 read in conjunction with IS:806.

1.7.23 If luminaries are proposed to be fixed on gantries / towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

1.7.24 Foundation bolts shall be designed for maximum tension occurring when 0.9 times minimum Dead Loads are combined with lateral loads.

1.7.25 Lighting mast of required height shall be provided. Lighting masts shall be provided with a structural steel ladder. The ladder shall be provided with protection rings. Two platforms shall be provided for mounting of lighting fixture. The platforms shall also have protection railing. The details for mounting lighting fixtures would be as per the approved drawings of lighting fixtures

1.7.26 For materials and permissible stresses IS: 802, part–1, section –2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

a) Minimum thickness of galvanized lower member shall be as follows:

| Members | Minimum thickness (mm) |
|---|---|
| Leg members, ground wire peak members / main members | 5 |
| Other members | 4 |
| Redundant members | 4 |

b) Maximum slenderness ratio for leg members, other stressed members and redundant members for compression force shall be as per IS:802.

c) Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

d) The minimum bolt diameter shall be 16 mm or higher as per design requirement.

e) Each tower shall be provided with step bolts not less than 16 mm diameter and 175 mm long spaced not more that 450 mm apart, staggered on faces on one leg extending from about 0.5 meters above ground level to the tower. The step bolt shall conform to IS:10238. Ladders on towers with lighting appliances shall be provided with safety guards.

f) The fabrication and erection works shall be carried out generally in accordance with IS:802. A reference however may be made to IS:800 in case of non-stipulation of some particular provision in IS:802. All materials shall be completely shop fabricated and finished with proper connection, materials and erection marks for ready assembly in the field.

g) Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate. HDG 8.8 grade foundation bolts with hot-dip galvanizing shall be provided for erection of structures.

## 1.8 Buildings and Civil Works

1.8.1 It shall cover design and constructional requirement for all civil works such as foundation for buildings, towers, equipment and equipment support structures, cable trenches, paving, drains, etc.

**Foundation for Substation Structures**

1.8.2 The type of foundation system, i.e. pile foundation, isolated, strip, or raft to be adopted shall be decided based on the structure, loading arrangement, load intensity and soil strata based on the soil investigation report recommendation. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

1.8.3 All foundations shall be designed for the most critical load combination of dead loads, live loads, inertia forces, wind and seismic loads, short circuit forces and secondary effects such as shrinkage, rise and fall in temperature, swelling and shrinking pressure of soil etc. and other relevant loading from

service condition arrived based on detailed structural analysis of the Substation gantry structures, equipment superstructures etc.

1.8.4 For Substation structure foundations, anchor bolt with mechanical anchorage will be provided along with foundation concrete. Bolts in pocket shall not be adopted. All foundation bolts shall be fully galvanized. The min. thickness of galvanizing shall be 126 All foundation bolts and its material shall confirm relevant Indian Standards codes (IS codes) / International standards. All foundation bolts shall be provided with two number standard nuts, one check nut, one plain washer and MS plate at the bottom of foundation bolt.

1.8.5 All tower / gantry structures, lightning mast foundations and equipment supporting structures shall have foundation bolts and base plate type of connection for transferring load from the superstructure to the foundations.

1.8.6 Foundation for all towers equipment support structure, equipment, railroad and poles shall be designed as per the recommendations of IS : 4091. The structural design of the foundation shall be done as per limit state method of design as given in IS:456 and considering the following partial safety factors on working load:

- Normal and broken wire condition 1.5
- Broken wire condition with short circuit forces 1.2

1.8.7 The foundation design shall be done based on soil parameters obtained from the soil investigation report.

1.8.8 Normally, all the four legs of tower / gantry structures column / equipment supporting structures shall be supported on a common foundation until and unless the leg spacing of structures at foundation level and soil conditions permit isolated foundation under each leg of the structure. For checking the stability, the following factor of safety shall be used:

- Normal and broken wire condition 2.2
- Broken wire condition with short circuit forces 1.65

1.8.9 The stability of the foundations shall be checked against overturning, bearing on soil, uplifting, sliding etc.

1.8.10 The pedestal provided for the towers shall be designed for combined action of axial forces viz. compression and tension and bending moments due to horizontal shears in both the longitudinal and transverse directions. A minimum of 4 numbers 16 mm diameter bars or 0.15% of cross section area of the pedestal, whichever is more shall be provided and spacing of the main bar shall not be more than 300 mm.

1.8.11 The centroidal axis of the tower leg shall coincide with the axis of the pedestal. The design of the foundation shall take into consideration the additional forces resulting from eccentricity introduced due to any reason.

1.8.12 The bottom raft / pad shall be designed both for bearing pressure as well as dead load of foundation and over weight of earth. The actual soil pressure under the footing shall be considered to calculate the maximum moments and shears at various sections.

1.8.13 The presence of surface / sub soil water shall be considered in the design of all foundations and underground faculties.

**Control building**

1.8.14 This building shall be of 230 mm thick brick wall with and metal sheet roofing supported on structural steel. The control rooms shall have a clear height of minimum 3.5m between the bottom of false ceiling and top of flooring. The switchgear room shall have a clear height of minimum 4.5m. The SCADA room shall be provided with false ceiling. The control building shall have Pantry, Toilet and Bathroom facilities.

**Crushed Stone Paving and Anti-weed Treatment**

1.8.15 In the BESS Plant plot area and in Substation, metal spreading using 40mm crushed stone shall be provided for a thickness of not less than 150 mm and shall extend one meter beyond the respective areas. The sub grade of gravel area shall be compacted to 90% modified proctor density. Before laying gravel fill, the top layer of soil shall be treated suitably by injecting approved anti weed chemicals as per manufacturers' recommendation. The Contractor shall submit for approval, the details of chemical proposed to be used before application of the same. Crushed stone shall be laid over Geotextile of sheet laid over soil. 150 dia holes shall be provided in geotextile sheet at 2m c/c for rainwater percolation into the soil. Sub grade shall have minor slope toward the storm water drain and weep holes shall be provided in trench wall for draining out water.

**Transformer Foundation with Soak Pit**

1.8.16 Transformers shall be founded on RCC foundations with rails on the top and oil soak pits filled with 40mm hard stone aggregate. Jacking pads shall be provided. Size of the soak pit shall be decided based on the transformer details and oil volume.

1.8.17 Fire wall of adequate thickness and height, if required as per TAC regulations shall be provided for transformers.

1.8.18 RCC foundations shall be provided with rail to transport transformers out of transformer yard during maintenance. To facilitate such placing and transportation of transformers, road with suitable width and turning radius shall be provided

1.8.19 Where rails cross the fencing, if required, fencing shall be made of removable type to facilitate transport of transformer.

**Transformer Burnt Oil Pit**

1.8.20 Common burnt oil pit (RCC) shall be provided to collect oil from individual transformer soak pits through heavy duty pipes laid to slope. Burn oil pit shall be equipped with portable sump pump or fixed pump of required rating with power outlet.

1.8.21 Oil collecting pit shall be sized based on volume of oil drained from the biggest transformer with additional 25% capacity.

**Cable Trenches**

1.8.22 In Cable trenches the spacing of insert plates for cable tray support angle shall be not more than 1.5 M. RCC precast cover slabs shall be designed for a live load of 10 kN / sqm. Cable trenches crossing roads shall be designed for Class A loading as per IRC-6 standard. Alternatively duct banks (hume pipes) embedded in RCC / PCC may be provided wherever feasible. Box culverts may also be provided at road crossings of cable trenches.

1.8.23 Cable trench inside the buildings shall be covered with 6mm thick galvanized chequred plate painted with epoxy paint and with stiffeners and lifting hooks.

1.8.24 The bed of the cable trenches along the length shall be provided with a slope of 1:500 to 1:750 by laying PCC (1:2:4) in second stage to drain out rain / seepage water without compromising the clearance required between the bottom most tray of cable trench and the bed of cable trench.

1.8.25 Outdoor trenches shall be covered with precast R.C.C. cover of suitable thickness and joints shall be pointed with cement mortar 1:3 to prevent entry of rainwater from top. The weight of a single RCC cover shall not be more than 75 kg. Suitable lifting hooks shall be provided for easy handling. Depression at lifting hook portion shall be filled with sand-bitumen to avoid rainwater stagnation. The top of the trenches shall be kept 150 mm above FGL. Suitable lugs of reinforcement steel shall be welded to edge protection angles for ensuring fixity in the concrete.

1.8.26 Sump pump shall be provided in cable trenches in the control building where there is no possibility of gradient flow and exit of water to the nearest drain. Type, capacity and other technical specification shall be fixed during detail engineering.

**Containerized Battery Storage System Foundation**

1.8.27 RCC foundation shall be provided for Containerized Battery Storage System. Other details shall be as per system requirements and applicable standards and regulations.

**PCS Platform Foundation**

1.8.28 RCC foundation shall be provided for PCS platforms. Other details shall be as per system requirements and applicable standards and regulations.

**High Mast and Street Lighting Foundations**

1.8.29 RCC foundations shall be provided for high mast and street lighting.

**HVAC**

1.8.30 Suitable air conditioning shall be provided in SCADA / Maintenance / Battery room. And Ceiling fans shall be provided for all other remaining rooms except toilets.

1.8.31 Proper ventilation of rooms shall be provided wherever applicable.

## 1.9 Common Requirements for Civil Works

**Grade of Concrete**

1.9.1 Unless required otherwise, cement used shall be Sulphate Resistant Cement conforming to IS 12330. Special cement, as appropriate, shall be used for structures, or portions of structures, exposed to chemicals. The type of cement shall be as per the soil investigation report. All structural concrete shall be design mixes only. Ready mix concrete may be used where feasible, minimum cement content shall be 350 kg / m3 of concrete unless otherwise specified in the detailed soil investigation report.

1.9.2 The following grades of concrete as per IS : 456 shall be adopted for the type of structures noted against each.

| | | |
|---|---|---|
| M25 | - | RCC structures below ground (min). |
| M25 | - | RCC structures above ground (min). |
| M25 | - | Precast trench covers |
| M15 | - | PCC |
| 1:4:8 | - | Mud mat |

**Clear Cover**

1.9.3 Clear cover to reinforcement shall be as follows:

| | Top (mm) | Bottom (mm) | Sides (mm) |
|---|---|---|---|
| Footings / Pile caps | 50 | 75 | 50 |
| Column / Pedestal | 40 | 40 | 40 |
| Grade Beam | 40 | 40 | 40 |
| Precast units | 25 | 25 | 25 |

1.9.4 Approved quality make and same grade of Concrete spacer block shall be provided as a cover in concrete structure.

1.9.5 All reinforcement shall be of high yield strength deformed TMT bars conforming to IS: 1786 Grade of rebar shall be Fe 500.

**Minimum thickness of RCC elements**

The following minimum thickness shall be followed:

| | | |
|---|---|---|
| a. | Ground floor slab (non - suspended) | 150mm |
| b. | Water Retaining Slab / Walls | 200mm |
| c. | Cable / Pipe Trenches / Underground pit | 125mm |
| d. | All footings (including raft foundations) | 300mm |
| e. | Precast trench cover slabs – indoor | 100mm |
| f. | Precast trench cover slabs – outdoor | 100mm |
| g. | RCC Paving | 150mm |
| h. | RCC Paving with vehicular load | 200mm |

**Excavation and Backfilling**

1.9.6 Excavation and backfilling shall be accordance to IS standards. Contractor shall carry out deep / shallow excavation by considering safety at side against any collapse. Temporary design against sliding and supports shall be providing by Contractor. Backfilling shall be with non-expansive soil. Any organic matter like roots and barks of trees shall be removed, if found at foundation level and surplus excavation shall be filled with PCC 1:4:8.

**Dewatering from construction Site**

1.9.7 Whenever water table is met during excavation, it is Contractor responsibility to dewater and water table shall be maintained below the bottom level of excavation during excavation, concerting and backfilling. Delay due to such cause will not be entertained and at no additional expense to Owner.

**Compaction of soil**

1.9.8 Density to which filler material is compacted shall be as per relevant IS codes and as per direction of Owner. Backfilling earth shall be compacted to minimum 95% of the standard proctor's density at OMC. Earth material shall be free from lumps and concrete debris.

**Reinforcement Fixing**

1.9.9 Reinforcement fixing shall be as per IS 2502. Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing,

supporting, and fastening the reinforcement. Spacers shall be cast from concrete of the same quality as that in which they will be embedded. Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size. Coated binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Contractor shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

**Formwork**

1.9.10 Formwork shall be designed and constructed so as to remain sufficiently rigid during placing and compaction of concrete and shall be such as to prevent loss of cement slurry. The face of formwork in contact with concrete shall be cleaned and treated with form release agent. Striping out formwork shall be as per IS:456 standards. Formwork shall be in good condition to have good surface of concrete. Approved quality make and same grade of Concrete spacer block shall be provided as a cover in concrete structure.

**Concrete placement**

1.9.11 Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

1.9.12 The Contractor shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

1.9.13 The temperature of concrete shall not exceed 40°C measured at discharge into the works.

1.9.14 The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable temperature differential between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Contractor to prepare a process control chart and method statement verifying measures to achieve these requirements. Temperature monitoring of concrete work is required where:

a) the minimum dimension of any casting is 0.8 metres or more, or

b) where otherwise instructed by the Owner.

1.9.15 Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

1.9.16 Concrete shall not be dropped into place from a height exceeding 1.5 metres.

1.9.17 Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

**Compaction and mechanical vibration of concrete**

1.9.18 As concrete is being placed it shall be compacted by mechanical vibrators complying with IS:2505, IS:2506, IS:2514 & IS:4656, to obtain a dense material free from honeycombing, ree from water and air holes. The Contractor shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation caused, but complete compaction of the concrete is achieved.

**Finish of concrete**

1.9.19 The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

**Curing**

1.9.20 Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed. Trowelled surfaces, except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

**Plumbing and Sanitation**

1.9.21 All plumbing work shall be executed to comply with the requirement of the appropriate bye-laws, Rules and regulation of the Local Authority and Owner's requirement. Sintex or equivalent make roof water tank of adequate capacity depending on the numbers of users for 24 hours storage shall be provided. However, minimum of 02 nos. of 1500 lit capacity shall be provided. Contractor shall provide permanent access and platform to supervise and cleaning of water tanks.

1.9.22 Chlorinated polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading confirming to relevant IS code.

1.9.23 Each toilet shall have the following fittings.

- WC (western type) with toilet paper roll holder and all other fitting.
- Urinals (430mm X 260mm X 350mm in size) with all fittings and built –in sensor for automatic flush after use
- Wash basin (550mm X 450mm) with all fittings.
- Bathroom mirror (600mm X450mm X 6mm) with hard board backing.
- CP brass tower rail (600 mm X 20mm) with CP brass bracket
- Soap holder and liquid soap dispenser.
- Automatic hand dryer.

1.9.24 Water cooler for drinking water with adequate water storage facility shall be provided in kitchen.

1.9.25 Stainless steel kitchen sink (510mm X1040mm X 180mm bowl depth) with drain board for pantry shall be provided.

1.9.26 All fittings, fasteners, gratings shall be chromium plated.

**Septic tank and Soak pit**

1.9.27 Contractor shall provide necessary no. of septic tank; soak pit and inspection chambers with adequate capacity to treat the sewage / sullage from the buildings.

**Water Supply for horticulture and Domestic use in Control Building**

1.9.28 Water storage provision of suitable size and adequate water capacity shall be constructed with necessary power supply, water pipeline network with rated pressure and pump provision for horticulture of landscaping area and green belt.

**Roof Access**

1.9.29 Galvanized Steel Cage ladder of required size shall be fixed outside for access roof. If the height is more than 3.0 m, then intermediate steel platform shall be provided with steel gratings. Anchoring of ladder shall be with RCC. Cage ladder shall extend to 1.0 m up vertically above the roof level.

**Doors and Partitions**

1.9.30 External doors shall be double leaf glazed aluminum door unless fire rated doors as mandatory required. Fire rating shall be as per applicable standards. All internal doors shall be single leaf glazed aluminum door or Fire rated steel doors as per requirements.

**Signage Boards**

1.9.31 Contractor shall provide to the Owner, detailed specification of sign boards. For Substation and transformer yard, the sign board shall be made of Aluminium composite sheet. Letters on the board

shall be proper illumination arrangement. All sign boards at open area and on road shall be placed on 400 X 400 mm and 600mm deep RCC foundations. Vertical posts shall be 65NB circular GI pipe, painting with epoxy paint with black and white Strip of 300mm with required Dry film thickness. Post shall be in two pieces. Short arm embedded in concrete pedestals and long armed above the ground shall be connected with short arm by bolt and nut connection. Each room shall be provided identification name plate of 2mm thick stainless steel with black letter engraving on it.

**Damp proof Course (DPC)**

1.9.32 Contractor shall make provision of Damp proof course to prevent moisture raising by capillary action in block masonry walls as per relevant IS code and approved make by Owner.

**Plinth Protection**

1.9.33 Plinth protection shall be provided for all buildings. It shall be 100 mm thick PCC, with a width of 1000 mm or the distance between the building outer wall to the RCC garland drain. It shall be laid over prepared subgrade and base formed with 40mm down rubble stone to a thickness of 150 mm.

**Plastering**

1.9.34 All external surface of masonry shall have 18mm thick plaster in two layers, with the under layer of 12mm thick 1:4 cement – sand plaster and the top layer of 6mm thick 1:6 cement sand plaster. Inside surface shall be 12mm thick 1:6 cement sand plaster. GI chicken mesh shall be fixed at brick / block and concrete joints before plaster.

**Switch Boards and Cable Wiring**

1.9.35 Contactor shall provide all required power outlets in each room with some extra provision with concealed wiring.

**Furniture, Fixtures and Cabinets.**

1.9.36 Adequate number of furniture, fixtures and cabinets shall be provided in all rooms including pantry.

**External painting**

1.9.37 External plastered surface of building walls shall be painted with exterior acrylic paint as per manufacturer specification and approval of Owner.

**Finishes**

1.9.38 The finishes for the buildings be as follows.

| Building Room | Flooring with 150mm skirting | Wall (internal) | Ceiling |
|---|---|---|---|
| Switchgear Room, SCADA room, Electrical room, Battery Maintenance room | Vitrified tiles of 8mm thick and 600X 600mm | Premium acrylic emulsion paint with on smooth surface applied with plaster of Paris on block wall | Oil bound washable distemper |
| Kitchen / pantry / Corridor | Vitrified tiles of 8mm thick and 600X 600mm | Premium acrylic emulsion paint with on smooth surface applied with plaster of Paris on block wall | Oil bound washable distemper |
| Toilet | Heavy duty anti-skid ceramic tiles | Dado glazed tiles | Oil bound washable distemper |
| Weather proofing for RC roof slabs | Elastomeric water proofing membrane with foam concrete | | |

**Substructure finishing**

1.9.39 All substructure or concrete surfaces which are in direct contact of soil and ground water shall be treated as critical and suitable surface protection shall be done to make the concrete durable against effects of acid / alkali soil substances.

**Aluminum doors / Windows / Ventilators**

1.9.40 All aluminum section shall be anodized. Section of door and window frame shall be approved make. Door shutter shall be made out from Aluminum and combination of compact sheet and clear float / wired glass of 5.5mm thick with sun film sheet on it. Rooms shall have adequate size and number of fixed / openable sliding windows and louvers with sun film over it to facilitate adequate ventilation / fresh air circulation. All windows shall have hot dip GI coated MS grill. All windows shall have curtains of approved make and have mosquito / fly net. These nets shall be removable for cleaning purpose. All doors / windows / louvers shall have weather shade. All door / window / ventilators sills shall have 20mm thick granite lining.

## 1.10 Design Loads for Civil Structures and Buildings

**Dead Load**

1.10.1 Dead loads consist of the weights of the structure complete with finishes, fixtures, partitions, wall panels and all equipment of semi-permanent nature including partitions, roofing, piping, cable trays, bus ducts etc. The following unit weight of material shall be considered for computation of loads:

| | |
|---|---|
| Plain Cement Concrete | 24 kN / $m^3$ |
| Reinforced Cement Concrete | 25 kN / $m^3$ |
| Structural Steel | 78.5 kN / $m^3$ |
| Brick work | 19 kN / $m^3$ |

**Equipment Load**

1.10.2 The imposed load generally shall include the panel loads.

**Earth Pressure Loads**

1.10.3 Earth pressure for all underground structures shall be calculated using coefficients of earth pressure at rest. In addition to earth pressure and ground water pressure, etc. a minimum surcharge load of 20 kN / sqm shall also be considered for the design of all underground structures including channels, sumps, cable and pipe trenches, etc. to take into account the vehicular traffic in the vicinity of the structure.

**Imposed Load**

Imposed loads in different areas shall include live loads, minor equipment loads, cable trays, erection loads, operation / maintenance loads etc. The loads considered shall not be less than that specified in IS : 875 (Part II).

| | | |
|---|---|---|
| Switchgear room floor | : | 10 kN / $m^2$ |
| Battery room floor | : | 10 kN / $m^2$ |
| Flat roof | : | 1.5 kN / $m^2$ + Equipment load |

**Wind Load**

1.10.4 Wind loads on structures shall be calculated as per provisions of IS : 875 (Part 3). The wind shall be assumed to blow in any direction and most unfavorable condition shall be considered.

| | | |
|---|---|---|
| K1 factor | = | 1.08 |
| K2 factor | = | Corresponding to Terrain Category 2 |

1.10.5 The external / internal pressure coefficients shall be as per respective clauses of IS : 875.

**Seismic Load**

1.10.6 Seismic forces shall be as per IS:1893.

**Load Combinations**

1.10.7 The individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load

combinations shall be taken as per IS:875 (Part-V) and other relevant IS codes. Wind and seismic forces shall not be considered to act simultaneously. Load factors shall be based on the factors given in the relevant codes of practice – in general all loads which are variable (including earth and ground water pressure) shall be treated as live loads for purpose of determining the load factor.

## 1.11 Fabrication and Erection of Structural Steel

**Structural steel**

1.11.1 All structural steel shall be of tested quality. Rolled steel sections and plates shall conform to IS: 2062. Steel tubes were used for equipment support structure shall conform to IS: 1161.

**Bolts and nuts**

1.11.2 All bolts and nuts shall be galvanized of mild steel and shall conform to IS : 6639. Unless shown or specified all bolts and nuts shall be hexagonal. All nuts shall fit tight. Mechanical properties shall conform to property class 4.6 and 4 of IS: 1367 for bolts and nuts respectively. Bolts of property class 5.6 conforming to IS: 12427 may also be used.

**Washers**

1.11.3 Plain washers shall be made of galvanized steel, unless otherwise specified and shall conform to IS: 2016. Spring washers shall be provided for those parts which carry dynamic loads and where black bolts for connections are permitted. Heavy washers shall conform to IS: 6610 and spring washers to IS: 3063.

**Electrodes**

1.11.4 Mild steel electrodes shall conform to IS:814 and high tensile steel electrodes to IS:1442. The Contractor shall furnish to the Owner a certificate issued by the manufacturer to the effect that the electrodes supplied are in accordance with the above specifications. For welding in any particular position, the electrodes used shall be those recommended by the manufacturer for use in that position.

**Galvanizing**

1.11.5 Galvanizing of Substation structures shall conform to IS:4759. The min. thickness of galvanizing shall be 126 microns at any point of the galvanized structure. Galvanization shall be measured with elcometer or the material can be sent for testing to laboratory as and when required. No averaging is allowed for measuring the thickness of galvanization. All side shall be galvanization with same specification and shall be maintained for any hollow components of structures. Galvanization shall be considering the Moderate zone C2 as per ISO 14713.

**Other Materials**

1.11.6 Other materials used in association with steel work shall comply with the appropriate Indian Standard specifications.

**General Requirements of Materials**

1.11.7 Before ordering bought out items, special accessories, equipment etc. and materials of any description, the Contractor and it's sub Contractors shall submit, the names of the proposed manufacturers or suppliers together with the specification of the materials for the approval of the Owner and shall, thereafter, send copies of the orders to the Owner.

1.11.8 In addition to the special provisions made hereafter as to the sampling and testing of materials by particular methods, samples of materials and workmanship proposed to be employed in the execution of the works comprised in this Contract may be called for any time by the Owner and when so called for by the Owner, the same shall be furnished by the Contractor free of charge without delay. The samples, when approved, shall be kept by the Owner who shall reject all materials or workmanship not in conformity with the quality and character of the approved samples. Suitable labelled boxes for the storage of the said samples shall be provided by the Contractor free of charge.

1.11.9 The Contractor shall furnish to the Owner the following certificates, if required, before commencement of fabrication:

i) A certificate stating the process of manufacture and chemical composition of the steel supplied.

ii) Test certificates by the manufacturer giving the results of each of the specified mechanical tests applied to the structural steel, bolts, nuts and washers and the chemical composition of the same.

**Workmanship**

1.11.10 All workmanship shall be equal to the best practice in modern structural shops. Greatest accuracy shall be observed in the manufacture of every part of the work and all similar parts shall be strictly interchangeable. Fabrication and erection shall generally be as per IS:802 and IS:800; wherever there is a contradiction between two codes, the provision of IS:802 shall be considered.

**Templates**

1.11.11 Templates used throughout the work shall be all steel, steel bushed in such cases as the Owner may consider necessary. In cases where actual materials have been used as templates for drilling similar pieces the Owner shall decide whether they are fit to be used as parts of the finished structure.

**Straightening**

1.11.12 All materials shall be straight and if necessary, before being worked shall be straightened and / or flattened by pressure unless required to be of curvilinear form and shall be free from twists.

**Clearance**

1.11.13 The erection clearances for cleared ends of members connecting steel to steel should preferably be not greater than 2.0 mm at each end. The erection clearance at ends of beams without web cleats should be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary, suitably designed seatings should be provided.

**Shearing, Flame Cutting and Planning**

a) Shearing or flame cutting may be used at the Contractor's option provided that a mechanically controlled cutting torch shall be used for the flame cutting and that the resulting edge shall be reasonably clean and straight. Sheared members shall be free from distortion at sheared edges.

b) The edges and ends of all flange plates and web plates of plate girders and built-up columns of plates forming chords or web members of lattice girders and all cover plates, the ends of all angles, tees, channels and other sections forming the flanges of plate girders and columns and chords and web members of lattice girders shall be planed.

c) The ends of all stiffeners shall be planed or ground to fit tightly between the main angles or flanges. Care shall be taken to ensure a full bearing of the stiffeners at the supports and at other points where concentrated load is applied. The ends shall not be drawn or caulked.

d) The butting surfaces at all joints of girders or columns shall be planed so as to butt in close contact throughout the finished joint.

e) The ends of all built-up girders and of all columns shall be faced. The bearing surfaces of all slabs and plates for caps and bases of columns and for seatings for heavy girders shall be machined.

f) Unless clean, square and true to shape, all flame cut edges shall be planed.

g) Cold sawn ends if reasonably clean and flame cut ends of sections not inferior to sawn ends in appearance need not be planed except for butting ends.

**Holing**

a) Holes for black bolts shall be not more than 1.5 mm larger than the nominal diameter of the bolt, unless specified otherwise. All holes, except as stated hereunder shall be drilled to the required size or sub-punched 3 mm less in diameter and reamed thereafter to the required size.

b) All matching holes for black bolts shall register so that a gauge 1.5 mm less diameter than the hole can pass freely through the members assembled for bolting. All holes for turned and fitted bolts shall be drilled and reamed, if necessary, to a tolerance of only plus 0.13 mm unless specified otherwise. When the number of thicknesses to be riveted exceeds three or the total thickness is 90 mm or more, the holes shall be drilled or reamed in position after assembly, except when steel-bushed jigs are used. The parts shall be firmly bolted together during such block drilling and taken apart for removal of burrs after drilling.

c) Holes in purlins, side sheeting, runners, packing plates and lacing bars may be punched full size.

d) All punching and sub-punching shall be clean and accurate and all drilling free from burrs. No holes shall be made by gas cutting process.

**Assembly**

a) All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at both top and bottom without being drawn or caulked.

b) The component parts shall be so assembled that they are neither twisted nor otherwise damaged and specified cambers, if any, shall be provided.

**Bolting**

1.11.14 Bolted construction shall be permitted only in the case of field connections. Unless otherwise specified, faces of heads and nuts bearing on steel work shall be machined. All such bolts shall be provided with washers having a hole of 1.6 mm larger in diameter than the barrel of bolt and thickness not less than 6.5 mm so that the nut, when tightened, shall not bear on the unthreaded body of the bolt. In all cases, where the full bearing area of the bolt is to be developed, the threaded portion of the bolt should not be within the thickness of the parts bolted together. The threaded portion of each bolt shall project through the nut by at least one thread. Tapered washers shall be provided for all heads and nuts bearing on levelled surface.

**Welding**

1.11.15 The welding and the welded work shall conform to IS:816 unless otherwise specified. All welding shall be restricted to shop and shall involve base plates, gussets etc. only. Weld connections are allowed only after approval from Owner, anti-corrosion paint on welded part shall be applied as per procedure approved by Owner.

**Galvanizing**

**General**

1.11.16 Structural steelwork for Substation or other structures as may be specified in the contract shall be hot dip galvanized in accordance with IS : 4759.

**Surface Preparation**

1.11.17 All members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, dirt, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

1.11.18 The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

**Procedure**

a) Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS:2633 - Methods of Testing Weight, Thickness and Uniformity of coatings on hot dipped galvanized articles. The zinc coating shall be uniform, clean and of a standard thickness on the entire surface of the material galvanized.

b) The galvanized surface shall consist of continuous and uniformly thick coating of zinc firmly adhering to the surface of steel. The finished surface shall be cleaned and smooth and shall be free from defects like discontinuous patches, base spots, globules, spiky deposits, blistered surface, flaking, peeling of etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection. There shall be no flaking of loosening when struck squarely with chisel faced hammer. The galvanized steel member shall withstand minimum 4 numbers of one minute successive dips in copper sulphate solution as per IS:2633 unless specified otherwise.

c) All galvanized members shall be treated with sodium dichromate solution or an approved equivalent; after galvanizing so as to prevent white storage stains.

d) Galvanizing of each member shall be carried at in one complete immersion. Double dipping shall not be permitted.

   Wherever galvanized bolts, nuts, washers, accessories etc. are specified, these shall be hot dip galvanized. Spring washers shall be electro galvanized. Readily available GI nuts, bolts and washers conforming to galvanizing requirements may also be used.

e) The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

f) Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having been dipped twice the same shall be rejected. Special care shall be taken not to injure the skin on galvanized surfaces during transport, handling and erection. Damages, if any, shall be made good in accordance with the provisions of this specification or as directed by the Owner.

**Painting of Structural Steel, Crane gantry girders, Walkway, Ladder / Staircase Handrail**

a) All steel structures shall receive two primer coats and two finish coats of painting.

b) All structural steel painting coats shall be done at fabrication yard before delivery for erection (with MTC and other relevant test documents). Only touchup paint to be done at Site.

c) Steel surface which is to painted shall be cleaned of dust and grease and the heavier layers of rust shall be removed by chipping prior to actual surface preparation. The surface shall

be abrasive blasted to Sa-2½ finish as per SIS05-5900. Primer paint shall be zinc silicate of approved make.

d) Finish paint shall be 2 coats of High built epoxy finish of approved brand. Dry film thickness of each finish coat shall be 90 microns. The undercoat and finish coat shall be of different tint to distinguish the same from finish paint. The total dry film thickness shall be 300 microns. All paints shall be of approved brand and shade as per the Owner's requirement.

e) Joints to be Site welded shall have no paint applied within 100 mm of welding zone. Similarly where Friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified. Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly.

f) Surfaces inaccessible after erection including top surfaces of floor beams supporting gratings or chequered plate shall receive one additional coat of finish paint over and above number of coats specified before erection. Portion of steel member embedded / to be encased in concrete shall not be painted.

g) Colour scheme

Colour scheme matching with local aesthetics and best industry practice shall be submitted by Contractor for approval of Owner. Three alternative colour isometric with colour code shall be submitted for approval. Colour of the roof sheet shall be light in colour to minimize heat observation. External and internal paint of block masonry shall be painted with suitable colour to match with coloured steel sheet.

h) Touchup paint application

It is Contractor's prime responsibility to handover the building with neat, clean and damage proof. Any damages to paint of structure or floor / wall / ceiling surface will not accepted till successful commission and final handover. In such case to rectify, Contractor shall submit the repair / rectification work methodology to Owner for review and approval. Contractor shall carry out all such rectification post to approval at no additional charge to Owner.

i) Gratings

All gratings shall be pressure locked type (preferably Electro-forged) manufactured in accordance with applicable Indian Standard. All removable grating shall be bolted or clipped to supports. Sizes of grating shall be such as to allow easy handling. Grating units at all penetrations shall be made up in split section All gratings shall be arranged such that bars in either direction are in line. All gratings and accessories shall be hot dip galvanized.

j) It may be of rectangular pattern of parallel bearing bars of 40 mm depth and 5 mm thickness and cross bars of 25 mm depth and 3 mm thickness. Bearing bars shall be at 30 / 40 mm c/c with cross bars at 100 mm c/c.

**Handrails**

1.11.19 Handrail shall be fixed and removal as per Site requirement. Handrails shall be provided at appropriate places to ensure safety e.g. around all floors / roof openings, projections / balconies, walkways, platforms, steel stairs etc.

1.11.20 All walkways, stairs, and platforms shall be provided with handrails, supports, and bracing as well as kick-plates of minimum thickness of 8 mm & projecting 100 mm above the platform surface.

1.11.21 All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS: 1161 and shall be galvanized.

1.11.22 Handrail shall be a three-rail system with elevations of each rail from floor level shall be as listed below.

- the top rail at 1250 mm
- the intermediate rail shall be at 850 mm
- the bottom rail shall be at 450 mm

1.11.23 Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening and shall not exceed 1850 mm in such a case.

**Marking, Packing and Dispatching**

1.11.24 Each piece shall be distinctly marked before delivery, in accordance with an approved marking diagram and shall bear such other marks as will facilitate erection. For easy identification at Site, a small distinguishing mark shall be painted on each end of every member before dispatch from fabrication shop. The fabricated steel work shall be dispatched in such portions as may be found convenient for erection or as ordered by the Owner.

1.11.25 All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

**Erection**

1.11.26 The material shall be verified with marking on the marking plan or shipping lists which shall be supplied by the Contractor.

1.11.27 Any material found damaged or defective shall be stacked separately and the damaged or defective portions be painted in distinct colour. Such material is to be dealt with under the orders of the Owner without delay.

1.11.28 The field assembling of the component parts of a structure shall involve the use of method and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until the defects are corrected and members seriously damaged in handling shall be rejected.

1.11.29 All small bends or twists received by members shall be rectified before such members are put in place; any serious bends or damage shall be reported at once to the Owner by the Contractor for instructions. The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury.

1.11.30 Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

**Setting Out**

1.11.31 The Contractor shall assume full responsibility for the correct setting out of all steel work and erecting it correctly as per alignment and levels shown on the drawings and plumbing of vertical members. Datum points shall be arranged by the Contractor near the work Site. Notwithstanding any assistance rendered to the Contractor by the Owner, if at any time during the progress of the work any error should appear to arise therein, on being required to do so, the Contractor at it's own expense shall remove and amend the work to the satisfaction of the Owner.

**Erection Drawings**

1.11.32 Erection shall be carried out as per erection drawings. Erection drawings shall show each individual member with its identification mark, location and position of the outstanding leg of angles, number and length of connection bolts on their diameter. These drawings shall also show location and details of splicing, bolts of base plate, levels and location of all cross connections. All drawings shall be of one standard size. The main views like plan and elevation of towers shall be drawn to a scale not smaller than 1:15. All connection details shall be drawn to a scale of not smaller than 1:5. Separate erection drawings to a convenient scale shall be prepared for facility of use in the field. Any special erection techniques proposed / required in erection of the structure shall be shown on the erection drawings.

**Field Bolting**

1.11.33 All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steel work shall also be applicable for field bolting in addition to the following.

1.11.34 Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers, shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts.

1.11.35 Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this Sub-Clause.

**Bedding, Grouting and Dry Pack**

1.11.36 Bedding shall be carried out with non-shrink grout. For the main column, the Contractor shall provide screed bars of mild steel flats and fix them in mortar. The Owner will be the sole authority in deciding "main" and "secondary" columns and his decision in this matter will be binding on the Contractor within the terms of this contract.

1.11.37 The bedding shall not be carried out until a sufficient number of columns has been properly aligned, leveled and plumbed and sufficient girders, beams, trusses and bracings are in position to the satisfaction of the Owner.

1.11.38 Immediately before grouting, the space under the base plate and around bolts shall be thoroughly cleaned, well soaked and made free from excessive moisture.

1.11.39 The grout shall be mixed as thick as possible consistent with fluidity and shall be poured under pressure with pressure grouting machine, until the space has been filled with mortar.

**Correction of Misfits**

1.11.40 Correction of minor misfits, a reasonable amount of reaming and cutting of excess-stock from rivets will be considered a legitimate part of the erection.

1.11.41 Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or a moderate use of reaming and slight chipping or cutting shall immediately be reported to the Owner and it's approval of the method of correction obtained.

## 1.12 Quality Control

1.12.1 Contractor shall establish fully equipped quality control laboratory at Site to conduct all acceptance test on all construction materials, concrete cube test, compaction of soil testing. This shall be housed with covered buildings. All testing equipment like Owen, Electric operated cube testing equipment, sieves for grading of sand and aggregates, flakiness and elongation index testing sieve, density of aggregates, abrasion testing equipment, impact testing equipment, bitumen testing equipment like thermometer, Marshall test apparatus.

1.12.2 Other apparatus like cube moulds, sump cones. Vicat apparatus, moisture meter, dry film thickness gauge meter.

1.12.3 Contractor shall arrange for design mix of concrete for each grade of concrete from BSUL approved laboratory or NABL(National accreditation board for testing and calibration laboratories)

1.12.4 All testing equipments shall be periodically calibrated to the satisfaction of Owner and as per manufacturer manual and instruction

## 1.13 Inspection and Testing

1.13.1 The Owner shall have free access at all times to those parts of the manufacturer's works which are concerned with fabrication of the steel work and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of this specification.

1.13.2 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch Tolerance for fabricated structures shall be as per IS:7215.

1.13.3 Should any structure or part of a structure be found not to comply with any of the provisions of this specification, it shall be liable to rejection. No structure or part of the structure once rejected shall be resubmitted for test, except in cases where the Owner considers the defect as rectifiable.

1.13.4 Defects which may appear during fabrication shall be made good with the consent of and according to the procedure laid down by the Owner.

1.13.5 All gauges and templates necessary to satisfy the Owner shall be supplied by the manufacturer.

1.13.6 The Owner may, at his discretion, check the test results obtained at the manufacturer's works by independent tests at the Government Test House or elsewhere, the expenses of such tests shall be borne by the Contractor.

1.13.7 Before dispatch from fabrication shop, prototype of each structure shall be shop assembled and checked for fabrication tolerance. Also, if ordered, by the Owner, the same shall be presented for inspection.

## 1.14 Drawings & Documents

1.14.1 The Contractor shall submit it’s detailed schedule for submission of all information, documentation, calculations, drawings, schedules etc. within such periods or dates, which are required to guarantee a smooth handling of the project without delays.

1.14.2 After award of contract, the Contractor shall submit the designs, layout and construction drawings and detailed working drawings including fabrication drawings and bar bending schedule for all structures and items covered under the scope of this contract. The quality of the submitted documents must be in accordance with acceptable national practice and allow a speedy checking procedure.

1.14.3 The design drawings shall consist of general arrangement drawings showing location of tower and various equipment foundation along with cable trenches and all other related items / services required for the project. Subsequently detailed drawings along with design calculation shall be submitted by the Contractor for approval. Subsequent to approval of GA drawings, fabrication drawings for steel structures and Bar Bending Schedule for RCC structures shall be submitted before commencement of construction.

1.14.4 Detailed dimension drawings and design calculation for all civil and structural works shall be submitted to the Owner for scrutiny and approval. No construction shall commence prior to obtaining of written

approval from the Owner. Any approval given by the Owner to the designs & drawings shall not relieve the Contractor of it's responsibilities for the correctness of the same and for execution of the work in accordance with the terms of the specifications. Detailed drawings approved by the Owner shall supersede the general drawings when they differ from them.

1.14.5 The drawings bearing the Owner's approval or drawings corrected in accordance with the comments of the Owner shall be deemed to be contract drawings and no variation there from shall be taken without the Owners written consent.

1.14.6 The Contractor shall submit the following along with the bid:

- Brief Design basis for structural works including description of software to be used.

The successful Contractor shall submit the following after award of Contract in line with the scope of work:

Structural Steel Works

- Detailed Design Basis Report for civil and structural works.
- Structural calculations including inputs / outputs
- Erection Scheme / Sequence
- Design Drawings, Erection drawings and fabrication drawings for structural steel works.
- Any other drawing or document required by the Owner for completion of project.

1.14.7 Civil Works

- Design Basis for Civil and Architectural Works
- General layout drawing / Master Plan layout drawing including boundary fence
- General Equipment arrangement drawing
- Design and detailed drawings for all civil works such as tower foundations, equipment support foundations, mast foundation etc.
- Design, detail and architectural drawing of Roof and wall cladding with roof gutter and downspout pipe.
- Design and detailed drawing of cable trench
- Design and detailed drawings for roads, drainage, culverts etc.
- Detailed drawings for Fencing and gates, paving etc.
- Street light poles around fence, roads and at transformer.
- Landscape drawing
- Bar Bending Schedule
- Any other drawing or document required by the Owner for completion of project.

1.14.8 Unless otherwise stated, the Contractor shall be responsible for all necessary lists such as indents, rivet and bolt lists, material lists, Dispatch lists and lists for all bought out items.

1.14.9 Fabrication work shall not be taken in hand until the relevant shop drawings have been approved by the Owner. The Contractor shall take into account any revisions in drawings furnished by the Owner at no extra charge.

## 1.15 Design Requirements

**BESS Control Building (Main Control Room):**

1.15.1 The construction of RCC single storey BESS control building shall house following

1. Battery room (if applicable)
2. PCS room (if applicable)
3. HT (if applicable)
4. LT Switchgear
5. Storeroom
6. Toilet
7. BESS EMS and SCADA control room.

1.15.2 The size and layout of the building for indoor and outdoor facilities shall be modified as per the Site condition. The modification to be done with a prior approval of the Owner.

**Grid Substation Control Building:**

1.15.3 This building shall be of prefabricated construction with sandwich panel roofing and cladding. Layout, clear headroom and other details shall be as per the existing grid substation specification and philosophy, Electrical system requirements.

1.15.4 Electrical panel support system shall be painted with minimum GI coating / painting as per Corrosion zone of ISO 12944. PEB support system shall be hot dip galvanized. Zinc coating shall not be less than 0.610 kg/sq-mtr(85 microns) at any point of the galvanized structure. Uniform coating shall be specified. Galvanization shall be measure with elcometer or the material can be sent for testing laboratory as and when required. No averaging is allowed for measuring the thickness of galvanization. All side shall be galvanization with same specification and shall be maintained for any hollow components of Prefab structures. The gap between base plate of structural members and concrete top of foundation shall be filled with GP-2 grouting material of reputed make. The material of all J-bolts shall be of HDG 8.8 grade for erection of Prefab structures.

1.15.5 For erection of Prefab structures, welded connection if possible, shall be avoided. If weld connections are provided (after approval by Owner) then anti-corrosion paint shall be applied on welded part. For overall PEB, the corrosion zone as per ISO 12944 shall be considered.

1.15.6 BLDC ceiling fans, high energy efficiency shall be provided. Ceiling Fans of reputed makes shall be provided. These PEBs shall be placed generally unmanned; therefore, the ventilation shall be reliable, maintenance free and designed for long life.

1.15.7 Proper sealing arrangements (with silicon / PU foam sealant) shall be provided for cables / Gas ducts / cutouts. Proper cable clamping / support arrangements / cable trays / conduits shall be provided as per requirement finalized during detail engineering of Owner.

1.15.8 Lightning protection of the PEBs shall be provided with minimum 25 x 3 mm GI Flat running through the roof all over or, higher as per calculation & manufacturers' standard.

1.15.9 All structural steel shall be hot dip galvanized.

1.15.10 Necessary roof anchors shall be provided above roof cladding for fixing safety harness of personnel walking on the roof.

**Transformer Yard:**

1.15.11 Transformer supporting structure & foundations shall be founded on piles/block/slab/isolated spread footings depending on the geotechnical investigation report. 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. Transformer track rails shall conform to IS: 3443. The requirement of fire barrier wall between transformers shall be as per Electricity Rules and IS: 1646 recommendations.

**RCC concrete pedestal/slab:**

1.15.12 Finished level of the top of concrete shall be minimum 450mm from the existing/ finished ground level.

1.15.13 BESS yard shall be as per recommendation of Containerized Battery Storage System manufacturer. Layout of yards shall be such that crane movements for placing, lifting of battery units, PCS units, transformer, etc. shall not disturb the adjacent facility. All side fencing, cladding/ roof sheets shall be fitted in such a way that they can be removed at any point of time. Adjacent and surrounded area of BESS, PCS, etc. shall be gravel filled if PCC slab is not provided. All the systems, room and building shall be connected by rigid road/pavement with substation internal approach road.

1.15.14 RCC Trenches shall be constructed in reinforced cement concrete of M-20 grade of wall thickness min 125 mm. Trench walls shall not foul with the foundations. The trench bed shall have a slope of approx. 1/500 along the run & 1/250 perpendicular to the run. Bidder can also provide directly buried cable trench as mentioned in specification.

1.15.15 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.

1.15.16 Chain link fencing and gate shall be as per Chain link fencing drawing enclosed with specification.

## 1.16 Specification for RCC building for BESS control room

**Toilet**

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

**Floor finishes**

1. Control room: Heavy duty vitrified ceramic tiles with skirting.
2. Battery room: Acid/Alkali resistance tile flooring and dado (2100 mm).
3. Toilet: Heavy duty anti-skid ceramic Tiles and dado upto 2100 mm.
4. Steps: Kota stone/Granite- 20 mm thick.

1.16.2 Finish floor level of all building shall be minimum 450 mm above from Finish graded level. Concrete ramp shall provide at rolling shutter gate for access of room.

**Roof finishes**

1.16.3 Roof of the building shall be cast-in-situ RCC slab. The roof of the building shall be waterproof with Polymeric membrane type waterproofing as per DSR 2021, Items no. 22.6. The roof shall be designed for minimum superimposed load to 150 kg/m2.

1.16.4 For efficient disposal of rainwater, the runoff gradient for the roof shall not be less than 1:100. The roof of all building shall be projecting out by at least 500 mm all around the building from external walls for protection from rainwater.

1.16.5 Height of parapet wall shall be minimum 300 mm above top of roof level. A service ladder shall be provided in front/side of building to provide access to terrace.

**Windows, Doors, Ventilators and Rolling Shutters**

1.16.6 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 micron) aluminium framework with glazing. Window shall be provided with suitable aluminium grill. Toilet doors will be of fibre reinforced plastic (FRP) type.

1.16.7 Minimum size of 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.

1.16.8 Doors and windows on external walls of the buildings shall be provided with RCC sunshade over the openings. Projection of sunshade from the wall shall be minimum 450mm over window openings and 750 mm over door openings except for main entrance door to the control room where the projection shall be 1000mm.

1.16.9 Rolling shutter (Mechanical gear operated). Rolling shutters shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling shutters 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.

1.16.10 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. The glass used should be from reputed brand / manufacturer and as approved by Owner. The glass should be free from distortion and thermal stress.

**Paintings of wall and ceilings**

1. Internal wall surfaces: Acrylic Distemper
2. External faces of walls: Exterior emulsion paint
3. All ceiling: Oil bound distemper

1.16.11 The paint shall be anti-fungal quality of reputed brand suitable for masonry. All painting on masonry or concrete surface shall preferably be applied by 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.

1.16.12 For painting on steel work 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.

1.16.13 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 commencement of work.

**Plumbing and sanitary**

1.16.14 Attached common toilet shall the following minimum fittings of ISI approved of 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. Wash basin (550 x 400 mm) above platform with all fittings.
3. Bathroom mirror (600 x 450 x 6 mm thick) hard board backing
4. CP brass towel rail (600 x 20 mm) with C.P. brass brackets
5. Soap holder and liquid soap dispenser.

1.16.15 All fittings, fastener, grating shall be brass with chromium plated as per relevant IS code. Necessary plumbing lines 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.

1.16.16 The PVC storage water storage tank conforming to IS: 12701 shall be provided over the roof of the CMCS with adequate capacity of 24 hr requirement, complete with all fitting including float valve, stop cock etc. The capacity of the tank shall be minimum 500 litres.

1.16.17 The bidder shall design & provide packaged sewerage treatment Plant/septic tank 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 board requirement.

**Electrification of Building:**

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

**Specification of PEB for PCS (Indoor) (if applicable):**

1.16.19 Indoor PCS shall be provided inside a Pre-Engineered Building with framed structure.

1.16.20 The height of Building shall be minimum 4 meters and it shall be covered from all four sides. The roof and cladding walls of the building shall be made of permanently colour coated galvalume profile sheets with 40 mm PUF. Peripheral brick masonry upto height lintel level shall be provided for building. The minimum BMT (Base material thickness) of roof and side wall sheets shall be 0.5mm. Gate/Door provision shall be made on at least two sides of the building with suitable ramps. The store shall be at least 450mm above FGL. The roof sheet shall have a projection of 500mm on all around. Provision of window &ventilation shall be provided for PEB and suitable turbo vent on roof of building.

1.16.21 The building shall be made of structural steel material as per relevant IS codes. All RCC work & steel work shall be in line with IS: 456 and IS 800 respectively. Alternatively, the store shed may also be made with structural steel columns with self-supporting roof truss system. The store shed shall be designed in line with wind loads as per IS: 875, part-III.

1.16.22 The building flooring shall be made of 150mm thick RCC (reinforcement of 8mm dia. at 200mm c/c both side, single layer) laid over 200mm thick well graded and compacted boulders with sand. Top surface of floor shall be provided with suitable flooring as required of indoor PCS facilities. All indoor structural members shall be painted with minimum two coats of synthetic enamel paint over one coat of primer. The design and drawing of the store shed shall be submitted for Owner approval before start of work.

**General civil works**

1.16.23 Reinforced Concrete Structure, Allied Works and Foundation:

1.16.24 All RCC works shall be design 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 Soil Investigation report.

1.16.25 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. Sand shall be hard, durable, clean and free from adherent coatings of organic matter and clay balls or pellets.

1.16.26 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.

1.16.27 Reinforcement steel shall be of high strength deformed TMT steel 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.

1.16.28 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.

1.16.29 M-25 - All RCC structural elements above and below ground level, precast concrete, transformer foundation, Equipment foundation.

1.16.30 M-20 (Equivalent nominal Mix of 1:1.5:3) - Fencing work, cable trench, oil pit. Grade Slab, Paving, culverts & road.

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

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

1.16.33 The bidder shall carry out the design mix of M-25 grade concrete. The design mix shall be approved from Owner Site before start of work.

1.16.34 In case geotechnical investigations require any special kind of cement or higher grade of concrete, the same shall be provided.

1.16.35 All loads shall be considered in line with IS: 875. A seismic load for design shall be in accordance with IS: 1893 and relevant Standards.

1.16.36 IS: 2502 Code of Practice for Bending and Fixing of Bars for concrete. Reinforcement must be complied for reinforcements. IS: 5525 and SP: 34 shall be followed for reinforcement detailing.

1.16.37 A minimum 75 mm thick PCC shall be provided below RCC wherever RCC is laid over the ground. Proper and sufficient formwork/shuttering shall be provided for the required period as per IS: 456.

**Structural Steel:**

1.16.38 All structural steel design shall be carried out as per IS 800. Structural steel shall conform IS 2062, 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.Outdoor structure steel shall be Hot dip galvanized and galvanization shall be as per IS:4759 or relevant Indian standard and the minimum coating thickness shall be maintained as 80 or 110 micron (required as per exposure condition/ corrosivity category of atmosphere as defined in ISO 9223) for all structural steel members.

**Grouting:**

1.16.39 Cement mortar (1:2) grout of minimum 25mm thickness with non-shrink additives shall be used for grouting below base plate of column. The grout shall be high strength grout having a minimum characteristic compressive strength of min 30 N/mm2 at 28 days.

**Masonry Work:**

1.16.40 Brick works shall be using at least class designation 5.0 of approved quality as per Indian Standard code. Concrete blocks shall be of minimum compressive strength of 5 N/mm2 and shall be of Grade-A as per IS Code. Stone masonry work with hard stone in building works, foundation, plinth and drains shall be Coursed Rubble or Random Rubble masonry work with 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.

1.16.41 The cement mortar for all kind of masonry work shall be in the ratio 1 cement and 6 sand by weight.

1.16.42 Bricks/blocks required for masonry work shall be thoroughly soaked in 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.

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

1.16.44 Bricks of class designation 3.5 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 subjected to approval of Owner. Tolerances on dimensions up to +/- 8% shall be permitted. Dimension test to be carried out as per IS code. Use of fly ash brick for masonry shall be subjected to approval of Owner.

**Plastering:**

1.16.45 All external surfaces shall have 18 mm cement plaster in two coats, under layer 12 mm thick cement plaster 1:5 and finished with a top layer 6 mm thick cement plaster 1:6.

1.16.46 White cement primer shall be used as per 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 comply 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 control room. Plaster of Paris (Gypsum Anhydrous) conforming to IS: 2547 shall be used for plaster of paris punning. HDPE Rainwater down Pipe shall be provided with suitable gutters all around.

**Foundation system**

1.16.47 Foundation system for various facilities shall be designed and adopted as per approved geotechnical investigation report and relevant IS standard. All structures/equipment shall be supported either on

suitable open foundations (isolated, combined, raft) or pile foundation. The water table for design purpose shall be considered at Finished Ground Level.

1.16.48 Minimum width of foundation and minimum depth of foundation below Ground Level shall be worked out based on relevant IS codes such as, IS 1904/ IS 6403. No foundation shall rest in black cotton soil. For open foundations, the total permissible settlement and differential settlement shall be governed by IS: 1904 / IS: 13063 and from functional requirements whichever is more stringent.

1.16.49 In case, pile foundation is required to be adopted, then design, construction and testing of pile foundation shall be as per the requirements of IS: 2911, latest revision.

**Geo-Technical Investigation Report**

1.16.50 Geo-Technical Investigation report should be accompanied by a key plan showing the location of the bore holes and other relevant details. Necessary references to related Standards shall be given in the report.

1.16.51 Following information obtained at the Bore Holes shall be tabulated:

a. Job Name and Location
b. Contractor's name
c. Exploratory hole reference number
d. Natural ground level
e. Borehole Location reference co-ordinates
f. Dates of boring referred to the depth
g. Diameters and depths of all casings used
h. Records of ground water
i. Preliminary description of each stratum
j. Depth at which samples are taken
k. Depth of all in-situ tests
l. Any addition of water to the boring
m. Details of time spent in overcoming obstructions/obstacles met with (if any) and time spent on overcoming it
n. Site Photograph (Must) for each Bore Hole

1.16.52 The final geotechnical report shall contain geological information of the region, procedure adopted for investigation, field observations, summarized test data, conclusions and recommendations.

1.16.53 The report shall include detailed bore logs, soil conditions at the surface, expected soil conditions below the surface, laboratory observations and test results both in tabular as well as in graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculations for the conclusions drawn etc.

**Report on Boreholes**

1.16.54 The report shall also include but not be limited to the following:

a. Detailed write up on the methods, procedures and equipments used in all phases of work

b. Plan showing locations and reduced levels of all field tests e.g. bore holes, Standard penetration tests etc.

c. A true cross section in two perpendicular and diagonal directions of all individual bore holes with reduced levels and coordinates showing the classifications and thickness of individual stratum, position of ground water table, grain size distribution index and engineering properties of representative samples, various in situ tests conducted and samples collected at different depths and rock stratum if met with.

d. Detailed test results of all laboratory tests for both in tabular and graphical form for each sample with relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rocks.

e. Plot of SPT (N value both uncorrected and corrected) with depth for identified areas.

f. The value of cohesion, angle of internal friction, shear modulus and coefficient of sub grade reaction shall be furnished along with sample calculation.

g. Calculation of allowable bearing pressure and corresponding total settlements

h. Consolidation curves.

1.16.55 Recommendations

a. The report shall include specific and definitive information and all necessary interpretations on the following supported by detailed calculations duly considering the type of soil, structure and foundation in the area.

1. Type of foundation, minimum founding depth and width of foundation to be adopted for major structures of BESS power Plant considering sub soil characteristics, water table etc. Values obtained from field tests and laboratory tests shall be compared and suitable interpretation shall be furnished.
2. Net safe allowable bearing capacity (SBC) of soil at different founding depths below ground level considering both shear failure and settlement criteria.
3. Net safe allowable bearing pressure for raft foundations for widths greater than 5m at different depths below ground level considering shear failure and settlement criteria.
4. Recommendation of type of foundation to be adopted for the proposed structures and details of any soil improvement if required.
5. Consolidation characteristics.

**Area Grading & Levelling**

1.16.56 The Contractor shall make the Site ready and easily approachable by clearing vegetation and bushes. Erecting permanent benchmark pillars (min. 3 nos.) in undisturbed locations (approved by Engineer-in-charge) and transferring levels from nearby approved benchmark shall be done by the Contractor.

1.16.57 Except in exceptional cases (with approval of the Owner), filling shall normally be made up of cohesive non-swelling material. The filling for levelling / reclaiming the ground / area shall be done in layers not more than 150mm of compacted thickness in case of cohesive (clayey) soils and 250mm compacted thickness in case of granular (sandy) soils with compacting up to 95% of modified proctor density in case of cohesive (clayey) soils and 80% of relative density in case of granular (sandy) soils.

1.16.58 The slope at edge of graded areas shall not be flatter than 1:1.5 (1 Vertical: 1.5 Horizontal) in cutting and 1:2 (1 Vertical: 2 Horizontal) in filling. It shall be ensured that the land is graded or levelled properly for free flow of surface runoff and the grade levels shall be fixed considering drainage pattern and system requirements. It is advisable to follow the natural flow of water at the ground. Excess earth if any shall be disposed-off properly at location as directed by the Owner.

1.16.59 Site grading level shall be fixed considering Site drainage of the whole area, existing drainage pattern, maximum flood level and system requirements. Site levelling works/scheme shall match with the specific functional requirement of the project.

1.16.60 The Site shall be cleared of all trees, shrubs or other vegetation, rubbish, slush etc. and other objectionable matters. If any roots or stumps of trees are met during excavation, they shall also be removed. Where earth fill is intended, the area shall be stripped of all loose / soft patches or topsoil containing objectionable matter before filling commences. Any structure or services existing at the Site shall be removed / rerouted with the permission of the Owner.

1.16.61 Existing wells, pits, marshy areas etc. shall be filled up with earth of approved quality.

1.16.62 The Contractor shall be deemed to have viSited and carefully examined the Site and surroundings and to have satisfied himself about the nature of the existing structures, underground services, general Site conditions, the Site for disposal of surplus materials, debris etc. and all other items affecting the work. Claims due to ignorance of Site conditions shall not be considered after submission of Bid.

1.16.63 Area for disposal of unsuitable materials resulting from excavation will be identified by the Owner inside the project boundary at the time of execution.

1.16.64 Levelling and grading shall be in compliances with the robotic cleaning operations.

**Construction Enabling Works**

1.16.65 The Contractor shall provide for at it's xpense, the following buildings and facilities for proper execution and quality control of the job, while meeting the provision stipulated by Factory Rules regarding staff welfare facilities. All these building shall have brick cladding, Steel sheet roofing over steel roof truss with cement concrete flooring and false ceiling with A / C as required.

1.16.66 Site office for Contractor's Use

a. An A/C Conference room to accommodate about 20 people shall also be provided in the Site office complex. Basic facilities like toilet for gents and ladies, potable water tanks, soak pit and septic tank for sewage disposal shall also be provided.

1.16.67 Site Stores Complex

a. A covered store shall be provided with brick cladding and colour coated sheeting to store at least one month requirement of cement. Cement in bags shall be stored on a raised floor well away from outer walls and insulated from the floor to avoid moisture. Not more than 15 bags shall be stacked in any tier. Each consignment of cement shall be stored separately and consumed in its order of receipt.

b. Covered storage area may also be provided to store other construction material which shall be affected on exposure to wind, sun and rain.

c. Proper fencing and security arrangement shall be provided for the stores complex.

1.16.68 Temporary Workshop and Garage

a. The Contractor shall provide for a temporary workshop and garage to attend to routine maintenance and repair of the construction equipments as well as his fleet of vehicles used for construction activities.

1.16.69 Quality Control Laboratory

a. A fully equipped quality control laboratory shall be established at Site with qualified personnel to conduct acceptance test on all construction material, weldments, concrete cubes etc. This laboratory shall be housed in a covered building with A / C facility as required by the testing facility.

b. All testing equipment shall be periodically calibrated to the satisfaction of the Owner. All testing shall be carried out in presence of Owner.

c. Testing laboratory shall be equipped with the following minimum apparatus, materials and competent, trained staff required for carrying out field tests.

1. Slump cone apparatus to measure slump.
2. Concrete cube testing machine with adequate number of moulds of (15cm x 15cm x 15cm) to measure compressive strength of concrete.
3. Vicat apparatus to find initial and final setting time of concrete.
4. IS-sieves with vibrating machine to determine fineness modulus of coarse and fine aggregate.
5. Abrasion & impact testing Equipment for testing coarse aggregate and apparatus to determine Flakiness Index of aggregates.
6. Complete apparatus for the test of air content of concrete by pressure method as per IS:1199.

7. Density bottle to determine sand bulkage
8. Hydro meter for testing pH value of water .
9. Thermometer for checking temperature
10. Apparatus for measuring proctor density, water content of compacted soil, determining CBR values.
11. All apparatus for determining dry density and water content of compacted soil determining CBR values.
12. Any other equipment felt appropriate by the Owner for measurement of thickness testing of structural members, welding etc. The moulds for cubes shall be checked frequently and made to conform to specifications contained in IS:516.

1.16.70 Staff Welfare Facilities

a. Contractor shall provide adequate facility for it's staff inside the boundary such as Toilets for both gents and ladies, Canteens, drinking water facility, rest places, creches etc.
b. Adequate number of mobile toilets shall be provided at various work Sites inside the boundary.
c. Necessary approach roads to the construction facility complex and internal roads within the complex as well as proper drainage of the area shall be the Contractor's responsibility.
d. Contractor shall also provide for proper disposal of sewage and other wastewater to meet with the requirement of Pollution Board.
e. Contractor shall identify sufficient area outside the boundary to locate it's staff and labour colony. Construction and maintenance of the staff and labour colony to satisfy all statutory requirement is the sole responsibility of Contractor.

**Surface Drainage**

1.16.71 BESS shall have internal storm water network and the same shall be discharging into their respective rainwater harvesting ponds.

1.16.72 The drainage scheme shall be designed considering the Plant plot area and the catchment area contributing to the Plant area drainage. The storm water drainage system shall be a network of open surface drains (with rectangular or trapezoidal cross section) and shall generally be designed to follow the natural flow of water and ground contours.

1.16.73 The drain network shall be connected to the rainwater harvesting ponds to be constructed in low lying areas. It shall be ensured that the drainage water shall not encroach / flood in the adjacent property / plot. The proposed drainage scheme shall be submitted to the Owner for review/ approval before start of construction.

1.16.74 The drainage system shall be designed for rainfall intensity of 100mm per hour/ as per recommendation provided in the "Hydrological report.

1.16.75 Run off coefficients for paved areas and unpaved areas for design of storm water drainage system shall be 0.9 and 0.6 respectively / as per recommendation provided in the "Hydrological report.

**Security Cabin**

1.16.76 The Plant shall be provided with prefabricated security cabins and shall be located at main entrance of the Plant area. The security cabins shall be provided with lights, fans and minimum two persons seating arrangements including toilet area facility. Contractor shall be considered minimum 8.5 sqm area for prefabricated security room.

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, metal sheeting, metal gutter, rainwater down comers (PVC pipe), sunshades, openings, etc., along with associated structural steel, wall and roofing work insulation. Each item of PEB like masonry work, plastering, flooring, foundation, fittings etc. shall be suitable for complete life of Plant.

**Parking shed near Control room**

1.16.77 The parking shed will be constructed with galvanized steel and have a metal sheet roof with anti-rust coating. The walls can be precast concrete, brick, or steel sheets. The floor will be concrete or asphalt. The shed will comply with local building codes and have a roof slope of 10 degrees for drainage. The dimension of the parking area should be sufficient enough to park 5 cars and 10 motor bikes. LED lights, natural ventilation and security cameras will be included.

1.16.78 One store shed shall be constructed near control Building for storage of Mandatory Spares.

**Fire Protection**

1.16.79 Fire protection systems shall include Portable Fire extinguishers and Wheel / Trolley mounted fire Extinguishers. Adequate number of portable fire extinguishers of Dry Chemical Powder and Carbon Dioxide type shall be provided at suitable locations in buildings. Wheel / Trolley mounted Mechanical Foam type Fire Extinguishers, are proposed to be provided for protection of Inverter Transformers.

# SECTION - 5 INSTRUCTION FOR SUPERVISION, LABOUR & INSTALLATION METHODOLOGY

# 1. General Instruction for Supervision and Labour

1.1.1 Benchmark: The Bidder shall be responsible for the true and proper setting-out of the facilities

1.1.2 Bidder's Supervision: The Bidder shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full-time superintendence of the installation. The Bidder shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

1.1.3 Labour

a. The Bidder shall provide and employ on the Site in the installation of the facilities such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Contract. The Bidder is encouraged to use local labour that has the necessary skills

b. The Bidder shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

c. The Bidder shall be responsible for obtaining all necessary permit(s) and/or visa(s) from the appropriate authorities for the entry of all labour and personnel to be employed on the Site into the country where the Site is located.

d. The Bidder shall at its own expense provide the means of repatriation to all of its and its sub vendor's personnel employed on the contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Bidder defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the expense of doing so from the Bidder.

e. The Bidder shall at all times during the progress of the Contract use its best endeavours to prevent any unlawful, riotous or disorderly conduct or behaviour by or amongst its employees and the labour of its sub-Bidders.

f. The Bidder shall, in all dealings with its labour and the labour of its sub vendors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labour.

1.1.4 Plant Equipment

a. All Plant Equipment brought by the Bidder for the project shall be deemed to be intended to be used for the execution of the Contract. The Bidder shall not remove the same from the Site

without the Owner's consent which shall not be unreasonably withheld, that such Plant Equipment is no longer required for the execution of the Contract.

b. Unless otherwise specified in the Contract, upon completion of the Facilities, the Bidder shall remove from the Site all Equipment brought by the Bidder onto the Site and any surplus materials remaining thereon.

1.1.5 Site Regulation and Safety

a. The Owner and the Bidder shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Bidder shall prepare and submit to the Owner, with a copy to the Engineer In-Charge, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld. Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care and fire prevention.

1.1.6 Emergency Work

a. If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Bidder shall immediately carry out such work.

1.1.7 Site Clearance

a. Site Clearance in Course of Performance: In the course of carrying out the Contract, the Bidder shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Bidder's Equipment no longer required for execution of the Contract.

b. Clearance of Site after Completion: After Completion of all parts of the Facilities, the Bidder shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

1.1.8 Watching and Lighting

a. The Bidder shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection of the Facilities, or for the safety of the Owners and occupiers of adjacent property and for the safety of the public.

1.1.9 Work at Night and Holidays

a. Unless otherwise provided in the Contract, no work shall be carried out during the night and on public holidays of the country where the Site is located without prior written consent of the Owner, except where work is necessary or required to ensure safety of the Facilities or for the protection of life, or to prevent loss or damage to property, when the Bidder shall immediately advise the Owner, provided that provisions of this Sub-Clause shall not apply to any work which is customarily carried out by rotary or double shifts.

b. Notwithstanding, if and when the Bidder considers it necessary to carry out work at night or on public holidays so as to meet the Time for Completion and requests the Owner's consent thereto, the Owner shall not unreasonably withhold such consent

# 2. General Installation Guidelines

## 2.1 Introduction

2.1.1 The scope of this specification is to cover the minimum installation guidelines including handling, Unloading, Storage, loading and erection, testing and commissioning of each equipment for Plant Construction.

2.1.2 Bidder shall follow the equipment manufacturer procedures with best engineering practices for installation of every equipment.

## 2.2 Tools & Tackles and Machineries Required

a. Measuring Tape
b. Incline meter
c. Torque wrench
d. Spanners
e. Cotton waste
f. Drilling machine
g. Suitable ladder for climbing
h. Bending arrangements for Earth flat
i. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
j. First Aid Equipment and High Visibility Vests or Clothing with reflective strips

## 2.3 List of Records

a. BESS Installation checklist
b. BESS test reports

## 2.4 Installation Works for BESS

2.4.1 When the battery modules are transported in the project Site, the transportation route shall be selected on a smooth road to avoid damage or crack of the battery modules caused by turbulence, collision, extrusion, tilt, and other factors.

2.4.2 The forklift arms need to be protected to avoid the scrapes the bottom of the cabinet.

2.4.3 Before the forklift fork arm reaches into the bottom of the cabinet, make sure the height of the fork arm is lower than the bottom of the cabinet to avoid collision with the cabinet.

2.4.4 When using a forklift to move the packing boxes to the operation area, the forklift shall be slowly and steadily lifted and put down gently during loading and unloading, and the battery modules shall avoid turbulence and violent vibration during transportation.

2.4.5 In the battery rack, the management system and a variety of sensing devices are installed. The whole battery system must be installed firmly and reliably without any loosening or shacking.

2.4.6 According to the Site conditions and mechanical equipment, the selection of good performance of lifting equipment, rigging, shackle calculation selection; Ensure that the crane and rope meet the load bearing requirements.

2.4.7 All kind of sling, shackle, etc. should be checked in good condition before entering the Site; before formal lifting, it should be reconfirmed that the specifications and quality meet the requirements of this lifting.

2.4.8 The installation position of the node cannot be in a low-lying area, and the Site level is higher than the highest historical water level in the area.

2.4.9 No bad geological conditions such as rubber soil and soft soil layer are allowed. The ground that is easy to accumulate water and sink should be avoided.

2.4.10 Keep away from places that produce dust, fume, harmful gases, and produce or store corrosive, flammable, and explosive materials.

2.4.11 An anti-collision device with sufficient strength must be installed on the periphery of the installation space of battery system to ensure that no safety accident will be caused by general collision which will not directly harm the battery systems and batteries.

2.4.12 The battery modules should be placed in the operation area neatly with a required quantity each row wise.

2.4.13 Proper wear protective gloves during unpacking and handling to avoid scratching hands on the product.

## 2.5 BESS Cable Connection Methodology

2.5.1 Identify the proposed cable route plan as per the approved drawing received at Site. Refer the drawing and calculate the approximate quantity of cable expected to be consumed at Site on actual basis. Record for any deviation if found.

2.5.2 Once the quantity calculation is verified with respect to drawings, refer to the factory test report for the cables.

2.5.3 Use compatible lugs of same conducting material of the cable for the connection /crimping of the cables (Use proper crimping tool).

2.5.4 Do the connections of Male/Female contacts with Connectors at respective ends and provide the ferrule if required.

2.5.5 Ensure that the connectors (+ve & -ve) are tightened, fixed, and locked as per the instruction manual from the OEM.

2.5.6 Ensure the dressing of cables shall be proper with the help of cable ties.

2.5.7 Strictly prevent any form of short circuit during the cable connection process.

2.5.8 All connections must be made under explicit guidance, and any form of guessing and vague trial operation methods are strictly prohibited.

2.5.9 The key points of the connections are, ensure the connection is correct, reliable (will not be loosened), good contact, no short circuit.

2.5.10 After the connection is completed, it must be measured and confirmed point by point.

2.5.11 Check whether the positive and negative poles of the output power cable in the battery rack are connected properly.

2.5.12 Inspect whether the polarity of DC cables is correct, nuts and bolts are installed properly, and cable signs are correct.

2.5.13 Check whether all the communication cables and sub connections at the connection end are tight and reliable.

2.5.14 Before power on, check the connection cable of the whole system, and make sure that the cable connection is reliable without aging fracture and insulation damage.

## 2.6 Preparation Works for PCS

2.6.1 Received Inverter number, technical specification and dimensions shall be confirmed as per design requirements.

2.6.2 Review the factory test report and routine test report submitted by manufacturer. Also refer to the material inspection report during material intake for any physical damage.

2.6.3 After the shuttering of Inverter wooden package visual inspection shall be done to ensure any physical damage during transportation.

2.6.4 Inverter foundation/ platform shall be ensured, and civil department clearance shall be checked.

2.6.5 The installation of the inverter inside the inverter room to be ensured as per dimensions. (Dimensions may vary from manufacturer to manufacturer).

2.6.6 Sufficient capacity of lifting machine shall be ensured and lifting methodology has been confirmed as per manufacture catalogue.

2.6.7 Proper tools and tackles have been arranged for Inverter installation/erection.

## 2.7 PCS Erection / Installation

2.7.1 Inverter unpacking shall be done carefully without any physical damage.

2.7.2 Proper lifting tools like steel rope, recycling hooks and hydraulic jacks were used for Inverter installation.

2.7.3 Manufacture installation methodology shall be followed during installation.

2.7.4 The transportation of the inverter is to be carried out using a forklift / pallet truck as shown.

2.7.5 Inverter placement shall be done as appropriate area which is shown as per approved drawing.

2.7.6 Minimum acceptable clearance for the inverter shall be maintained as per design requirement. Ensure that the distances are maintained within the inverter room premises. Dimensions may vary depending on different manufacture.

2.7.7 In case of outdoor cooling systems, foundation for outdoor unit shall be checked as per approved drawing.

2.7.8 Once the inverter is installed properly on the base or cable trench, check for DC and AC Cabinet for inspection of different parameters and record the same in the record register.

**2.8 Inverter Cable Terminations**

2.8.1 Verify the type of the bolt and fasteners required for crimping the DC main feeder. Usually manufacturer provides / supplies the required fastener excluding lugs. Check for the lugs compatibility and material used for crimping of the lugs.

2.8.2 Refer the installation manual from the inverter manufacturer. Mechanical assembly of lugs should follow all the instructions provided in the installation manual. Only flat washer is to be used with lug surface followed by fender washers on both the sides of the terminal. Ensure that the assembly should be installed in such a way so as to avoid any direct contact of two metals and head of the bolts should always face plastic cover.

2.8.3 Mechanical assembly for the lugs and crimping are as shown below. Flat washer should be with the lugs surface on both sides followed by fender washer.

2.8.4 An auxiliary cable connection is to be carried out on the respective compartment / ports provided. Refer the installation manual for the inverter from manufacturer.

2.8.5 Tightening of the DC lugs and bolts with proper torque wrench (wrench with extension) are to be carried out with specified torque limit value.

2.8.6 Polarity checks for the DC Feeders are to be ensured before tightening it on the respective terminal. Instrument used for measurement is to be calibrated first or calibration reports to be referred before using the instruments.

2.8.7 Check for fuse continuity and ratings for different DC Feeders terminals.

2.8.8 Check and duly verify all the DC Compartment connections and electrical network diagrams.

2.8.9 Record all the technical parameters of installation in checklist after duly verifying all the connections.

**2.9 Preparation for Earthing**

2.9.1 Inspect all the earthing materials like GI flats, Copper flats, earth rod/pipe dimensions and thickness shall be as per approved drawing and design specification.

2.9.2 All Earthing material factory test certificate shall be verified.

2.9.3 GI coated material thickness shall be verified using Elcometer.

2.9.4 Ensure that depth, width, and routing of earthing trench excavation shall be done as per approved drawing. Earth flat shall be laid minimum of 600mm depth / as per approved drawing.

2.9.5 GI/CU flat shall be straightened and properly stored near the work location.

2.9.6 Required material shall be issued from store in charge as per BOQ.

2.9.7 Welding transformers shall be capable of generating minimum 200A current during welding.

2.9.8 Welding shall be done as per standard procedure and two welding strips should be hold with the help of C clamp during welding to avoid air gap between two strips.

2.9.9 Over lapping shall be maintained minimum 100 mm as per Indian Standard 3043.

2.9.10 For underground earthing joints, black bitumen paint should be applied over the welding point and above ground joints Cold galvanized zinc rich paint should be applied to avoid rusting on welding joints.

2.9.11 Bolting system shall be preferred for copper flat joints and screw joints should be done as mentioned below.

2.9.12 Double bolt shall be used for straight joints and single bold for T joints.

2.9.13 For nut-bolt type holes shall be done with the help of drilling machine and proper plain and spring washer should be used.

2.9.14 Earth strip installation on wall shall be clamped with insulated epoxy clamp at regular intervals.

**2.10 Earth Pit Installation (Pipe Earthing)**

2.10.1 Drilling depth shall be done as per approved drawing with the help of auger machine.

2.10.2 Earth electrode size and dimension shall be verified with drawing/design specification.

2.10.3 Excavated areas should be barricaded temporarily for safety measures.

2.10.4 Place electrode in the drilled area and fill the charcoal and salt in alternate layer as per standard practice.

2.10.5 Finally pour some quantity of water to make the component homogeneous with earth.

2.10.6 In case of chemical treated earth pit, installation shall be done as per manufacture instruction.

2.10.7 Disconnecting clamp shall be used to connect the electrode and earth flats with proper nut and bolt system.

2.10.8 Precast/constructed type chamber shall be provided for individual maintenance earth pits and identification board should be kept with details of earth pit number/identity, individual pit resistance value and grid resistance value.

2.10.9 Individual Earth pit resistance and grid resistance tests should be conducted with the help of earth resistance tester and maintains the records.

## 2.11 Points to be Earthed

2.11.1 Double side body earthing shall be done for all HT and LT panels with appropriate earth flat sizing as per approved drawing.

2.11.2 Transformer neutral earthing shall be solidly earthed by copper flats or as per design specification or approved drawing with individual earth pit.

2.11.3 Lightning arrester should be individually earthed with separate earth pit.

2.11.4 Inverter earthing shall be done as per manufacture requirement or approved drawing.

2.11.5 Cable tray shall be earthed at minimum two places by GS flat.

2.11.6 The metallic frames of wiring, heavy power equipment such as Electric Motors, Iron clad, Main Switches, Distribution board, Transformers and Structural Steel work of substations etc., should be earthed by two independent earth conductor and electrodes.

2.11.7 Fabricated steel transmission lines towers, Rail or Tubular posts which carry over head conductors. The individual posts may be earthed by connecting them suitably to overhead earth wires. In addition, independent earth should be provided at least 3 per km for the structure and at every 8th post of service mains and the steel structure of the earth wire connected to it solidly. This will ensure that the overall earth resistance is low since several earths will be in parallel.

2.11.8 Stay wires provided for overhead lines should be earthed.

2.11.9 The metal casing of portable apparatus should be earthed.

2.11.10 The metal body of Iron clad switch, G.I. pipe or conduit pipes encasing the cables, the Iron clad fuse boards, the down rod of ceiling fans and metallic reflectors of fittings.

2.11.11 Earth pin of three pin plug and socket or four pin power plug sockets.

2.11.12 Railway to run an overhead Earth conductor and earth all the metal parts of the supporting structures. All guarding is to be effectively earthed at intervals of not more than five spans.

## 2.12 Inspection of Earthing Arrangements

2.12.1 Earth resistance should be within the prescribed limits. If not, immediate remedial measures should be taken.

2.12.2 Earth conductor should have its cross-sectional area as large as possible. (Not less than minimum limit specified)

2.12.3 The earth wire and earth electrode will be of same material.

## 2.13 Methods of Reducing Earth Resistance

2.13.1 The earth resistance can be considerably reduced by digging around the earth electrode to a depth of 1.5 or 1 meter, cleaning the surface of the earth plate or pipe of rust, filling with charcoal soaked in salt solution.

2.13.2 Further reducing the earth resistance of the system are increasing plate areas, increasing pit depth, and increasing of number of electrodes in parallel.

2.13.3 However, the above said methods have limitation for reducing earth resistance.

2.13.4 Factors influencing earth resistance:

a. Conduction of soil.
b. Temperature of soil.
c. Moisture content of soil
d. Size and spacing of earth electrodes.
e. Depth at which the electrode is embedded.
f. Material of conductor.
g. Quality of coal, dust, charcoal, and salt in the earth electrode pit.
h. No. of electrodes connected in parallel.

## 2.14 Testing of Earthing

2.14.1 Testing shall be done as per the earth resistance measurement procedure.

2.14.2 Test Precautions:

a. The electrode under test should be disconnected from the system installation while measuring the resistance.
b. The resistance areas of the electrodes should not overlap.

2.14.3 Dos & Don'ts

a. Do ensure that the electrode shall, as far as practicable, be embedded below permanent moisture level.
b. Do inspect earth electrode regularly.
c. Do ensure that every earth wire shall be of copper, galvanized iron, or steel.
d. Do ensure good and reliable electrical connection between earthing leads and earth electrodes.
e. Do ensure that path of earth wire should as far as possible, be out of reach of any person.
f. Do consider all parameters while designing earth system.
g. Do ensure the size of earthing wire are proper and according to IS 3043 (Code of practice for earthing and IE rules)
h. Do ensure that all materials, fittings etc. used in earthing system shall confirm to IS specification wherever they exist.
i. Do ensure safety earthing while working on electrical installations.
j. Do ensure that as far as possible all earth terminals should be visible.

k. Don't connect single pole switch or fuse in a neutral circuit. Always connect it in the live or phase wire circuit.

l. Don't renew a blown fuse until you are satisfied as to the cause of its blowing and also as to the removal of the cause.

m. Don't use copper or aluminium wire as substitute for fuse wire.

n. Don't touch or tamper with any electrical gear or conductor unless you have made sure that it is dead and earthed. High Voltage apparatus may give shock or flashover without touching.

o. Don't disconnect earthing connections or render ineffective the safety gadgets installed on mains and apparatus till you are at work.

p. Don't expose your eyes to an electric arc. Painful injury may result even with short exposure.

q. Don't take unnecessary risks with electricity. Low voltage under certain circumstances can be dangerous.

r. Don't use paint, enamel, and grease on the electrodes.

s. Don't use neutral conductor as earth wire.

t. Don't use water pipelines for earthing.

### 2.15 Preliminary Checks

2.15.1 Visual inspection to be carried out for damages.

2.15.2 Dead condition of the Equipment shall be ensured before start of works if applicable.

2.15.3 Check tightness of accessible bolted joints.

2.15.4 Megger value to be checked as per manufacturer guidelines, if applicable.

2.15.5 Check the dimension of the Equipment's and ensure that it can be transported from its storage location to its permanent location.

2.15.6 Check the name plate details and rating etc.

### 2.16 General Recommendations

2.16.1 The suitability of environmental condition can be checked to start the works.

2.16.2 All the tools and the tackles shall be kept ready prior to receipt of panels at workplace.

2.16.3 Orientation of the truck/trailer shall be studied to facilitate the unloading process (It should be nearer to the workplace).

### 2.17 Installation Procedures

2.17.1 Visual inspection to be carried out for dimensions and damage.

2.17.2 Lift the lightning arrester with the help of lifting holes provided on its base plate.

2.17.3 The direction of the equipment shall ensure to string the conductor and make the connector arrangements.

2.17.4 Ensure that the pulse counter installation and proper connection with the lightning arrester.

2.17.5 The levelling to be checked with a spirit level and shims to be provided for adjustment on need basis.

2.17.6 Check the tightness and torque all bolted joints.

2.17.7 The Structure & Equipment shall be cleaned from dirt, oil, and lubricating grease as applicable.

2.17.8 Damaged surfaces of supports shall be applied with touch up paint as applicable.

2.17.9 Connect all the earthing connections and check the tightness of all Earthing joints.

2.17.10 Check the tightness of all bolted joints.

2.17.11 Fire extinguisher and firefighting equipment should be installed as recommended in the drawing/specification.

2.17.12 Layer of high resistivity material, such as gravel, are spread on the earth's surface above the ground grid (0.08 - .15m) to increase the contact resistance between the soil and the feet of persons in the substation.

**2.18 AC system installation**

2.18.1 Scope

a. The intent of this specification is to cover the AC components installation procedures including handling, Unloading, Storage, loading and erection, testing and commissioning of each equipment for BESS Power Plant Construction.

2.18.2 BESS Transformer Installation Tools & Tackles Required

a. Mobile Crane/ Tower Crane (sufficient capacity to lift Transformer)
b. Comprising slings/lifting slings/ D- shackles
c. Spanners set/ Hand tools.
d. Hydraulic jacks
e. Torque wrench
f. Measuring Tape
g. Level indicator
h. Screwdriver set.
i. Hammers
j. Cotton waste
k. Plumb Bob/Crowbar
l. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
m. First Aid Equipment and High Visibility Vests or Clothing with reflective strips
n. Preparation for Transformer Installation

1. Received Transformer Serial number, technical specification and dimensions shall be confirmed as per design requirements.

2. Review the factory test report and routine test report submitted by manufacturer. Also refer to the material inspection report during material intake for any physical damage.
3. Incoming inspection shall be ensured to confirm transformer fitting accessories were received as per BOQ.
4. Transformer foundation/ platform shall be ensured, and civil department clearance shall be checked.
5. Transformer if not placed immediately on plinth, care shall take so that transformer shall be kept on wooden sleepers slightly raised from the ground to avoid damage.
6. For transporting transformer from storage place to work Site, transformer shall be taken on a suitable capacity truck/trailer, properly tied with steel ropes and with stopper to avoid damage due to sliding or tilting due to vibration or jerks.

2.18.3 Transformer Unloading/Installation/Erection

(Considerations before unloading)

a. Availability of access road between unloading point and plinth.
b. Ensure overhead crane capacity for weight of main unit.
c. Keep under base of main unit at least 300 – 400 mm above ground level by providing wooden slippers to facilitate jacking.
d. Remove lashing before unloading.
e. The transformer should be unloaded by means of a crane or suitable lifting device of sufficient capacity (For weight details, please refer the Rating & Diagram Plate). Always use lifting mechanisms, cranes, chain pulleys, etc. of adequate capacity. Use of any under capacity lifting mechanism or accessories could result in severe damage to the transformer, lifting equipment and possibly personnel involved in handling the transformer.
f. For lifting, suitable lugs are provided on the cover & on sides of tank. Lifting lugs on the sides of tank are for lifting the complete unit, whereas the lugs provided on the tank cover must only be used for lifting the cover.
g. Jacking pads are provided to lift the transformer with jacks. Jacks should never be placed under any valves or radiators. Do not use low-capacity lifting jacks.
h. Skid type under base channels is provided on the bottom of the transformer, having towing holes for pulling & mounting holes for foundation of transformer. For heavy transformers, the under base is equipped with rollers allowing the unit to be manoeuvred into final position and then anchored.
i. The following should be avoided during the unloading process.
    1. The transformer imbalance (Maximum 10 degree)
    2. Abrupt movements

3. Impact against the ground
4. Side Impact

j. After checking the exact position of transformer, the following sequence should be followed.

1. Install all wheels to transformer using hydraulic jacks sized for at least 50% of the unit's weight.
2. Before resting the wheels into groove, make sure all of them are properly adjusted.
3. Lower the transformer with the help of the hydraulic jacks until it remains resting on the bottom of the groove. Never allow the transformer to remain inclined.

2.18.4 Transformer Accessories Erection and Storage

a. Accessories / Fittings dispatched separately from main consignment are usually packed in case/crate, although certain items like conservator are sometimes dispatched loose without packing. All items as received should be stored in a dry and covered place provided there are no signs of damage or rough handling.

b. If oil received in drums is not to be used immediately, the drums should be stored in a covered space where the temperature variation is minimum. If it is necessary to store the oil outside, adequate protection must be provided at all times. Drums should not stand on end but should be placed on their sides in semi horizontal (lying) position with the bottom tilting at 45° downwards.

c. After arrival at Site, it is desirable to erect and commission the transformer with minimum delay. In case this is not possible, the transformer should be fitted with conservator, dehydrating breather, etc. and filled with oil. The condition of desiccant (environ-gel) must be checked periodically, particularly during warm and wet periods.

d. Indoor type transformer must be protected from the weather. Outdoor units may be stored outside, in a warm area, if possible, protected from the prevailing weather.

e. Whenever possible, it is recommended that the transformer is energized even at a low voltage so that the oil temperature is about 10° to 15°C higher than the surrounding ambient temperature.

f. Heaters for marshalling boxes, cable boxes, etc., should preferably be kept energized to avoid possible internal condensation / deterioration of the internal components.

g. Major Transformer accessories are listed below,

1. Radiators
2. Conservator
3. Buchholz Relay
4. Pressure release valve (PRV)
5. Breather

6. Radiator fan
7. Oil Surge Relay (OSR)
8. Temperature Sensors
9. Temperature Indicators
10. Marshalling box for all wiring
11. Wheel/Roller

2.18.5 Gasket and Joints

a. To make a gasket joint, first clean all metal surfaces ensuring freedom from oil, rust, scale, etc.
b. Insert and evenly tighten each bolt so that uniform pressure is exerted on the gasket until the gasket is compressed to approx. 2/3 of its original thickness.
c. Gaskets are best stored in hermetically sealed containers in a cool place. They must be protected from damp, oil, and grease.

2.18.6 Terminals / Bushings

a. Bushing should be assembled with their adapters.
b. When clamping the bushings to the tank, care should be taken to ensure that an even pressure is obtained on the flange of the porcelain and its gasket by tightening the diagonally oppoSite nuts alternatively.
c. The external line termination / connection to all types of bushings should be flexible to ensure that there is no strain exerted on the bushings because of line movement such as swing, expansion, contraction etc.
d. Arcing horns are fitted; the gap shall be checked as per the drawing.

2.18.7 Conservator

a. While assembling the conservator, ensure that internal surface, all openings, pipe works, valves, etc., are clean & free from moisture and all gasket joints are oil tight.

2.18.8 Explosion Vent / Pressure Relief Device

a. The explosion vent pipe fitted with suitable diaphragm and airtight gasket joints.
b. The space above the oil in the explosion vent is usually connected by a pipe to the top of the conservator to equalize the pressure & vent it to the atmosphere through a breathing device.

2.18.9 Buchholz Relay

a. The Buchholz (gas / liquid operated) relay is connected in the pipe work between transformer tank and conservator.
b. The pipe work on either side of the relay and the relay itself, are all set at the same angle. A machined surface is provided on the housing of the relay to check the level. And the arrow shown on the relay should point towards the conservator.

2.18.10 Radiator

a. All the radiators, pipework and headers should be cleaned and flushed with clean dry oil before fitting.

b. During assembly care must be taken that all the gasket joints between radiator and the transformer tank are air-tight and the flanges are evenly fitted.

c. After assembly of radiators, the shut off valves provided at top & bottom should be opened.

d. Air should be released from top of the header of each radiator.

2.18.11 Current Transformers

a. Secondary circuit of any CT fitted MUST always be short-circuited or connected with the load circuit.

2.18.12 Earthing Connection

a. The tank should be permanently and effectively connected to earth by means of flat / flexible conductor of suitable size & materials (galvanised steel / copper equivalent) terminated on earthing terminals / pads provided at the bottom of the tank, cable box, marshalling box, switch gear box, etc.

2.18.13 Other Installation Works

a. Any work such as secondary wiring from various Phase CT's / Neutral CT, wiring of various alarm trip contacts from various accessories of the transformer to Marshalling Box, Control Gear Box, if/as required shall be completed at Site.

b. All the scheme wiring, relay settings, functional checks, etc., should be completed before the transformer is released for commissioning into service.

2.18.14 Auxiliary Transformer Installation

a. Tools & Tackles Required

1. Mobile Crane/ Tower Crane (sufficient capacity to lift Transformer)
2. Comprising slings/lifting slings/ D- shackles
3. Spanners set/ Hand tools.
4. Hydraulic jacks
5. Torque wrench
6. Measuring Tape
7. Level indicator
8. Screwdriver set.
9. Hammers
10. Cotton waste
11. Plumb Bob/Crowbar
12. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
13. First Aid Equipment and High Visibility Vests or Clothing with reflective strips

b. Auxiliary Transformer Installation

1. Accessories / Fittings dispatched separately from main consignment are usually packed in case/crate, although certain items like conservator are sometimes dispatched loose without packing. All items as received should be stored in a dry and covered place provided there are no signs of damage or rough handling.
2. If oil received in drums is not to be used immediately, the drums should be stored in a covered space where the temperature variation is minimum. If it is necessary to store the oil outside, adequate protection must be provided at all times. Drums should not stand on end but should be placed on their sides in semi horizontal (lying) position with the bottom tilting at 45° downwards.
3. After arrival at Site, it is desirable to erect and commission the transformer with minimum delay. In case this is not possible, the transformer should be fitted with conservator, dehydrating breather, etc. and filled with oil. The condition of desiccant (environ-gel) must be checked periodically, particularly during warm and wet periods.
4. Indoor type transformer must be protected from the weather. Outdoor units may be stored outside, in a warm area, if possible, protected from the prevailing weather.
5. Whenever possible, it is recommended that the transformer is energized even at a low voltage so that the oil temperature is about 10° to 15°C higher than the surrounding ambient temperature.
6. Heaters for marshalling boxes, cable boxes, etc., should preferably be kept energized to avoid possible internal condensation / deterioration of the internal components.

c. Gasket and Joints

1. To make a gasket joint, first clean all metal surfaces ensuring freedom from oil, rust, scale, etc.
2. Insert and evenly tighten each bolt so that uniform pressure is exerted on the gasket until the gasket is compressed to approx. 2/3 of its original thickness.
3. Gaskets are best stored in hermetically sealed containers in a cool place. They must be protected from damp, oil, and grease.

d. Terminals / Bushings

1. Bushing should be assembled with their adapters.
2. When clamping the bushings to the tank, care should be taken to ensure that an even pressure is obtained on the flange of the porcelain and its gasket by tightening the diagonally opposite nuts alternatively.

3. The external line termination / connection to all types of bushings should be flexible to ensure that there is no strain exerted on the bushings because of line movement such as swing, expansion, contraction etc.
4. Arcing horns are fitted; the gap shall be checked as per the drawing.

e. Conservator

1. While assembling the conservator, ensure that internal surface, all openings, pipe works, valves, etc., are clean & free from moisture and all gasket joints are oil tight.

f. Explosion Vent / Pressure Relief Device

1. The explosion vent pipe fitted with suitable diaphragm and airtight gasket joints.
2. The space above the oil in the explosion vent is usually connected by a pipe to the top of the conservator to equalize the pressure & vent it to the atmosphere through a breathing device.

g. Buchholz Relay

1. The Buchholz (gas / liquid operated) relay is connected in the pipe work between transformer tank and conservator.
2. The pipe work on either side of the relay and the relay itself, are all set at the same angle. A machined surface is provided on the housing of the relay to check the level. And the arrow shown on the relay should point towards the conservator.

h. Radiator

1. All the radiators, pipe work and headers should be cleaned and flushed with clean dry oil before fitting.
2. During assembly care must be taken that all the gasket joints between radiator and the transformer tank are air-tight and the flanges are evenly fitted.
3. After assembly of radiators, the shut off valves provided at top & bottom should be opened.
4. Air should be released from top of the header of each radiator.

i. Earthing Connection

1. The tank should be permanently and effectively connected to earth by means of flat / flexible conductor of suitable size & materials (galvanised steel / copper equivalent) terminated on earthing terminals / pads provided at the bottom of the tank, cable box, marshalling box, switch gear box, etc.

j. Other Installation Works

1. Any work such as secondary wiring from various Phase CT's / Neutral CT, wiring of various alarm trip contacts from various accessories of the transformer to Marshalling Box, Control Gear Box, if/as required shall be completed at Site.
2. All the scheme wiring, relay settings, functional checks, etc., should be completed before the transformer is released for commissioning into service.

2.18.15 ICOG / LT Panel

a. Tools & Tackles Required for LT Panel Installation

1. Multi-meter
2. DC Tester Clamp meter
3. Hand Tools
4. Ladder of Appropriate length
5. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
6. First Aid Equipment and High Visibility Vests or Clothing with reflective strips

b. ICOG / LT Panel Installation

1. Identify the LT PANEL installation location as per drawing.
2. Take LT PANEL dimensions and cross-check at installation location and make sure there is adequate space around as per drawing.
3. Please ensure the availability of OEM manufacturer drawings and manual for installation of LT PANEL.
4. Prepare and assemble these LT PANEL stand at installation location for LT PANEL mounting and make sure there is adequate space for working once mounting is done.
5. Once LT PANEL stand assembly and installation is completed, cast PCC blocks around both the support legs for better stability and load sharing or Grout both legs to the ground using grouting chemical and anchoring bolts.
6. As per holes given on LT PANEL backside, take dimensions and drill same holes at same distance at height on support structure for mounting the LT PANEL.
7. Once LT PANEL support structure is ready and properly grouted, gently pick up the LT PANEL and match holes given on LT PANEL back with ones on support structure. Once aligned use appropriate nuts and bolts to mount the LT PANEL.

c. Testing

1. Open LT panel and check cable terminations and earthing i.e., phase sequence, torque marking, heat sleeves/Insulation tapes should all be proper and as per equipment installation drawing.
2. Verify all three-phase Indicator is 'ON' and working.
3. At inverter cable terminations side check current and voltage phase-phase-neutral voltage and current.
4. At outgoing side check current and voltage across phase-phase-neutral terminations using clamp on multi-meter.

2.18.16 Power Cable Installation

a. Tools & Tackles Required

1. Crane (mobile/tower type)
2. Cable lifting jack & Cable rollers
3. Nylon Ropes
4. Measuring Tape
5. HT Termination Kits
6. Screwdriver set.
7. Hand Tools
8. Cable cutting and Stripping Tool
9. Cable Crimping and assembling Tool.
10. Torque Wrench
11. Insulation Resistance tester
12. Cotton waste
13. Heat blower/Gas heater
14. Ladder of appropriate length
15. Multimeter / Continuity tester
16. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
17. First Aid Equipment and High Visibility Vests or Clothing with reflective strips.
18. MC4 assembling Spanner.
19. Cable Reel (Small/Large as per requirements)

b. Storage and Handling of Power Cables

1. The cable drums shall be stored on a well-drained, hard surface, so that the drums do not sink in the ground causing rot and damage to the cable drums. Paved surface is preferred, particularly for long term storage.
2. The drums shall always be stored on their flanges, and not on their flat sides.
3. Both ends of the cables should be properly sealed to prevent ingress/ absorption of moisture by the insulation during storage.
4. Protection from rain and sun is preferable for long term storage for all types of cables. There should also be ventilation between cable drums.
5. During storage, periodical rolling of drums once in, say, 3 months through 80 degrees shall be done, in the case of paper insulated cables. Rolling shall be done in the direction of the arrow marked on the drum.
6. Damaged battens of drums etc. should be replaced as may be necessary.
7. When the cable drums have to be moved over short distances, they should be rolled in the direction of the arrow marked on the drum.

8. For manual transportation over long distances, the drum should be mounted on cable drum wheels, strong enough to carry the weight of the drum and pulled by means of ropes. Alternatively, they may be mounted on a trailer or on a suitable mechanical transport.
9. For loading into and unloading from vehicles, a crane or a suitable lifting tackle should be used. Small sized cable drums can also be rolled down carefully on a suitable ramp or rails, for unloading, provided no damage is likely to be caused to the cable or to the drum.

c. Procedure for Cable Laying

1. Cables with kinks, straightened kinks or any other apparent defects like defective armouring etc. shall not be installed.
2. Entire Tray work shall be completed like joining and tightening of trays with coupling plates and corner bends throughout the cable route wherever tray work is applicable.
3. In case of underground cable trenches, width, depth and routing of the excavation have to be ensured as per approved drawing.
4. Sand cushion of required thickness shall be ensured as per the approved drawing.
5. Ensure the specification (Voltage level, cable make, size and insulation grade) of the supplied cables and factory test certificate has to be verified.
6. Physical inspection should be done to ensure the damage of cable drum may occur during transportation.
7. Availability of Required tools like Cable drum lifting jocks, rolling shafts and rollers for cable pulling.
8. Before the cable laying work is undertaken, the route of the cable shall be decided by the Engineer-in-Charge considering the following.
9. While the shortest practicable route should be preferred, the cable route shall generally follow fixed developments such as roads, foot paths etc. with proper offsets so that future maintenance, identification etc. are rendered easy. Cross country run merely to shorten the route length shall not be adopted.
10. Cable route shall be planned away from drains and near the property, especially in the case of LV/MV cables, subject to any special local requirements that may have to be necessarily complied with.
11. As far as possible, the alignment of the cable route shall be decided after taking into consideration the present and likely future requirements of other services including cables enroute, possibility of widening of roads/lanes etc.
12. Corrosive soil, ground surrounding sewage effluent etc. shall be avoided for the routes.

d. Route for Cables of Different Voltages

1. Whenever cables are laid along well demarcated or established roads, the LV/MV cables shall be laid farther from the kerb line than HV cables.
2. Cables of different voltages, power and control cables shall be kept in different trenches with adequate separation. Where available space is restricted such that this requirement cannot be met, LV/MV cables shall be laid above HV cables.
3. Where cables cross one another, the cable of higher voltage shall be laid at a lower level than the cable of lower voltage.
4. Power and communication cables shall as far as possible cross each other at right angles. The horizontal and vertical clearances between them shall not be less than 60cm.
5. Cables under railway tracks shall be laid in spun reinforced concrete or cast iron or steel pipes at such depths as may be specified by the railway authorities, but not less than 1m, measured from the bottom of the sleepers to the top of the pipe. Inside railway station limits, pipes shall be laid up to the point of the railway station limits, pipes shall be laid up to a minimum distance of 3m from the centre of the nearest track on either side.
6. Way leaves for the cable route shall be obtained as necessary from the appropriate authorities, such as Municipal authorities, Department of telecommunication, Gas Works, Railways, Civil Aviation authorities, Owners of properties etc.

e. Methods of Laying

1. The cables shall be laid directly in ground, pipe, closed or open ducts, cable trays or on surface of wall etc. The method(s) of laying required shall be specified in the approved drawings or schedule of work.

f. Laying Directly in Ground

1. This method shall be adopted where the cable route is through open ground, along roads/lanes, etc. and where no frequent excavations are likely to be encountered and where re-excavation is easily possible without affecting other services.

g. Trenching

1. Width of trench shall be determined on the following basis:
    - The minimum width of the trench for laying a single cable shall be 35cm Where more than one cable is to be laid in the same trench in horizontal formation, the width of the trench shall be increased such that the inter-axial spacing between the cables, except where otherwise specified, shall be at least 20cm.
    - There shall be a clearance of at least 15cm between axis of the end cables and the sides of the trench.
    - Depth of trench shall be determined on the following basis:

- Where the cables are laid in a single tier formation, the total depth of trench shall not be less than 75cm for cables up to 1.1KV and 1.2m for cables above 1.1KV.
- When more than one tier of cables is unavoidable and vertical formation of laying is adopted, the depth of the trench shall be increased by 30cm for each additional tier to be formed.
- Where there is no sand cushioning and protective covering are provided for the cables, the trench shall be increased by 25 cm.

h. Excavation of Trenches

1. The trenches shall be excavated in reasonably straight lines. Wherever there is a change in the direction, a suitable curvature shall be adopted complying with approved drawings where gradients and changes in depth are unavoidable.
2. The bottom of the trench shall be level and free from stones, brick bats etc.
3. The excavation should be done by suitably, means-manual or mechanical and that the excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench.
4. Adequate precautions should be taken not to damage any existing cable(s), pipes or any other such installations in the route during excavation. Wherever tiles or protective covers or bare cables are encountered, further excavation shall not be carried out without the approval of the Engineer-in-Charge.
5. Excavation through lawns shall be done in consultation with the Department concerned.

i. Cable Laying

1. Cable drums of required length and size according to cable schedule shall be shifted to the location with the help of suitable vehicle.
2. Cable drum shall be lifted to the required height to get clearance from the ground level while rolling with the help of jacks. Heavy drums shall be jacked using hydraulic jacks.
3. Packing of drum shall be removed and care shall be taken to avoid the cable damage.
4. Cable Insulation Resistance test with respect to system voltage and continuity shall be checked before cable laying and record in the checklist.
5. Drum shall be rolled in the direction which is mentioned as per manufacturer.
6. The cable shall always be pulled from the top of the cable drum and drum stopper shall be used while laying the cables from the drum, in order to avoid further rolling of cable drums.
7. During cutting of the length required (with reference to cable schedule) extra length/loop shall be kept for future use. At the time of original installation, approximately 3m of surplus cable shall be left on each terminal end of the cable and on each side of the underground

joints. The surplus cable shall be left in the form of a loop. Where there are long runs of cables such loose cables may be left at suitable intervals as specified by the Engineer-in-Charge.

8. The minimum safe bending radius for PVC/XLPE (MV) cables shall be 12 times the overall diameter of the cable.
9. At joints and terminations, the bending radius of individual cores of a multi core cable of any type shall not be less than 15 times its overall diameter.
10. Bending radius for LT cables (Multi core) shall be 12 times the diameter of the cable while that of HT cables (Multi core) shall be 15 times the diameter of the cable or shall be as per the Indian Standard below.
11. During cable laying, overlapping cables should be avoided.
12. For cable laying in tray, tray shall be curved enough angle to allow the cable with correct bending radius.
13. Sufficient Power and control cable clearance shall be maintained as per approved drawing.
14. After completion of the laying and cutting, Cable identification tags (defines voltage range/ Size/ from-to details) shall be provided at both the ends and regular intervals as per drawing/specification.
15. Clamping at required intervals shall be provided for vertical cable tray.
16. For single core three phase cables, trefoil arrangement shall be formed and clamped at regular intervals.
17. Dressing of cable shall be done. After laying the cable, insulation resistance and continuity of the cable shall be measured/checked and recorded in the check list.
18. After IR testing, both ends of the cable should be sealed properly to avoid moisture.

j. Completion of Cable Laying

1. Cable trenches shall be closed with sand cushion followed by mechanical protection as per drawing and removed soil without any boulders.
2. In case of RCC Cable trenches precast slabs shall be used and aluminium sheet cover shall be used for tray mounted.
3. Danger/caution tape shall be provided at required depth.
4. Cable trench route markers shall be provided along the route at regular intervals.
5. Laying of single core cables, three single core cables forming one three phase circuit shall normally be laid in close trefoil formation and shall be bound together at intervals of approximately 1m. The relative position of the three cables shall be changed at each joint at the time of original installation, complete transposition being affected in every three consecutive cable lengths.

6. Backfilling of trenches shall be done with excavated earth, free from stones or other sharply ended debris and shall be rammed and watered, if necessary, in successive layers not exceeding 30cm depth.
7. Route markers shall be provided along the runs of cables at locations approved by the Engineer-in-Charge and generally at intervals not exceeding 30m. Markers shall also be provided to identity change in the direction of the cable route and at locations of underground joints.

## 2.19 SCADA Installation Tools & Tackles for SCADA

2.19.1 SCADA Installation and Mounting

a. Preliminary Checks:

1. Visual inspection to be carried out for damages.
2. Check the dimension of the SCADA panels and ensure that it can be transported from its storage location to its installation location.
3. Check the name plate details, mounting arrangement and rating etc.

b. General Recommendations:

1. The suitability of environmental condition can be checked to start the works.
2. Before shifting the panels to the permanent location clearance to be obtained to start installation.
3. The floor level, cut-outs and clearance from the wall should be checked.
4. The handling of the Panels shall be strictly in accordance with safety procedure and manufacturer instructions.
5. All the tools and tackles shall be kept ready prior to receipt of panels at workplace.
6. Orientation of the transportation vehicle shall be studied to facilitate the unloading process.
7. Installation Procedure:
8. Lift the SCADA RTU Panel with the help of forklift/crane/manual support.
9. Shift the SCADA RTU Panel from store yard to installation location.
10. Gradually lower the panel to installation location.
11. The packing woods need to be removed and keep the area neat and clean.
12. Place the SCADA RTU Panel to its location by referring the orientation by using proper tools and equipment.
13. When SCADA RTU panel is to be erected, the alignment of the fronts has to be checked.
14. Tight the cubicles with bolts in the fitting holes close to the front and rear sides.

c. Finishing Works:

1. The SCADA RTU panel to be cleaned from dirt using cotton cloth.

2. Damaged surfaces shall be applied with touch up paint.
3. Earthing can be made as per drawing and all used holes to be sealed.
4. Verify name plate details against data sheet.
5. Check equipment fixings and mountings are secure.
6. Check doors can be opened and are not obstructed.
7. Check and ensure that all devices in the panels are correctly labelled in accordance with drawings.
8. Water level checking of the Earthing Pits.
9. Clearance/location dimension from wall/column etc.
10. Alignment & levelling of panel on Eps as per the GA drawing.
11. Welding of base frame to EP is as per drawing, approved welding procedure.
12. Painting of Eps and base frame as per painting procedure and the finish coat of paint is black enamel.

2.19.2 SCADA Communication Cable Laying

a. Optical fibre cable to be laid from control room to transformer yard.
b. Ethernet cable to be laid between the accessories of SCADA system.
c. RS485 cable to be laid from PLC to HT panel & LT panel.
d. Earthing Connection should be carried out in accordance with manufacturer manual & provide grounding drawing.
e. Ensure that the cables are not installed in front of the air ventilation grids as it leads to improper ventilation, overheating of the equipment, and dust accumulation.
f. Avoid placing multiple cable bundles over each other, or over bundling the cables, as it leads to performance degradation of the cables below.
g. Ensure that the cables twisted together for cancelling out Electromagnetic Interference (EMI) from the external sources are not exposed even partially, as it results in EMI issues.
h. Separate the copper and fibre cables in the runs because the weight of the copper cables can crush the fibre cables that are placed below it.
i. Use cables that are resistive to bend loss if excessive bending of cables cannot be prevented due to installation constraints.
j. Avoid mounting the cabling components in places that block accessibility to other equipment in and out of the racks.
k. Maintain extra cables for contingency needs as spares for the backbone and horizontal runs.
l. Avoid the following actions that can stress the cable:
    1. Applying extra twists.
    2. Pulling or stretching beyond the specified pulling load rate.

3. Bending it beyond the specified bend radius, and not beyond 80 degrees.
4. Creating tension int eh suspension runs.
5. Stapling or applying pressure with the cable runs.

m. Maintain extra cables for contingency needs as spares for the backbone and horizontal runs.

n. Test should be done for each cable during installation and termination. If a problem occurs, tag the malfunctioning cables, and separate them out.

o. If applicable, locate the main cabling distribution area close to the central region of the installation Site to minimize the cable distances.

p. Preserve the same density of twists in the cable pairs till its termination for horizontal and neckbone twisted-pair cabling as applicable.

q. Dedicate outlets for terminating horizontal cables, that is, assign a port in the patch panel for each horizontal run.

r. Include sufficient vertical and horizontal runs when designing the cables. Otherwise, even a slight change, such as removal of a cable can cause downtime.

s. Use angled patch panels in high-density areas, such as the cable distribution area. Use the straight patch panels in the distribution racks.

t. Avoid exposing cables to areas of condensation and direct sunlight.

u. Remove the abandoned cables, as they restrict the airflow, and contribute to the possible increase in the operational temperature, which can affect the durability of the system.

v. Avoid routing the cables over equipment and other patch panel ports. Instead, route the cables below or above, and into the horizontal cable manager.

w. All cabling between component unit of RTU, RTU to interface cabinet, RTU to MFTs and to the Owner control and relay panels shall be laid as per drawings.

x. Plug-type connectors with captive fasteners or compression type connectors shall be for all internal interconnections. The connectors shall be polarized to prevent improper assembly.

y. Each end of interconnection cables shall be identified by a marker which includes the cable number and the identifying number and location of each of the cable terminations.

z. Adequate space and hardware shall be provided for routing of the field wiring within the enclosures.

aa. Wiring within enclosures shall be neatly arranged and shall not be directly fastened to the enclosure frame.

bb. All internal interconnection wiring, and cables shall be routed separately from field wiring to the RTU terminals & power wiring.

cc. Metal clamps must have insulating inserts between the clamps and the wiring.

dd. Wiring between stationary and movable components, such as wiring across door hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wiring.

2.19.3 Pre-Commissioning Testing

a. Check for specific product to be mentioned in BOQ, Technical details, Construction & witing as per SCADA system drawings.
b. Check for PLC database & configuration settings.
c. Check the operation for all analogue inputs, status input & control output points of SCADA panel.
d. Check operation of all communication ports of SCADA panel.
e. Check for communication between master PLC and Slave PLC.
f. Test for PLC time synchronization from master.
g. Test power supply voltage Margin, Ripple levels and short circuit protection.
h. Test for PLC operation with DC power supply voltage.
i. Check for auto restoration of PLC on DC power recovery after its failure.
j. Test for PLC diagnostic feature.
k. Test for PLC SOE feature.
l. Test for control Security and safety for control outputs.
m. Other functional tests as per commissioning checklist SCADA supplier.
n. End to end test for all I/O points.

2.19.4 Cable Dressing and Finishing

a. Install higher cable configurations to meet the application requirements that may arise in the future.
b. Use thin and high-density cables as necessary to enable more cable runs in tight spaces.
c. Use modular cabling systems to map the ports from equipment with high density port counts.
d. Avoid leaving loose cables on the floor, as this could constitute as a major safety hazard. Instead, use the vertical horizontal, or overhead cable managers.
e. Store a few spare patch cables. The type and quantity of the patch cables cam be determined from the installation and projected growth. Ensure to store all the unused cables in a bagged and capped condition when not in use.
f. Use the patch cable of exact length and leave some slack at each end for end device movements.
g. Use vertical and horizontal cable guides for routing cables within and between the racks.
h. Use cable spool devices in the cable managers to prevent kinks and sharp bends in the cable.
i. Bundle the related cables together in groups, as this eases management and troubleshooting.

j. Use the Velcro-based ties every 1 to 2 meters for bundling or security the cables and avoid using the zip ties as they apply pressure on the cables.

k. Regularly maintain the cabling documentation, labelling and physical or logical cabling diagrams. Also, Document and regularly update all the cabling components and their mapping.

l. Cable guides are particularly useful because excessive bending of the interface cables damages them. Example of an efficient way of cabling using the cable guides. The minimum long-term, low-stress bend radius of the fibre optic cable should be less than 15 times the cable diameter. A smaller bend radius can change the characteristics of fibre cable, which could cause signal errors.

## 2.20 Lightning Arrestor Installation Tools & Tackles Required

a. Crane & Hydra (mobile/tower type)

b. Comprising slings/lifting slings, Nylon Rope

c. Measuring Tape

d. Hand Tools

e. Cotton waste

f. Ladder of Appropriate length

g. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.

h. First Aid Equipment and High Visibility Vests or Clothing with reflective strips

### 2.20.1 Preliminary Checks

a. Visual inspection to be carried out for damages.

b. Dead condition of the Equipment shall be ensured before start of works if applicable.

c. Check tightness of accessible bolted joints.

d. Megger value to be checked as per manufacturer guidelines, if applicable.

e. Check the dimension of the Equipment's and ensure that it can be transported from its storage location to its permanent location.

f. Check the name plate details and rating etc.

### 2.20.2 Installation Procedures for Lightning Arrestor

a. Visual inspection to be carried out for dimensions and damage.

b. Lift the lightning arrester with the help of lifting holes provided on its base plate.

c. The direction of the equipment shall ensure to string the conductor and make the connector arrangements.

d. Ensure that the pulse counter installation and proper connection with the lightning arrester.

e. The levelling to be checked with a spirit level and shims to be provided for adjustment on need basis.
f. Check the tightness and torque all bolted joints.
g. The Structure & Equipment shall be cleaned from dirt, oil, and lubricating grease as applicable.
h. Damaged surfaces of supports shall be applied with touch up paint as applicable.
i. Connect all the earthing connections and check the tightness of all Earthing joints.
j. Check the tightness of all bolted joints.
k. Fire extinguisher and firefighting equipment should be installed as recommended in the drawing/specification.
l. Layer of high resistivity material, such as gravel, are spread on the earth's surface above the ground grid (0.08 - 0.15m) to increase the contact resistance between the soil and the feet of persons in the substation.

## 2.21 Earthing Installation Tools & Tackles and Machineries Required

a. Measuring Tape
b. Cutting machine
c. Welding machine
d. Spanners
e. Bituminous paint
f. Petroleum jelly
g. Welding electrodes
h. 3-Phase Power supply
i. Cotton waste
j. Drilling machine
k. Bending arrangements for Earth flat
l. Earth tester
m. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
n. First Aid Equipment and High Visibility Vests or Clothing with reflective strips

2.21.1 Method of Earthing

a. Strip or Wire Earthing
b. Rod Earthing
c. Pipe Earthing
d. Plate Earthing

2.21.2 Preparation for Earthing

a. Inspect all the earthing materials like GI flats, Copper flats, earth rod/pipe dimensions and thickness shall be as per approved drawing and design specification.
b. All Earthing material factory test certificate shall be verified.
c. GI coated material thickness shall be verified using Elcometer.
d. Ensure that depth, width, and routing of earthing trench excavation shall be done as per approved drawing. Earth flat shall be laid minimum of 600mm depth / as per approved drawing.
e. GI/CU flat shall be straightened and properly stored near the work location.
f. Required material shall be issued from store in charge as per BOQ.
g. Welding transformers shall be capable of generating minimum 200A current during welding.
h. Welding shall be done as per standard procedure and two welding strip should be hold with the help of C clamp during welding to avoid air gap between two strips.
i. Over lapping shall be maintained minimum 100 mm as per Indian Standard 3043.
j. For underground earthing joints, black bitumen paint should be applied over the welding point and above ground joints Cold galvanized zinc rich paint should be applied to avoid rusting on welding joints.
k. Bolting system shall be preferred for copper flat joints and screw joints should be done as mentioned below.
l. Double bolt shall be used for straight joints and single bold for T joints.
m. For nut-bolt type holes shall be done with the help of drilling machine and proper plain and spring washer should be used.
n. Earth strip installation on wall shall be clamped with insulated epoxy clamp at regular intervals.

2.21.3 Earth Pit Installation (Pipe Earthing)

a. Chemical earthing with Cu plated rod
b. Drilling depth shall be done as per approved drawing with the help of auger machine.
c. Earth electrode size and dimension shall be verified with drawing/design specification.
d. Excavated areas should be barricaded temporarily for safety measures.
e. Place electrode in the drilled area and fill the charcoal and salt in alternate layer as per standard practice.
f. Finally pour some quantity of water to make the component homogeneous with earth.
g. In case of chemical treated earth pit, installation shall be done as per manufacture instruction.
h. Disconnecting clamp shall be used to connect the electrode and earth flats with proper nut and bolt system.

i. Precast/constructed type chamber shall be provided for individual maintenance earth pits and identification board should be kept with details of earth pit number/identity, individual pit resistance value and grid resistance value.

j. Individual Earth pit resistance and grid resistance tests should be conducted with the help of earth resistance tester and maintains the records.

2.21.4 Points to be Earthed.

a. Double side body earthing shall be done for all HT and LT panels with appropriate earth flat sizing as per approved drawing.

b. Transformer neutral earthing shall be solidly earthed by copper flats or as per design specification or approved drawing with individual earth pit.

c. Lightning arrester should be individually earthed with separate earth pit.

d. Inverter earthing shall be done as per manufacture requirement or approved drawing.

e. Cable tray shall be earthed at minimum two places by GS flat.

f. The metallic frames of wiring, heavy power equipment such as Electric Motors, Iron clad, Main Switches, Distribution board, Transformers and Structural Steel work of substations etc., should be earthed by two independent earth conductor and electrodes.

g. Stay wires provided for overhead lines should be earthed.

h. The metal casing of portable apparatus should be earthed.

i. The metal body of Iron clad switch, G.I. pipe or conduit pipes encasing the cables, the Iron clad fuse boards, the down rod of ceiling fans and metallic reflectors of fittings.

j. Earth pin of three pin plug and socket or four pin power plug sockets.

k. Railway to run an overhead Earth conductor and earth all the metal parts of the supporting structures. All guarding is to be effectively earthed at intervals of not more than five spans.

2.21.5 Inspection of Earthing Arrangements

a. Earth resistance should be within the prescribed limits. If not, immediate remedial measures should be taken.

b. Earth conductor should have its cross-sectional area as large as possible. (Not less than minimum limit specified)

c. The earth wire and earth electrode will be of same material.

2.21.6 Methods of Reducing Earth Resistance

a. The earth resistance can be considerably reduced by digging around the earth electrode to a depth of 1.5 or 1 meter, cleaning the surface of the earth plate or pipe of rust, filling with charcoal soaked in salt solution.

b. Further reducing the earth resistance of the system are increasing plate areas, increasing pit depth, and increasing of number of electrodes in parallel.

c. However, the above said methods have limitation for reducing earth resistance.

d. Factors influencing earth resistance.

1. Conduction of soil.
2. Temperature of soil.
3. Moisture content of soil
4. Size and spacing of earth electrodes.
5. Depth at which the electrode is embedded.
6. Material of conductor.
7. Quality of coal, dust, charcoal, and salt in the earth electrode pit.
8. No. of electrodes connected in parallel.

2.21.7 Testing of Earthing

a. Testing shall be done as per the earth resistance measurement procedure.

b. Test Precautions

1. The electrode under test should be disconnected from the system installation while measuring the resistance.
2. The resistance areas of the electrodes should not overlap.

c. Dos & Don'ts

1. Do ensure that the electrode shall, as far as practicable, be embedded below permanent moisture level.
2. Do inspect earth electrode regularly.
3. Do ensure that every earth wire shall be of copper, galvanized iron, or steel.
4. Do ensure good and reliable electrical connection between earthing leads and earth electrodes.
5. Do ensure that path of earth wire should as far as possible, be out of reach of any person.
6. Do consider all parameters while designing earth system.
7. Do ensure the size of earthing wire are proper and according to IS 3043 (Code of practice for earthing and IE rules)
8. Do ensure that all materials, fittings etc. used in earthing system shall confirm to IS specification wherever they exist.
9. Do ensure safety earthing while working on electrical installations.
10. Do ensure that as far as possible all earth terminals should be visible.
11. Don't connect single pole switch or fuse in a neutral circuit. Always connect it in the live or phase wire circuit.
12. Don't renew a blown fuse until you are satisfied as to the cause of its blowing and also as to the removal of the cause.

13. Don't use copper or aluminium wire as substitute for fuse wire.
14. Don't touch or tamper with any electrical gear or conductor unless you have made sure that it is dead and earthed. High Voltage apparatus may give shock or flashover without touching.
15. Don't disconnect earthing connections or render ineffective the safety gadgets installed on mains and apparatus till you are at work.
16. Don't expose your eyes to an electric arc. Painful injury may result even with short exposure.
17. Don't take unnecessary risks with electricity. Low voltage under certain circumstances can be dangerous.
18. Don't use paint, enamel, and grease on the electrodes.
19. Don't use neutral conductor as earth wire.
20. Don't use water pipelines for earthing.

## 2.22 LT Panel Installation and Mounting

2.22.1 Tools & Tackles and Machineries Required

a. Multimeter
b. DC Tester Clamp meter
c. Hand Tools
d. Ladder of Appropriate length
e. Safety PPEs viz., full body harness, Safety Shoe, helmet, Goggles.
f. First Aid Equipment and High Visibility Vests or Clothing with reflective strips

2.22.2 Installation and Mounting

a. Identify the ACCB installation location as per drawing.
b. Take ACCB dimensions and cross-check at installation location and make sure there is adequate space around as per drawing.
c. Please ensure the availability of OEM manufacturer drawings and manual for installation of ACCB.
d. Prepare and assemble the ACCB stand at installation location for ACCB mounting and make sure there is adequate space for working once mounting is done.
e. Once ACCB stand assembly and installation is completed, cast PCC blocks around both the support legs for better stability and load sharing or Grout both legs to the ground using grouting chemical and anchoring bolts.
f. As per holes given on ACCB backside, take dimensions and drill same holes at same distance at height on support structure for mounting the ACCB.

g. Once ACCB support structure is ready and properly grouted, gently pick up the ACCB and match holes given on ACCB back with ones on support structure. Once aligned use appropriate nuts and bolts to mount the ACCB.

h. Testing

i. Open ACCB panel and check cable terminations and earthing i.e., phase sequence, torque marking, heat sleeves/Insulation tapes should all be proper and as per equipment installation drawing.

j. Verify all three-phase Indicator is 'ON' and working.

k. At inverter cable terminations side check current and voltage phase-phase-neutral voltage and current.

l. At outgoing side check current and voltage across phase-phase-neutral terminations using clamp on multi-meter.

2.22.3 Outdoor HT Panel Installation

a. ICOG Outdoor and RMU are installed on Civil platform, Channels supported from canopy structures.

b. It is necessary to read and follow the instructions of respective equipment manufacturer's attachment "INSTALLATION PROCEDURE / MANUAL" which will speak about safety measures, Unpacking, Storage condition, Climate conditions, Electrical wiring.

c. The attachment might be as single or multiple documents.

d. Bidder shall be responsible for equipment once delivered.

e. Bidder to consider the availability of roads between unloading point and plinth/foundation.

f. Ensure the overhead crane capacity / Forklift / Truck is available for weight of main unit (without accessories) Equipment installed on channels/angles shall be suitably fastened with bolts/nuts/clamps. The alignment, ground clearance are maintained as per approved drawings with different equipment, termination requirement also differs.

g. Termination shall be properly done by termination kits, auxiliary power cables shall be terminated by suitable glands. It is necessary to identify the requirement of cable and suitably plan for the availability of respective equipment / cables / accessories / sufficient tools and tackles While assembling the accessories or installing equipment inside the panels, ensure the internal surface, all openings to be sealed are clean and free from moisture and to avoid any damage from external rodents.

# 3. Cable Installation Methodology

## 3.1 Introduction

3.1.1 The intent of this specification is to describe the Cable Installation Methodologies by listing the required Codes and Standards, specifying Design & Constructional Features and Installation processes.

## 3.2 Codes and standards

3.2.1 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.

| Standard | Description |
|---|---|
| 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 33kV rating |
| IS:1367 | Part-13 Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners). |
| IS:2147 | Degree of protection provided by enclosures for low voltage switchgear and control gear |
| IS:2309 | Code of Practice for the protection of building and allied structures against lightning. |
| IS:2629 | Recommended practice for hot dip galvanising of iron & steel |
| IS:2633 | Method for testing uniformity of coating on zinc coated articles. |
| IS:3043 | Code of practice for Earthing |
| IS:3063 | Fasteners single coil rectangular section spring washers. |
| IS:6745 | Methods for determination of mass of zinc coating on zinc coated iron & steel articles. |
| IS:8308 | Compression type tubular in- line connectors for aluminium conductors of insulated cables |
| IS:8309 | Compression type tubular terminal ends for aluminium conductors of |

| Standard | Description |
|---|---|
| | 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. | |

3.2.2 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.

### 3.3 Design Requirement

3.3.1 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.

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

3.3.3 General: The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling. Sizing criteria, derating factors for the cables shall be met as per respective chapters. However, for the power cables, the minimum conductor size shall be 6 sq.mm. for

aluminium conductor and 2.5 sq.mm. for copper conductor cable. Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:

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

### 3.4 Special Requirements

**Cable trays, Fittings & Accessories**

3.4.1 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.

3.4.2 Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables. 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.

3.4.3 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.

3.4.4 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.

**Support System for Cable Trays**

3.4.5 Cable tray support system shall be prefabricated.

3.4.6 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:

3.4.7 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.

3.4.8 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.

3.4.9 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

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

3.4.11 Support system shall be able to withstand

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

**Pipes, Fittings & Accessories**

3.4.12 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 based on maximum 40% fill criteria

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

3.4.14 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.

3.4.15 Hume pipes shall be NP3 type as per IS 458.

**Junction Boxes**

3.4.16 Junction Boxes with IP55 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.

3.4.17 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.

**Terminations & Straight through Joints**

3.4.18 Termination and jointing kits for all voltage grades of 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. Joints and terminations of all voltage grades shall be type tested as per IS:13573/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.

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

3.4.20 1.1 KV grade Straight through Joint shall be of proven design.

**Cable glands**

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

**Cable lugs/ferrules**

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

**Trefoil clamps**

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

**Cable Clamps & Straps**

3.4.24 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, deinterlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment.

**Receptacles**

3.4.25 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.

3.4.26 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.

3.4.27 The ONOFF 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.

3.4.28 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.

3.4.29 The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polyamide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

**Galvanizing**

3.4.30 Galvanizing of steel components and accessories shall conform to IS: 2629, IS4759 & IS: 2633. Additionally galvanizing shall be uniform, clean smooth, continuous and free from acid spots. The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS: 1367. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified.

**Welding**

3.4.31 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.

## 3.5 Installation

**Cable tray and Support System Installation**

3.5.1 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.

3.5.2 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. Bidder shall design the support system along with tray, spacing etc. in line with relevant standard.

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

3.5.4 The Bidder 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.

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

3.5.6 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.

**Conduits/Pipes/Ducts Installation**

3.5.7 The Bidder shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/ roof/ wall/ cable tunnel/ cable trenches made for conduit installation shall be sealed and made waterproof by the Bidder 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.

3.5.8 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.

3.5.9 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.

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

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

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

**Junction Boxes Installation**

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

**Cable Installation**

3.5.13 Cable installation shall be carried out as per IS:1255 and other applicable standards.

3.5.14 For Cable unloading, pulling etc. following guidelines shall be followed in general: Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal.

3.5.15 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.

3.5.16 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.

3.5.17 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.

3.5.18 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.

3.5.19 Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer.

3.5.20 Selection of cable drums for each run shall be so planned to avoid using straight through joints. Care should be taken while laying the cables to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.

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

3.5.22 Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings.

3.5.23 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.

3.5.24 Power and control cables shall be secured fixed to trays/support with self-locking type nylon cable straps with deinterlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five-meter interval.

3.5.25 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.

3.5.26 Bending radii for cables shall be as per manufacturer's recommendations and IS: 1255.

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

3.5.28 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. Bidder shall identify and accordingly procure the cable drum length.

3.5.29 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.

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

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

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

3.5.33 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. Bidder shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time.

**Separation**

3.5.34 At least 300mm clearance shall be provided between:

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

3.5.35 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 |

**Directly Buried Cables**

3.5.36 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.

3.5.37 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.

3.5.38 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 aluminium with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Bidder may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags.

3.5.39 While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

**Cable Terminations & Connections**

3.5.40 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. Bidder shall furnish for review documentary evidence/experience reports of the jointers to be deployed at Site.

3.5.41 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.

3.5.42 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Bidder 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.

3.5.43 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.

3.5.44 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.

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

# SECTION - 6 TENDER DRAWINGS

# 1. Tender Drawings

1.1.1 The following Site related technical and geo-technical details and other information/technical reports and assessment are preliminary details and other information/ technical reports related to project Site may be downloaded from the drive link created by Owner provided as below:

| SL. NO. | DRAWING NO. | TITLE | REVISION |
|---|---|---|---|
| 1) | FCE-20524144-RE-DWG-SLD-9600-001 (Sheet 03 OF 03) | 132kV BAY EXTENSION - TENTATIVE SINGLE LINE DIAGRAM (GRID SUBSTATION: SINGLE LINE DIAGRAM) | 02 |
| 2) | FCE-20524144-RE-DWG-SLD-9600-001 (Sheet 02 OF 03) | 132kV BAY EXTENSION - TENTATIVE SINGLE LINE DIAGRAM (POOLING SUBSTATION: SINGLE LINE DIAGRAM) | 02 |
| 3) | FCE-20524144-RE-DWG-SLD-9600-001 (Sheet 01 OF 03) | 132kV BAY EXTENSION - TENTATIVE SINGLE LINE DIAGRAM (BESS SYSTEM: SINGLE LINE DIAGRAM) | 02 |
| 4) | FCE-20524144-RE-DWG-LAY-9600-002 (Sheet 01 and Sheet 02) | BESS PLANT - TENTATIVE LAYOUT | 02 |
| 5) | APDCL/KUKURMARA/CONT/01 | TOPOGRAPHICAL SURVEY OF LOCATION FOR 25MW/100MWH BESS AT KUKURMARA (MIRZA) GRID SUB STATION. | R0 |
| 6) | APDCL/AIIB/LIL/GTIR/BONGARA/01 | GEO-TECHNICAL INVESTIGATION FOR 33/11kV; BONGORA S/S (SOIL TESTING REPORT) | - |
| 7) | FCE-20524144-RE-DWG-ARC-9600-001 | SCADA ARCHITECTURE (TENTATIVE) | R0 |
| 8) | FCE-20524144-RE-DWG-LAY-9600-003 | CONTROL BUILDING - TENTATIVE LAYOUT | 00 |
| 9) | Annexure | PERT CHART - BATTERY ENERGY STORAGE SYSTEM - DESIGN, SUPPLY, INSTALLATION & COMMISSIONING | R0 |
| 10) | - | OTHER DOCUMENT RELATED TO COORDINATE (KMZ FILE) | - |

1.1.2 Before submitting the bid, 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 it's offer. No consequent extra claims on any misunderstanding or otherwise shall be allowed by the Owner.

1.1.3 The list of drawings listed in this Technical Specification 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 financial implication to Owner.

# SECTION - 7 TECHNICAL DATA SHEETS & SCHEDULES

# 1. Guaranteed Technical Parameters

1.1.1 The following shall consist of the technical parameters to be guaranteed by the Bidder as applicable.

1.1.2 General design features of BESS Plant.

1.1.3 The Bidder shall be responsible for deployment of 25MW / 100MWh BESS Power Plant at identified location in Assam, India. Following technical parameters, as applicable, shall be guaranteed by the Bidder.

### 1.1 General design features of Plant

| S.no. | Parameter | Unit | Required | Parameter Offered (Bidder) |
|---|---|---|---|---|
| | **PLANT DESIGN DATA** | | | |
| **1** | **BESS Plant rated characteristics** | | | |
| 1.1 | BESS Plant nominal (nameplate) active power at Interconnecting Point (excluding auxiliary consumption) | MW | 25 | |
| 1.2 | BESS Plant rated apparent power at Point of Reference including auxiliary consumption | MW | | |
| 1.3 | Rated Output Power at Point of Reference (including auxiliary consumption) | MVA | | |
| 1.4 | Rated Input Power at Point of Reference (including auxiliary consumption) | MVA | | |
| 1.5 | BESS Plant nominal (nameplate) energy capacity (at Interconnection Point) | MWh | 100 | |
| 1.6 | Constant Power Charging Ratio | % | | |
| 1.7 | Loss of active power in case of largest single equipment failure | MW | | |
| 1.8 | Loss of Energy Capacity in case of largest single equipment failure | MWh | | |
| **2** | **BESS configuration** | | | |
| 2.1 | Number of Containerized Battery Storage System Units in the BESS Plant | Qty. | *DDE | |
| 2.2 | Number of feeders MV switchgears | Qty. | *DDE | |

| S.no. | Parameter | Unit | Required | Parameter Offered (Bidder) |
|---|---|---|---|---|
| 2.3 | Number of main MV/LV transformers | Qty. | *DDE | |
| 2.4 | Number of MV/LV transformers for auxiliary supply | Qty. | *DDE | |
| **3** | **Plant design ambient conditions** | | | |
| 3.1 | Maximum ambient temperature | °C | 50°C | |
| 3.2 | Design wind speed (3s gust) at 10m height | m/s | 50m/s | |
| **4** | **Plant space requirements** | | | |
| 4.1 | Land area required for the Plant | m2 | 6000 | |
| 4.2 | Space for a possible future installation of the BESS Plant | m2 | | |
| **5** | **Other design data** | | | |
| 5.1 | Estimated water requirement during construction phase | m3 | *DDE | |
| 5.2 | Estimated yearly water requirement during Operational phase | m3 | *DDE | |
| 5.3 | Water tank Capacity | m3 | *DDE | |
| **6** | **BESS UNIT CONFIGURATION** | | | |
| 6.1 | Number of Battery per BESS unit | pcs | *DDE | |
| 6.2 | Number of BESS unit per PCS | pcs | *DDE | |
| 6.3 | Number of HVAC units per BESS unit | pcs | *DDE | |
| 6.4 | BESS Unit local controller type | - | | |
| 6.5 | BESS Unit local controller manufacturer | - | | |
| 6.6 | BESS Unit type tested (system integration test / SIT, see Owner's Requirements) | Yes/No | Yes | |
| 6.7 | SIT test report attached | Yes/No | Yes | |

| S.no. | Parameter | Unit | Required | Parameter Offered (Bidder) |
|---|---|---|---|---|
| **7** | **BATTERY SYSTEM TECHNICAL DATA** | | | |
| 7.1 | Cell general information | | | |
| 7.2 | Manufacturer | - | | |
| 7.3 | Manufacturing location | City, Country | | |
| 7.4 | Anode material | | | |
| 7.5 | Cathode material | | | |
| 7.6 | Separator material | | | |
| 7.7 | Compliance with all standards as per Owner's Requirements | Yes/No | Yes | |
| 7.8 | Cell safety tests certified | Yes/No | Yes | |
| 7.9 | Certificates attached | Yes/No | Yes | |
| 7.10 | Independent manufacturing audit carried out and results attached | Yes/No | | |
| 7.11 | Independent test of cell cycle performance under comparable conditions to the Project. | Yes/No | | |
| 7.12 | Cell rated characteristics | | | |
| 7.13 | Nominal voltage | V | *DDE | |
| 7.14 | End of discharge voltage | V | | |
| 7.15 | End of discharge voltage used for this project | V | | |
| 7.16 | End of charge voltage | V | | |
| 7.17 | End of charge voltage used for this project | V | | |
| 7.18 | Nominal (nameplate) current | A | | |
| 7.19 | Rated discharge current | A | | |
| 7.20 | Rated charge current | A | | |
| 7.21 | Rated current used for this project | A | | |
| 7.22 | Nominal capacity | Ah | | |
| 7.23 | Nominal energy capacity | kWh | | |

| S.no. | Parameter | Unit | Required | Parameter Offered (Bidder) |
|---|---|---|---|---|
| 7.24 | Cell rated energy capacity at the power-to-energy ratio used in the project | kWh | | |
| 7.25 | Cell performance characteristics | | | |
| 7.26 | Efficiency at 10% of rated current | % | | |
| 7.27 | Efficiency at 20% of rated current | % | | |
| 7.28 | Efficiency at 30% of rated current | % | | |
| 7.29 | Efficiency at 40% of rated current | % | | |
| 7.30 | Efficiency at 50% of rated current | % | | |
| 7.31 | Efficiency at 60% of rated current | % | | |
| 7.32 | Efficiency at 70% of rated current | % | | |
| 7.33 | Efficiency at 80% of rated current | % | | |
| 7.34 | Efficiency at 90% of rated current | % | | |
| 7.35 | Efficiency at 100% of rated current | % | | |
| 7.36 | Battery system: general | | | |
| 7.37 | Type (unique identifier) | - | | |
| 7.38 | Manufacturer | - | | |
| 7.39 | Manufacturing location | City, Country | | |
| 7.40 | Compliance with all standards as per Owner's Requirements | Yes/No | | |
| 7.41 | Battery system safety tests certified by third party | Yes/No | | |
| 7.42 | Certificates attached | Yes/No | | |
| 7.43 | UL9540A test passed | Cell/Module/Unit/No | | |
| 7.44 | UL 9540A device under test | same type / previous type | | |
| 7.45 | UL 9540A test report attached | Yes/No | | |
| 7.46 | IEC 63056 compliance | No/same type/previous type | | |
| 7.47 | IEC 63056 test report attached | Yes/No | | |
| 7.48 | Battery system: Configuration | | | |

| S.no. | Parameter | Unit | Required | Parameter Offered (Bidder) |
|---|---|---|---|---|
| 7.49 | Number of cells per module | pcs | *DDE | |
| 7.50 | Number of modules per rack | pcs | *DDE | |
| 7.51 | Number of racks per battery system | pcs | *DDE | |
| 7.52 | Battery system: Performance characteristics | | | |
| 7.53 | Auxiliary consumption per battery system at standby | W | | |
| 7.54 | Auxiliary consumption per battery system at idle (contactors closed) | W | | |
| 7.55 | Auxiliary consumption per battery system at full load | W | | |
| 7.56 | Independent manufacturing audit carried out and results attached | Yes/No | | |
| 7.57 | DoD vs Lifecycle graph | | | |

### 1.2 Containerized Battery Storage System (BESS)

1.2.1 The Bidder shall be responsible for deployment of 25MW / 100MWh BESS Power Plant at 400/220/132kV Kukurmara (Mirza) Grid Substation, Sathikarpa, Assam, India. location in India having following design features.

| S.no. | Parameter | Minimum Requirement | Parameters Proposed (Bidder) |
|---|---|---|---|
| 1. | Battery chemistry | Lithium Iron Phosphate - LFP | |
| 2. | Useable Battery Capacity at 25 deg Celsius & Full load | 100MWh at interconnecting point | - |
| 3. | BESS cycle per day | 2 cycles per day | - |
| 4. | C-Rate (Energy/Power) | 0.25C minimum | - |
| 5. | Battery Life and cycle | Minimum 12 Years from Date of Commissioning of Facility | - |
| 6. | Plant Life excluding BESS | 25 Years from Date of Commissioning of Facility | - |

| S.no. | Parameter | Minimum Requirement | Parameters Proposed (Bidder) |
|---|---|---|---|
| 7. | Response Time | 1 Second | - |
| 8. | Power factor at PCC | 0.95 lead or lag in Four Quadrant Operation / CEA requirements | - |
| 9. | Container size | 20 or 40 feet | |
| 10. | Usable DOD (%) | >90% | - |
| 11. | Protection to cutoff the battery (below DOD level) | Available | |
| 12. | Battery cell discharge efficiency | >96% | - |
| 13. | Round trip efficiency with Auxiliary consumption | ≥86% | - |
| 14. | Battery Cooling type | Liquid | - |
| 15. | Protection Class | >IP54 | - |
| 16. | Self-Discharge per month | < 3% | - |
| 17. | Communication interface | CAN, RS485, Ethernet | - |
| 18. | Communication protocol | CAN, Modbus RTU, TCP/IP, IEC61850 | - |
| 19. | Operating ambient temperature (°C) | -30°C ~ 50°C | - |
| 20. | Recommended storage temperature (°C) | -20°C ~ 35°C | Higher storage temperature will lead to higher degradation |

1.2.2 Bidders shall share assumptions considered while calculating the total battery capacity in terms of Battery Module capacity (kWh), No of Modules / Rack, installed capacity/Rack, No of Battery Racks, total Installed capacity (MWh), One-way conversion efficiency considered, Battery Rack operating voltage (Vdc), Auxiliary power.

1.2.3 Bidders shall also share 12-year (wise) Capacity availability calculations considering minimum 90% DoD, Standard Operating Conditions @25°C & Full Load.

1. Year
2. No. of Cycles.
3. Degradation in %
4. SoH

5. Rated / Installed MWh
6. DC Usable MWh
7. Available Capacity (MWh) at POC including Aux consumption.
8. Available Capacity (MWh) at POC excluding Aux consumption.

1.2.4 Bidders shall also share equipment wise (PCS, Battery (BMS), EMS @Vdc, HVAC, FSS, Lighting and accessories etc.) Auxiliary power consumption in terms of Power loss (kW), Operating Time, Net Consumption (kWh) during Charging, discharging and standby time.

1.2.5 Cycle - Complete one charge cycle is used when an amount that equals 100% of battery's capacity is discharged — but not necessarily all from one charge. For instance, if 75% of your battery's capacity is used one day, then recharged it fully overnight. If 25% capacity is used the next day, then total discharged 100 % capacity, and the two days will add up to one charge cycle.

### 1.3 Cables

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Applicable Standard | – | |
| 2. | Voltage Grade (UO/U) | kV/kV | |
| 3. | Earthed / unearthed | – | |
| 4. | Conductor | | |
| | Material | – | |
| | Strands | Nos | |
| | Shape | – | |
| | Grade | kV | |
| 5. | Conductor Screen | | |
| 6. | Insulation | | |
| | Material | – | |
| 7. | Insulation Screen | | |
| 8. | Armour | | |
| | Material | – | |
| 9. | Metallic Screen | | |
| | Material | – | |
| 10. | Inner Sheath | | |
| 11. | Filler | | |
| | Material | – | |
| 12. | Outer Sheath | | |
| | Material and Type | – | |
| | Colour | – | |
| 13. | Maximum operating Temperature of Conductor | (°C) | |
| 14. | Maximum temperature of conductor during Short Circuit | (°C) | |

### 1.4 Power Conditioning Unit

| S.no. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | PCS Rating | Bidder to Specify | |
| 2. | Installation type | Indoor/Outdoor | |
| 3. | Maximum Input voltage DC | 1500V (preferred) | |
| 4. | Nominal output voltage frequency | 50Hz | |
| 5. | Continuous operating frequency range | 47.5 Hz to 52 Hz | |
| 6. | AC Voltage Range | ± 10% of rated AC voltage | |
| 7. | Efficiency | Max. Efficiency > 98%, Round Trip > 95% | |
| 8. | Surge Protection Device (SPD) | Type-II DC side<br>Type-II AC side | |
| 9. | Operating power factor range | 0.8 Lead to 0.8 Lag (adjustable) | |
| 10. | SVG | 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 control, reactive power, and<br>Power factor control features. | Required. Possible from EMS. | |

| S.no. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 20. | PCS designed AC fault current level | Maximum short circuit current of LV side of PCS Duty transformer and duration one sec. | |
| 21. | IP Rating | IP66 for Outdoor Application<br>IP20 or Better for Indoor Application | |
| 22. | Protection | Thermal Overload<br>Insulating monitoring ground fault Over Voltage: DC & AC Side Under voltage: DC & AC Side Over Current: DC & AC Side<br>Over and Under Grid Frequency Over Temperature<br>Short Circuit<br>Surge Protection (Power, Control & Signal Cables)<br>Lightening Protection<br>Surge Voltages induced on AC & DC Side due to external source.<br>Islanding & Anti Islanding as per IEC 62116 Internal Fault e.g. Logic failure<br>Neutral point high resister grounding type (DC side) for ground fault alarm shall be provided.<br>EMS requirement as per IEC61000 or equivalent | |

| S.no. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| | | standard<br>Protection against any fault in feeder / load line.<br>Earth leakage faults<br>Synchronization loss protection.<br>LVRT and HVRT protection | |

### 1.5 Inverter Duty Transformer (IDT)

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Transformer Type | _ | |
| 2. | IP class | _ | |
| 3. | Application | _ | |
| 4. | Core | _ | |
| 5. | Rating | kVA | |
| 6. | No. of Phases | _ | |
| 7. | No. of LV Windings | Nos | |
| 8. | Frequency | Hz | |
| 9. | HV winding | kV | |
| 10. | LV winding | | |
| | LV1 winding | kV | |
| | LV2 winding | kV | |
| 11. | Winding material | _ | |
| 12. | Winding insulation | _ | |
| 13. | Neutral on HV side | _ | |
| 14. | Vector Group | _ | |
| 15. | Rated Thermal Short time current withstand time | S | |
| 16. | % Impedance on principal tap, on LV Winding Power base at 75deg C and 50 deg C | % | |
| 17. | Termination HV/LV/Orientation | _ | |
| 18. | Cable entry on HV side | _ | |
| 19. | Tapping on HV winding | _ | |
| 20. | Loading Capability | _ | |
| 21. | Ambient temperature | (°C) | |
| 22. | Temperature rise | % (or) (°C) | |
| 23. | Flux density | T (or) w/$m^2$ | |
| 24. | Air Clearances | | |
| 25. | Core Losses | _ | |
| 26. | Harmonics | % (or) kW | |
| 27. | Noise level | % | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 28. | Highest system voltage | kV | |
| 29. | Insulation Class (Winding and bushing) | | |
| 30. | Insulation level (Impulse withstand voltage / Power Frequency withstand voltage) | | |
| 31. | Painting | _ | |
| 32. | Constructional features | _ | |
| 33. | Fittings and accessories | _ | |
| 34. | Provision of Shielding | _ | |
| 35. | No load current at rated voltage and frequency | A | |
| 36. | Efficiency at 75 Deg. C at UPF | % | |
| 37. | Maximum Efficiency (%) and load at which it occurs (kVA) | % @ kVA | |
| 38. | Overall dimension<br>Length x Breadth x Height | mm*mm*mm | |
| 39. | Oil capacity | L | |
| 40. | Weight of transformer | Kg | |
| 41. | Minimum creepage distance | mm/kV | |
| 42. | HV Side fault level | | |
| 43. | LV side Fault level | | |
| 44. | Short circuit withstand duration | Sec | |
| 45. | Tank type | _ | |

### 1.6 AC Cables

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Applicable Standard | – | |
| 2. | Voltage Grade (UO/U) | kV/kV | |
| 3. | Earthed / unearthed | – | |
| 4. | Conductor | | |
| | Material | – | |
| | Strands | Nos | |
| | Shape | – | |
| | Grade | kV | |
| 5. | Conductor Screen | | |
| 6. | Insulation | | |
| | Material | – | |
| 7. | Insulation Screen | | |
| 8. | Armour | | |
| | Material | – | |
| 9. | Metallic Screen | | |
| | Material | – | |
| 10. | Inner Sheath | | |
| 11. | Filler Material | | |
| 12. | Maximum operating Temperature of Conductor | (°C) | |
| 13. | Maximum temperature of conductor during Short Circuit | (°C) | |
| 14. | Outer Sheath | | |
| | Material and Type | | |
| | Colour | | |

### 1.7 HT panel

| S.no. | Parameter | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| **A. SYSTEM PARAMETERS** | | | |
| 1. | Highest System voltage | - | |
| 2. | Rated Frequency | 50Hz | |
| 3. | Number of phases/ poles | - | |
| 4. | System neutral earthing | Solidly Earthed | |
| 5. | One minute power frequency withstand voltage | | |
| | - for Type tests | 70kV | |
| | - for Routine tests | 70kV | |
| 6. | 1.2/50 microsecond Impulse withstand voltage | 170kV (peak) | |
| 7. | Minimum system fault level | As per System Fault current | |
| 8. | Short time rating for bus bars, circuit breakers, current transformers and switchgear assembly. | | |
| 9. | Dynamic withstand rating | 2.5 times of system fault current | |
| 10. | Space heaters | 240 V AC single phase with neutral solidly earthed | |
| 11. | Maximum ambient air temperature | 50 deg. C | |
| 12. | Internal Arc testing | As per system fault current (for Min 1 sec) | |
| **B. BUSBARS** | | | |
| 1. | Continuous current rating at 50ºC ambient: | As Per Requirement | |

| S.no. | Parameter | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 2. | Temperature Rise allowed above ambient | As per IEC 62271-1, 2017 | |
| **C. SWGR. CUBICLE CONSTRUCTION REQUIREMENTS** | | | |
| 1. | Colour finish | | |
| | a) Exterior | RAL9002 (Main body) RAL 5012 (Extreme end covers) | |
| 2. | Cable entry | | |
| | a) Power Cables | Bottom | |
| | b) Control Cables | Bottom | |
| 3. | Earthing conductor | Galvanized steel strip | |
| 4. | Service Continuity of switchgears (LSC2B-PM) | as per IS/IEC 62271-200 | |
| **D.CIRCUIT BREAKERS** | | | |
| 1. | The circuit breakers current rating shall be selected from the load current at an ambient of 50 deg. C. | | |
| 2. | Short circuit breaker Current | | |
| | a) A.C. component | | |
| | b) D.C. component | As per IS: 13118 or IEC-62271 | |
| 3. | Short Circuit making current | 2.5 times of system fault current (peak) | |
| 4. | Operating Duty | O-3 min-CO-3 min-CO | |
| 5. | Total break time | Not more than 4 cycles | |
| 6. | Total make time | Not more than 5 cycles | |

| S.no. | Parameter | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 7. | Operating Mechanism | Motor wound spring charged stored energy type as per IEC-62271 | |
| **E. CURRENT TRANSFORMERS** | | | |
| 1. | Secondary Current | 1A | |
| 2. | Class of Insulation | Class E or better | |
| 3. | Rated output of each | Adequate for the relays and devices connected, but not less than five (5) VA. | |
| 4. | Accuracy class | | |
| 5. | Protection | 5P20/PS as per requirement | |
| 6. | Measurement | 0.5 class or better as per requirement | |
| 7. | Instrument Security Factor for Measurement CTs | 5 | |
| 8. | CT Ratio | CT ratio shall be finalized during details engineering stage. Minimum CT primary side current shall be 110% of rated current. | |
| **F. VOLTAGE TRANSFORMER** | | | |
| 1. | Rated Voltage Factor | 1.2 continuous for all VTs, and 1.9 for 8 Hours for star connected VTs. | |
| 2. | Class of insulation | Class E or better | |

| S.no. | Parameter | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 3. | Other parameters | 0.5 Class or better as per requirement.<br>VA requirement shall be based on application/ requirement.<br>Additional open delta core with damping resistor shall be provided in all VT's to<br>prevent damage on account of Ferro-Resonance conditions | |
| 4. | 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** | | | |
| 1. | Accuracy Class | 0.5 or better | |
| 2. | Digital MFM shall be provided for VCB panels as per requirement | | |

### 1.8 Auxiliary Transformer - Dry type

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Transformer Type | _ | |
| 2. | IP class | _ | |
| 3. | Application | _ | |
| 4. | Core | _ | |
| 5. | Rating | kVA | |
| 6. | No. of Phases | Nos | |
| 7. | No of LV Windings | Nos | |
| 8. | Frequency | Hz | |
| 9. | HV winding | kV | |
| 10. | LV winding | | |
| | LV1 winding | V | |
| | LV2 winding | V | |
| 11. | Winding material | _ | |
| 12. | Winding insulation | _ | |
| 13. | Neutral on HV side | _ | |
| 14. | Vector Group | _ | |
| 15. | Rated Thermal Short time current withstand time | S | |
| 16. | % Impedance on principal tap, on LV Winding Power base at 75deg C and 50 deg C | % | |
| 17. | Termination HV/LV/Orientation | _ | |
| 18. | Cable entry on HV side | _ | |
| 19. | Tapping on HV winding | _ | |
| 20. | Loading Capability | _ | |
| 21. | Ambient temperature | (°C) | |
| 22. | Temperature rise | % or (°C) | |
| 23. | Flux density | Tesla (or) Weber/$m^2$ | |
| 24. | Air Clearances | | |
| 25. | Core Losses | kW | |

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 26. | Harmonics | % | |
| 27. | Noise level | % | |
| 28. | Highest system voltage | kV | |
| 29. | Insulation Class (Winding and bushing) | | |
| 30. | Insulation level (Impulse withstand voltage / Power Frequency withstand voltage) | | |
| 31. | Painting | | |
| 32. | Constructional features | _ | |
| 33. | Fittings and accessories | _ | |
| 34. | Provision of Shielding | _ | |
| 35. | No load current at rated voltage and frequency | A | |
| 36. | Efficiency at 75 Deg. C at UPF | % | |
| 37. | Maximum Efficiency (%) and load at which it occurs (kVA) | % @kVA | |
| 38. | Overall dimension in mm<br>Length x Breadth x Height | mm*mm*mm | |
| 39. | Oil capacity | L | |
| 40. | Weight of transformer | Kg | |
| 41. | Minimum creepage distance | mm/kV | |
| 42. | HV Side fault level | | |
| 43. | LV side Fault level | | |
| 44. | Short circuit withstand duration | s | |
| 45. | Tank type | _ | |

### 1.9 Auxiliary Transformer - Oil Immersed

| S.no. | Description | Unit | Parameter Proposed (Bidder) |
|---|---|---|---|
| 1. | Service | | |
| 2. | Type | | |
| 3. | No. of Phase | | |
| 4. | Rating | kVA | |
| 5. | No. of windings | | |
| 6. | Nominal system voltage (HV / LV) | kV | |
| 7. | Vector group | | |
| 8. | Type of cooling | | |
| 9. | Impulse withstand level | | |
| a) | HV side | kV | |
| 10. | One minute Power frequency withstand voltage | | |
| 11. | HV side | kV | |
| 12. | LV side | kV | |
| 13. | Connections | | |
| 14. | HV side | | |
| 15. | LV side | | |
| 16. | Neutral Earthing | | |
| 17. | HV side | | |
| 18. | LV side | | |
| 19. | Terminal arrangement | | |
| 20. | HV side | | |
| 21. | LV side | | |
| 22. | LV Neutral side | | |
| 23. | Bushings | | |
| 24. | Bushings Creepage distance | | |
| 25. | Tap Changer | | |
| 26. | Type | | |
| 27. | Tap provided on | | |
| 28. | Range of taps | % | |
| 29. | Short circuit withstand duration | Sec | |

| S.no. | Description | Unit | Parameter Proposed (Bidder) |
|---|---|---|---|
| 30. | LV neutral bushing CT | | |
| 31. | Energy Efficiency Class | | |
| 32. | Losses | | |
| 33. | Copper Loss | | |
| 34. | Iron Loss | | |
| 35. | Impedance | | |
| 36. | Winding Material | | |

### 1.10 Auxiliary Power Supply System - PART A

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1 | **UPS system** | | |
| 1.1 | UPS rating | kVA | |
| 1.2 | Make | _ | |
| 1.3 | Make & place of manufacture | _ | |
| 1.4 | No. of UPS | Nos | |
| 1.5 | Type | _ | |
| 1.6 | Reference Standard | _ | |
| 1.7 | Input AC Voltage with variation | V to V | |
| 1.8 | Input Frequency, Hz with variation | Hz | |
| 1.9 | Output Voltage with variation | V | |
| 1.10 | Output Frequency, Hz with variation | Hz | |
| 1.11 | Design Ambient temperature | (°C) | |
| 1.12 | Efficiency of complete UPS (AC to AC) | % | |
| 1.13 | DC System voltage | Voc | |
| 1.14 | Total Harmonic distortion | % | |
| 1.15 | Voltage regulation | | |
| 1.16 | Frequency regulation | | |
| 1.17 | Transient voltage regulation | | |
| 1.18 | Overload response of UPS | _ | |
| 1.19 | Dynamic response | _ | |
| 1.20 | Noise level | % | |
| 1.21 | Cooling | _ | |
| 1.22 | Communication interface | _ | |
| 1.23 | Heat dissipation | _ | |
| 1.24 | Thickness of sheet metal | mm | |
| 1.25 | Dimensions in mm (LxDxH) | mm*mm*mm | |
| 1.26 | List of protections/ indications/ metering/annunciations provided in UPS | _ | |
| 1.27 | UPS Enclosure | | |
| | a) Material | _ | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| | b) Thickness of sheet | mm | |
| | c) Degree of protection | _ | |
| 1.28 | Charger/Rectifier | | |
| | a) Make | _ | |
| | b) Type | _ | |
| | c) Current rating | A | |
| | d) Voltage rating | V | |
| 1.29 | Static inverter | | |
| | a) Make | _ | |
| | b) Type | _ | |
| | c) Current rating | A | |
| | d) Voltage rating | V | |
| | e) AC output voltage variation | V | |
| | f) Guaranteed efficiency | % | |
| | g) Total harmonic content at rated load | % | |
| 1.30 | Static transfer switch | | |
| | a) Make | _ | |
| | b) Type | _ | |
| | c) Current Rating | A | |
| | d) Voltage rating | V | |
| | e) Transfer time | S | |
| 1.31 | Manual by-pass switch | | |
| | a) Make | _ | |
| | b) Type | _ | |
| | c) Current Rating | A | |
| | d) Voltage rating | V | |
| 1.32 | Input Transformer | | |
| | a) Make | _ | |
| | b) Rated Capacity | kVA | |
| | c) Voltage ratio, frequency & no. of phase | _ | |
| | d) Vector group | _ | |
| | e) Insulation class | _ | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| | f) Rated current | A | |
| 1.33 | Output Transformer | | |
| | a) Make | _ | |
| | b) Rated Capacity | kVA | |
| | c) Voltage ratio, frequency & no. of phase | _ | |
| | d) Vector group | _ | |
| | e) Insulation class | _ | |
| | f) Rated current | A | |
| 1.34 | MCCB | | |
| | a) Make | _ | |
| | b) Rating | A | |
| | c) Type | _ | |
| 1.35 | HRC and Semiconductor Fuses | | |
| | a) Make | _ | |
| | b) Type | _ | |
| | c) Rating | A | |
| 1.36 | UPS DB | | |
| | a) Make | _ | |
| | b) Type | _ | |
| | c) Quantity | Nos | |
| | d) Voltage rating | V | |
| | e) Current rating | A | |
| | f) Degree of protection | _ | |
| | g) Material | _ | |
| | h) Short circuit rating | kA | |
| | i) Rating of incoming MCCB | A | |
| | j) Rating of outgoing MCCB feeders | A | |
| | k) Earth Busbar size | mm | |
| **2** | **UPS battery system** | | |
| 2.1 | Manufacturer of battery | _ | |
| 2.2 | Quantity | Nos | |
| 2.3 | Applicable standard | _ | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 2.4 | DC System Voltage | Vdc | |
| 2.5 | Battery type | _ | |
| 2.6 | Type of Container | _ | |
| 2.7 | Type of the cell | _ | |
| 2.8 | Cell designation as per IS | _ | |
| 2.9 | Cell dimensions | mm*mm*mm | |
| 2.10 | Weight of complete cell<br>a) Without electrolyte<br>b) With electrolyte | g | |
| 2.11 | Plates<br>a) No. of positive plates per cell<br>b) Types of positive plates<br>c) Types of negative plates | | |
| 2.12 | No. of Cells per battery | Nos | |
| 2.13 | Rated cell voltage | V | |
| 2.14 | Ampere Hour rating | AH | |
| 2.15 | Battery capacity referred to a cell end voltage of 1.85 | VARh | |
| 2.16 | Load cycle duration | Min | |
| 2.17 | 10-hour rating at 27°C to 1.85V per cell | __ | |
| 2.18 | Minimum cell voltage during duty cycle | V | |
| 2.19 | WH efficiency | % | |
| 2.20 | AH efficiency at 10-hour discharge rate | % | |
| 2.21 | Float charging | V/cell, A | |
| 2.22 | Boost charging in 10 hours<br>a) Start<br>b) Finish | V/cell, A | |
| 2.23 | Maximum short circuit current for a dead short across terminals | kA | |
| 2.24 | a) Internal resistance of Battery<br>b) Each cell of battery | Ohm | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 2.25 | Taps provided of cell No. | _ | |
| 2.26 | Mounting arrangement | _ | |
| 2.27 | Racks<br>a) Material<br>b) No.of racks<br>Overall dimension of rack | | |

### 1.11 Auxiliary Power Supply System - PART B

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| **1** | **DC Charger** | | |
| 1.1 | AH capacity at 27 ˚C 10-hour rate to give final cell voltage of 1.85V*/cell | AH | |
| 1.2 | Application | - | |
| 1.3 | Ambient Temperature | | |
| 1.4 | Maximum Site ambient | °C | |
| 1.5 | Minimum Site ambient | °C | |
| 1.6 | Type | - | |
| 1.7 | Rated Voltage | V | |
| 1.8 | Nominal system voltage | V | |
| 1.9 | Load cycle duration | Hour | |
| 1.10 | No. of Cells | Nos. | |
| 1.11 | End Cell Voltage | V | |
| 1.12 | Rated (Nominal) cell voltage | Volts/cell | |
| 1.13 | Float charging (normal) | V/Cell | |
| 1.14 | Boost charging (after complete discharge) | V/Cell | |
| 1.15 | Specific gravity of electrolyte | - | |
| 1.16 | AH efficiency of Battery | - | |
| 1.17 | WH efficiency of Battery | - | |
| 1.18 | Mounting arrangement on Rack | - | |
| 1.19 | Type of Rack | - | |
| 1.20 | Connection of Battery to Charger | - | |
| 1.21 | DC system grounding | - | |
| 1.22 | Float cum Boost Charger | | |
| | a) Output Voltage | V | |
| | b) No. of Charger System | - | |
| | c) Charger Rating | A | |
| | d) Design Ambient temperature | °C | |
| | e) Charger Type | - | |
| | f) Type of Cooling | - | |
| | g) Enclosure protection | - | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| | h) Input power supply | - | |
| | i) Voltage | V | |
| | j) Frequency | Hz | |
| | k) Combined frequency and voltage variation | % | |
| | l) Charger output Voltage | - | |
| | m) Charger Efficiency | - | |
| | n) Charger output regulation with input voltage variation of +/- 10% and frequency variation of +3 /- 5% | - | |
| | o) AVR time constant | Sec. | |
| | p) Ripple content in DC output voltage (peak to peak) | % | |
| **2** | **Battery Bank** | | |
| 2.1 | Manufacturer of battery | _ | |
| 2.2 | Quantity | Nos | |
| 2.3 | Applicable standard | _ | |
| 2.4 | DC System Voltage | Vdc | |
| 2.5 | Battery type | _ | |
| 2.6 | Type of Container | _ | |
| 2.7 | Type of the cell | _ | |
| 2.8 | Cell designation as per IS | _ | |
| 2.9 | Cell dimensions | mm*mm*mm | |
| 2.10 | Weight of complete cell<br>• Without electrolyte<br>With electrolyte | g | |
| 2.11 | Plates<br>• No. of positive plates per cell<br>• Types of positive plates<br>Types of negative plates | | |
| | No. of Cells per battery | Nos | |
| | Rated cell voltage | V | |
| | Ampere Hour rating | AH | |

| S.no. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| | Battery capacity referred to a cell end voltage of 1.85 | VARh | |
| | Load cycle duration | Min | |
| | 10-hour rating at 27°C to 1.85V per cell | __ | |
| | Minimum cell voltage during duty cycle | V | |
| | WH efficiency | % | |
| | AH efficiency at 10-hour discharge rate | % | |
| | Float charging | V/cell, A | |
| | Boost charging in 10 hours<br>• Start<br>Finish | V/cell, A | |
| | Maximum short circuit current for a dead short across terminals | kA | |
| | Internal resistance of<br>• Battery<br>Each cell of battery | Ohm | |
| | Taps provided of cell No. | _ | |
| | Mounting arrangement | _ | |
| | Racks<br>• Material<br>• No.of racks<br>Overall dimension of rack | | |

### 1.12 AC Distribution Boards

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Type | _ | |
| 2. | Service | _ | |
| 3. | Enclosure | _ | |
| 4. | System | _ | |
| 5. | Voltage | V | |
| 6. | Phase | _ | |
| 7. | Frequency | Hz | |
| 8. | Combined voltage and frequency variation | % | |
| 9. | System grounding | _ | |
| 10. | Rated Current: | | |
| 11. | Bus bar | A | |
| 12. | MCCB | A | |
| 13. | Short Circuit Rating | | |
| 14. | Interrupting | kA | |
| 15. | Short Time for 1 Sec | kA | |
| 16. | Hipot for 1 minute (minimum) | kA | |
| 17. | Molded Case Circuit Breaker | | |
| 18. | Duty Cycle | _ | |
| 19. | Breaking Current<br>A.C. Symmetrical | kA | |
| 20. | Making Current | kA | |
| 21. | Contactor duty | | |
| 22. | Maximum ambient<br>temperature<br>inside each module | (°C) | |

### 1.13 Lightning Protection System

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | ESE Air Terminal | | |
| | Lightning Current withstand | kA | |
| | Gain in Spark over time | ms | |
| 2. | Lightning Event Counter | | |
| | Display Type | _ | |
| | Power Source | _ | |
| | Minimum and Maximum Current | kA | |

### 1.14 Fire Detection and Protection System

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Smoke Detector | | |
| 2. | Type | _ | |
| 3. | Heat Detector | | |
| 4. | Type | _ | |
| 5. | Environment | _ | |
| 6. | Air Sampling Smoke Detector | | |
| 7. | Protection | _ | |
| 8. | Hooters | | |
| 9. | Frequency | Hz | |
| 10. | Sound level | dB | |
| 11. | Response Indicators | | |
| 12. | Type | _ | |
| 13. | Indication | _ | |
| 14. | Extinguishers | | |
| 15. | Type | _ | |
| 16. | Indication | _ | |

### 1.15 Surveillance System

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | General | | |
| | Bidder's name | _ | |
| | Address | _ | |
| 2. | CCTV monitoring System | | |
| | Make & model no. of camera | _ | |
| | Camera details | _ | |
| | Quantity of Cameras | Nos | |
| 3. | Perimeter Intruder Detection System | | |
| | Make & model no. of camera | _ | |
| | Camera details | _ | |
| | Quantity of Cameras | Nos | |
| | No. of licenses | Nos | |
| 4. | Security card access system | | |
| | Make | _ | |
| | Type | _ | |
| | Model no. | _ | |
| 5. | Encoder | | |
| | Make: | _ | |
| | Model no. | _ | |
| 6. | Server | | |
| | Make: | _ | |
| | Type | _ | |
| | Quantity | No | |
| | Specification | _ | |
| 7. | Workstation | | |
| | Make: | _ | |
| | Type | _ | |
| | Quantity | No | |
| | Specification | _ | |
| 8. | Printer | | |
| | Make: | _ | |

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| | Type | _ | |
| | Quantity | No | |
| | Specification | _ | |
| 9. | Distribution Panel | | |
| | Make & Place of manufacture | _ | |
| | Degree of protection | _ | |
| | Rating & type of incomer | A | |
| | Rating & type of outgoing feeders | A | |
| | Short circuit rating of MCB | A | |
| 10. | Camera poles | | |
| | Make & Place of manufacture | _ | |
| | Type & material | _ | |
| | Height | mm | |
| | Weight | Kg | |
| | Diameter | mm | |
| | Bracket length | mm | |
| | Thickness of galvanizing | mm | |
| 11. | Power Cables | | |
| | Make & Place of manufacture | _ | |
| | Applicable standard | _ | |
| | Voltage Grade | _ | |
| | Conductor material & size | _ | |
| | Insulation Material | _ | |
| | Inner sheath Material | _ | |
| | Inner sheath Extruded (Yes/No) | _ | |
| | Armour material | _ | |
| | Outer sheath Material | _ | |
| 12. | Signal Cables | | |

| Sl. No. | Description | Unit | Parameter proposed (Bidder) |
|---|---|---|---|
| | Make & Place of manufacture | _ | |
| | Applicable standard | _ | |
| | Voltage Grade | _ | |
| | Conductor material & size | _ | |
| | Insulation Material | _ | |
| | Inner sheath Extruded (Yes/No) | _ | |
| | Inner sheath Extruded? | _ | |
| | Armour material | _ | |
| | Outer sheath Material | _ | |
| 13. | Junction Boxes | | |
| | Make & Place of manufacture | _ | |
| | Type of enclosure | _ | |
| | Degree of protection | _ | |
| | Type & rating terminal blocks | A | |

### 1.16 Power Transformer

| S.No | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Rating | Min. 30MVA (shall be decided during detail engineering) | |
| 2. | System voltage (Primary / Secondary) | 132/33 kV | |
| 3. | Installation | Outdoor | |
| 4. | Type of earthing | Effectively earthed | |
| 5. | Rated frequency | 50 Hz | |
| 6. | For Power devices (like drive motors) | 415V + 10%, 3 phase, 4 wire, 50 Hz Neutral grounded A.C. supply. | |
| 7. | For A. C. control & protective devices, lighting fixture space heaters, fractional kW. motors | 240V, single phase, 2 wire, 50 Hz A.C. supply with neutral grounded. | |
| 8. | For D. C. Alarm, control & protective devices | 110 or 220 V DC, 2 wire | |
| 9. | A.C. Supply | | |
| | I. Voltage variation | ± 10% | |
| | II. Frequency variation | ± 5% | |
| 10. | DC Supply voltage variation | (-) 15% to (+) 10% | |

### 1.17 Surge Arrestor

| S.No | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 1. | Rated arrester voltage | 120 kV | |
| 2. | System voltage (nominal / highest) | 132/145 kV | |
| 3. | Installation | Outdoor | |
| 4. | Type of earthing | Effectively earthed | |
| 5. | Type of arrester | Metal oxide / Gapless | |
| 6. | Rated frequency | 50 Hz | |
| 7. | Nominal discharge current | 10 kA of 8/20 microsecond wave | |
| 8. | One minute power frequency withstand voltage | 275kV (rms) | |
| 9. | Full wave microsecond impulse voltage (1.2/50 µs) | 650kVp | |
| 10. | Rated thermal energy rating | 7 kJ/k | |
| 11. | Continuous operating voltage at 50°C | 102kV (rms) | |
| 12. | Max. residual voltage at discharge current | 330kV (peak) at 10kA | |
| 13. | Long duration discharge class (IEC) | 3 | |
| 14. | High current short duration test value | 100kA (peak) | |
| 15. | Current for pressure relief test | 40kA (rms) | |
| 16. | Low current long duration test value | As per IEC | |
| 17. | Partial discharge level at 1.05 COV | As per IEC | |

### 1.18 Isolator with Earth Switch

| S.No. | Item | Required | Parameter proposed (Bidder) |
|---|---|---|---|
| 1) | Type | Double break, horizontal type, Centre rotating, outdoor, air break. (With single/double earth switch or, without earth switch) | |
| 2) | Highest system voltage | 145kV | |
| 3) | Rated voltage | 132kV | |
| 4) | Rated continuous current | 1600A | |
| 5) | Rated frequency | 50Hz | |
| 6) | No. of phases | 3 | |
| 7) | Mounting | Horizontal, upright | |
| 8) | Rated short circuit | 40kA | |
| 9) | Rated short circuit making current | 100kA (peak) | |
| 10) | Short time current carrying capability | 40kA (rms) for 3 second | |
| 11) | Temperature rise | As per IEC | |
| 12) | Lightning Impulse with stand voltage | 650kV (peak) | |
| 13) | Switching Impulse with stand voltage | - | |
| 14) | One minute power frequency withstand voltage | 275kV (rms) | |
| 15) | Type of operating mechanism | Motor operated for isolator & earth switch | |
| 16) | Operating mechanism voltage | 3 phase 415V / 1 phase 231.5V operation | |
| 17) | Control supply | 220V DC, + 10% to -15% | |
| 18) | Auxiliary contacts | | |

| S.No. | Item | Required | Parameter proposed (Bidder) |
|---|---|---|---|
| | a) No. of contacts for isolator | As required plus 8 NO and 8 NC contacts per pole as spare | |
| | b) No. of contacts for earth switch | Total 6 NO and 6 NC | |
| 19) | Reference ambient temperature | 50°C | |
| 20) | Creepage distance | 25mm/kV | |
| 21) | Support structures | Hot dip galvanized steel structures | |

### 1.19 Isolator with Earth Switch

| S. No. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 1) | Type / Application | SF6 gas puffer type, electrically trip free / outdoor, single pressure | |
| 2) | Execution of poles | 3 single poles gang operated mechanically coupled for all breakers | |
| 3) | Highest system voltage | 145kV | |
| 4) | Rated frequency | 50Hz | |
| 5) | Rated current at design ambient | 2000 A for | |
| 6) | Short circuit breaking current | 40 kA for 3 sec | |
| 7) | Symmetrical interrupting capability | 40 kA (rms) | |
| 8) | Rated short circuit making current | 100kA (peak) | |
| 9) | Auto-reclosing 3 phase for all breakers | For line breakers | |
| 10) | Capacitive switching | Class C2 as per IEC | |
| 11) | Mechanical endurance | Class M2 as per IEC | |
| 12) | Closing resistors (PIR) | - | |
| 13) | Temperature rise | As per IEC 55 Deg.C considering ambient temp. 50 Deg.C for main contact | |
| 14) | Operating duty | O - 0.3 sec – CO - 3 min - CO | |
| 15) | Total break time (Maximum) | 60ms | |
| 16) | Total make time (Maximum) | 65ms | |
| 17) | First pole to clear factor | 1.3 | |
| 18) | TRV | As per IEC | |
| 19) | Lightning Impulse with stand voltage | 650kV (peak) | |

| S. No. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 20) | Switching Impulse with stand voltage | - | |
| 21) | One minute power frequency withstand voltage | 275kV (rms) | |
| 22) | Line charging current breaking | As per IEC 50 A | |
| 23) | Cable charging current breaking | As per IEC 160 A | |
| 24) | Single capacitor bank switching current | 400 A | |
| 25) | Small inductive current breaking | To switch the associated transformer magnetizing current | |
| 26) | Max. allowable over voltage under any switching condition | As per IEC | |
| 27) | Type of operating mechanism | Spring - Spring operated | |
| 28) | Operating mechanism voltage | 3 phase 415V/1 phase 240V operation | |
| 29) | Control voltage | 220V DC, +10%, -15% | |
| 30) | No. of trip coils per pole | 2 nos. | |
| 31) | Design ambient temperature | 50°C | |
| 32) | Creepage distance | 25mm/kV | |

### 1.20 Circuit Breaker

| S. No. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 1) | Type / Application | SF6 gas puffer type, electrically trip free / outdoor, single pressure | |
| 2) | Execution of poles | 3 single poles gang operated mechanically coupled for all breakers | |
| 3) | Highest system voltage | 145kV | |
| 4) | Rated frequency | 50Hz | |
| 5) | Rated current at design ambient | 2000 A for | |
| 6) | Short circuit breaking current | 40 kA for 3 sec | |
| 7) | Symmetrical interrupting capability | 40 kA (rms) | |
| 8) | Rated short circuit making current | 100kA (peak) | |
| 9) | Auto-reclosing 3 phase for all breakers | For line breakers | |
| 10) | Capacitive switching | Class C2 as per IEC | |
| 11) | Mechanical endurance | Class M2 as per IEC | |
| 12) | Closing resistors (PIR) | - | |
| 13) | Temperature rise | As per IEC 55 Deg.C considering ambient temp. 50 Deg.C for main contact | |
| 14) | Operating duty | O - 0.3 sec – CO - 3 min - CO | |
| 15) | Total break time (Maximum) | 60ms | |
| 16) | Total make time (Maximum) | 65ms | |
| 17) | First pole to clear factor | 1.3 | |
| 18) | TRV | As per IEC | |
| 19) | Lightning Impulse with stand voltage | 650kV (peak) | |

| S. No. | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 20) | Switching Impulse with stand voltage | - | |
| 21) | One minute power frequency withstand voltage | 275kV (rms) | |
| 22) | Line charging current breaking | As per IEC 50 A | |
| 23) | Cable charging current breaking | As per IEC 160 A | |
| 24) | Single capacitor bank switching current | 400 A | |
| 25) | Small inductive current breaking | To switch the associated transformer magnetizing current | |
| 26) | Max. allowable over voltage under any switching condition | As per IEC | |
| 27) | Type of operating mechanism | Spring - Spring operated | |
| 28) | Operating mechanism voltage | 3 phase 415V/1 phase 240V operation | |
| 29) | Control voltage | 220V DC, +10%, -15% | |
| 30) | No. of trip coils per pole | 2 nos. | |
| 31) | Design ambient temperature | 50°C | |
| 32) | Creepage distance | 25mm/kV | |

### 1.21 132kV Current Transformer

| S.No | Description | Required | Parameter proposed (Bidder) |
|---|---|---|---|
| 1) | Highest system voltage | 145 kV | |
| 2) | Rated system voltage | 132kV | |
| 3) | Rated frequency | 50 Hz | |
| 4) | Number of phases | 3 | |
| 5) | Rated short time thermal current | 40kA for 3 sec | |
| 6) | One minute power frequency withstand voltage | 275 kV (rms) | |
| 7) | Full wave impulse withstand voltage (1.2 / 50 µs) | 650 kV (peak) | |
| 8) | One minute power frequency withstand voltage between secondary terminals & earth | 5 kV | |
| 9) | Rated short circuit dynamic current | 100kA (peak) | |
| 10) | Temperature rise | As per IEC 60044 | |
| 11) | Type of insulation | Oil immersed Class E | |
| 12) | Type | Outdoor, oil filled, hermetically sealed | |
| 13) | Creepage distance | 25mm/kV | |
| 14) | CT particulars | As per enclosed 'Metering & Protection Single Line Diagram' | |
| 15) | Accuracy class | Metering – 0.2S<br>Protection – PS | |

### 1.22 132kV Voltage Transformer

| S.No | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 1) | Nominal system voltage | 132kV | |
| 2) | Highest system voltage | 145kV | |
| 3) | Rated Frequency | 50Hz | |
| 4) | System fault level | 40kA for 3 sec | |
| 5) | Temperature rise | As per IEC 60044 | |
| 6) | Type of insulation | Oil immersed class E | |
| 7) | Type | Outdoor, oil filled | |
| 8) | Rated lightning impulse withstand voltage | 650kV (peak) | |
| 9) | 1minute power frequency withstand voltage | 275kV (rms) | |
| 10) | 1 minute power frequency withstand voltage for secondary winding | 3kV | |
| 11) | Rated power factor | 0.8 lag | |
| 12) | Creepage distance | 25mm/kV | |
| 13) | System neutral earthing type | Effectively earthed | |
| 14) | Coefficient of earthing | < 0.8 | |
| 15) | Rated primary voltage | 132kV/√3 | |
| 16) | Rated secondary voltage | 0.11kV/√3 | |
| 17) | VT particulars | As per enclosed 'Metering & Protection Single Line Diagram' | |
| 18) | Rated voltage factor | 1.2 Continuous & 1.5 for 30 secs. | |
| 19) | Accuracy class for tariff metering and general metering | 0.2 | |

| S.No | Description | Requirement | Parameter proposed (Bidder) |
|---|---|---|---|
| 20) | Accuracy for protection core | 3 P | |
| 21) | Partial discharge level | 10pC | |

# 2. Schedules - Quality Assurance Plan

The Bidder shall submit the Quality Assurance Plan for the following equipment but not limited to;

- Battery Energy Storage System (BESS)
- Power Conditioning System (PCS)
- Inverter Duty Transformer (IDT)
- Power Transformer (PT)
- 132kV Cable

(Bidder shall submit quality assurance plan for the offered equipment.)

The format for QAP and FQP is provided in Section 9 of this technical specification.

# 3. Schedules - Overall Time Schedule

Bidder to fill-in and submit with it's Bid for each equipment.

| Sl. No. | Work Description | Start | Finish |
|---|---|---|---|
| 1.0 | Design and Engineering | | |
| 2.0 | Manufacture, Transport & Delivery at Site | | |
| 3.0 | Transport & Delivery at Site | | |
| 4.0 | Construction | | |
| 5.0 | Erection, Testing & Commissioning | | |

SIGNATURE OF BIDDER _____

NAME _____

DESIGNATION _____

COMPANY SEAL

DATE _____

# 4. Schedules - Test and Inspection

Bidder to fill-in and submit with it's Bid for each equipment.

The Bidder shall indicate the Schedule of tests proposed to be carried out at Manufacturer or Sub-Vendor' Works:

| Item of Equipment | Name of Tests | Place of Test and Inspection |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

SIGNATURE OF BIDDER _____

NAME _____

DESIGNATION _____

COMPANY SEAL

DATE _____

# 5. Schedules - Type Test

Bidder to fill-in and submit with it's Bid for each equipment.

The Bidder shall indicate the list of type tests already carried out on similar equipment and rating along with copy of test certificates.

| Name of the Test | Rating of Equipment | Year of Testing | Test Parameters | Place of Test & Testing Agency |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**SIGNATURE OF BIDDER** _____

**NAME** _____

**DESIGNATION** _____

**COMPANY SEAL** **DATE** _____

# SECTION - 8 QUALITY ASSURANCE PLAN

# 1. Manufacturing Quality Plan (MQP)

| NAME & ADDRESS OF MANUFACTURER'S WORKS<br>Tel No:<br>Fax No:<br>E- Mail: | **MANUFACTURING QUALITY PLAN (MQP)**<br>ITEM:<br>SUB-SYSTEM: | QP NO:<br>REV.NO.<br>DATE:<br>PAGE:.... of.... | PROJECT:<br>PACKAGE :<br>CONTRACT NO.:<br>MAIN-CONTRACTOR: |
|---|---|---|---|

| SL NO | COMPONENT/ OPERATION | CHARACTERISTICS | CATE-GORY OF CHECK# | TYPE OF CHECK | QUANTUM OF CHECK | | | REFERENCE DOCUMENT | ACCEPTANCE NORMS | FORMAT OF RECORD | | INSPECTION AGENCY | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | M | C | A | | | | | M | C | A | |
| 1 | 2 | 3 | 4 | 5 | 6 | | | 7 | 8 | 9 | D* | **10 | | | 11 |
| | | | | | | | | | | | | | | | |

| | | | For Office Use | |
|---|---|---|---|---|
| MANUFACTURER/ SUB-CONTRACTOR | MAIN CONTRACTOR | **LEGEND:-**<br>D* Records identified with tick (✓) shall be essentially included by Contractor in quality documentation.<br># Category of Check: - CRITICAL, MAJOR and MINOR<br>** **M**: MANUFACTURER / SUB-CONTRACTOR, **C**: MAIN CONTRACTOR, **A**: AUTHORIZED REPRESENTATIVE.<br>Use the following term as appropriate in columns 10:<br>**P**: PERFORM, **V**: VERIFICATION and **H**: 'CUSTOMER HOLD POINT' to be witnessed and work shall not proceed till it is witnessed and cleared in writing.<br>**Ref: Legend Appendix I** | Reviewed by<br>SIGN<br>NAME<br>DESIGNATION<br>SEAL | Approved by<br>SIGN<br>NAME<br>DESIGNATION<br>SEAL |

| | | | | |
|---|---|---|---|---|
| SIGNATURE:<br>NAME:<br>SEAL:<br>DATE: | SIGNATURE:<br>NAME:<br>SEAL:<br>DATE: | | DATE | DATE |

### 1.1 Legend for Manufacturing Quality Plan (QP)

Name and address of Manufacturer's works: In the column of "Name and address Manufacturer's works" name and full address, Tel No. Fax No, Email shall be indicated in "QP".

Item: In the column of Item /Sub System:

a) Item: Full name of the item for which QP is being prepared should be indicated along with the complete material, type, class, rating, range, size etc. or complete designation / description of the item or as recommended in the product specification (attached sheet if required).

b) Sub system: Full name of Sub-system to be given with details

Column 2: Component and Operation should be indicated in sufficient detail including exact area and stage of processing, testing, delivery etc.

Column 3: Following Characteristics of Check should be indicated, as applicable: - visual, dimensional, hydraulic, chemical, mechanical, performance, ultrasonic, magnetic particle, dye penetrant, radiographic, polarization index, high voltage, insulation resistance, etc.

Column 4: Check shall be classified as Critical, Major and Minor

Column 5: Type of Check shall indicate nature of check i.e. visual, measurement, verification, strength, chemical analysis, NDT etc.

Column 6: 100% Check or sample basis specifying percentage sample to be checked. *However, the column "6" 'Quantum of Check' can be sub-divided into 2 or 3 columns to facilitate clarity for a particular set of Contractor / Sub-Contractor / Manufacturer. The quantum of Checks by manufacturer and Contractor shall be clearly indicated.*

Column 7: Plant standard, IS, DIN, BS, ASME, IEC or other national/international standards, statutory codes, drawings etc. as per which checks/tests shall be carried out shall be indicated.

Column 8: The acceptable norms as per Plant standard, design data, national/international standard or other acceptance norms shall be indicated.

Column 9: Appropriate format/certificate on which test/inspection results recorded shall be indicated.

Column 9 'D': Records shall be identified with Tick (ü) marks shall be essentially included by Contractor in QA Documentation.

Column 10: Inspection Agency performing, reviewing or witnessing of tests/checks shall be indicated. Sub column M C A stand for M: Manufacturer / Sub-Contractor, C: Main Contractor and A: Authorized Representative respectively. Under these sub columns 'P', 'V' and CHP shall be indicated for Perform, Verification and Customer Hold Points respectively.

Column 11: Remarks: Any specific remark shall be written here.

(Attach additional sheets, if required.)

*(Note: This format can be modified with the approval of CEO as per requirement).*

## 2. Field Quality Plan (FQP)

| SUB-CONTRACTOR'S NAME AND ADDRESS: | **FIELD QUALITY PLAN (FQP)** | | PROJECT: |
|---|---|---|---|
| Tel No:<br>Fax No:<br>E-mail: | ITEM:<br><br>SUB-SYSTEM: | QP NO:<br>REV.NO.<br>DATE:<br>PAGE.... of..... | PACKAGE :<br>CONTRACT NO.:<br>MAIN-CONTRACTOR: |

| SLNO | ACTIVITY / OPERATION | CHARACTERISTICS | CLASS OF CHECK # | TYPE OF CHECK | QUANTUM OF CHECK | REFERENCE DOCUMENT | ACCEPTANCE NORMS | FORMAT OF RECORD | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | D* | 10 |
| | | | | | | | | | | |

| MANUFACTURER / SUB- CONTRACTOR | MAIN CONTRACTOR |
|---|---|
| Sign: | Sign: |
| Name: | Name: |
| Seal: | Seal: |
| Date: | Date: |

LEGEND: -

1. D* RECORDS, IDENTIFIED WITH 'TICK'( ✓) SHALL ESSENTIALLY BE INCLUDED BY SUPPLIER IN QA DOCUMENTATION

2. # CLASS OF CHECK: A, B & C

**NOTE: - All classes of checks shall be 'H' ('Customer Hold Point') and work shall not proceed till it is witnessed and cleared in writing.**

ABBREVIATION to be used for format of record: -
SR=Site Register, TR=Test Report, TC=Manufacturer's Test Certificate, LR=Lab Report, LB=Logbook.

Ref: Legend Appendix II

*For Office use*

| Reviewed by<br>Sign: | Approved by<br>Sign: |
|---|---|
| Name: | Name: |
| Designation | Designation |
| Seal: | Seal: |
| Date: | Date: |

## 2.1 Legend for Field Quality Plan (FQP)

**Sub-Contractor name and address:** Name and full address of Sub-Contractor shall be indicated in " FQP"

**a) Item:** In the column of 'Item': Full name of the item for which FQP is being prepared should be indicated along with the complete material, type, class, rating, range, size etc. or complete designation / description of the item or as recommended in the product specification (attach sheet, if required).

**b)** Sub-system – name of Sub-system with required details.

**Column 2:** **ACTIVITY / OPERATION**: Name of components/ equipment / system and operations like Site Receipts Inspection, Storage, Handling, Pre-Erection and Erection shall be indicated.

**Column 3: Characteristics**: Following characteristics of activity should be indicated, as applicable, visual, dimensional, levelling, alignment, hydraulic, chemical, mechanical, performance, ultrasonic, magnetic, particle, dye penetrant, radiographic, polarization index, high voltage, insulation resistance, etc. along with the item on which the these are performed, and Instruments used for checking shall be indicated.

**Column 4:** Each Check shall be classified as A, B or C depending upon its criticality in overall integrity of the equipment

| Classification / Categorization | Witnessing & Accepting Authority | Surveillance by Authorised Representative |
|---|---|---|
| **Category – A** | FQA Engineer (or Nominated FQA Agency), in association with Engineer of Executing Department (nominated by HOD at Site) | Head, FQA (Nominated FQA Agency) |
| **Category – B** | Engineer of Executing Department (nominated by HOD at Site) | FQA Engineer (Nominated FQA Agency) |
| **Category – C** | Contractor's Field Quality Engineer and Engineer of Executing Department (nominated by HOD at Site) | Any other Engineer authorized by Head of the Project / Station (VP) |

**Column 5:** Type of Check shall indicate nature of check i.e. visual, measurement, verification, strength, chemical analysis, NDT etc.

**Column 6:** 100% Check or sample basis specifying percentage sample to be checked. In case check has to be performed periodically frequency of testing to be indicated. ***However, the column "6" 'Quantum of Check' can be sub-divided into 2 or 3 columns to facilitate clarity for a particular set of Contractor / Sub-Contractor /Manufacturer.***

**Column 7:** Plant standard, IS, DIN, BS, ASME, IEC or other national/international standards, statutory codes, drawings etc. as per which checks/tests shall be carried out and their acceptance norms shall be indicated.

**Column 8:** Plant standard, design data, national/international standard or other acceptance norm shall be indicated.

**Column 9:** Appropriate format/certificate on which test/inspection results recorded shall be indicated.

**Column 9** 'D': Records shall be identified with Tick marks (✓) shall be essentially included by - Contractor in QA documentation.

**Column 10**: In Remark column any specific Remark shall be written here.

*(Note: This format can be modified with the approval of CEO as per requirement*

# GLOSSARY

| | |
|---|---|
| AC | Alternating Current |
| ACCB | AC Combiner Box |
| ACDB | AC Distribution Box |
| ACSR | Aluminium Conductor Steel Reinforced |
| ADSS | All Dielectric Self Supporting |
| AEGCL | Assam Electricity Grid Corporation Ltd. |
| AERC | Assam Electricity Regulatory Commission |
| AMC | Annual Maintenance Contract |
| APDCL | Assam Power Distribution Company |
| BOM/BOQ | Bill of Material/Bill of Quantity |
| BMS | Battery Management System |
| BESS | Battery Energy Storage System |
| CAPEX | Capital Expenditures |
| CCTV | Closed Circuit Television |
| CEA | Central Electricity Authority |
| CEIG | Chief Electrical Inspector of Government |
| CERC | Central Electricity Regulatory Commission |
| CPM | Critical Path Method |
| CPP | Central Public Procurement |
| CRGO | Cold Rolled Grain Oriented |
| CRP | Control and Relay Panel |
| CT | Current Transformer |
| CTU | Central Transmission Utility |
| CUF | Capacity Utilization Factor |
| DC | Direct Current |
| DEM | Digital Elevation Model |
| DoD | Depth of Discharge |
| DPR | Detailed Project Report |
| EGL | Existing Ground Level |
| EMC | Electromagnetic Compatibility |
| EMS | Energy Management System |
| EPC | Engineering, Procurement and Construction |
| ESE | Early Streamer Emission |
| ESS | Energy Storage System |
| FAT | Factory Acceptance Test |
| FDPS | Fire Detection and Protection System |
| FDRE | Firm and Dispatchable Renewable Energy |
| FEC | Frequency Error Correction |
| FI | Fichtner India |
| FGL | Finished Ground Level |
| FO | Fiber Optic |
| FRLS | Fire Retardant Low Smoke |
| FQP | Field Quality Plan |
| GDP | Gross Domestic Product |

| | |
|---|---|
| GFR | Generral Financial Rules |
| GNA | General Network Access |
| GPS | Global Positioning System |
| GST | Goods and Services Tax |
| GTR | General Technical Requirements |
| GW | Giga Watt |
| HAZOF | Hazard and Operability Study |
| HJT | Heterojunction |
| HMI | Human Machine Interface |
| HOTO | Handing Over and Taking Over |
| HT | High Tension |
| HVAC | Heating, Ventilation, and Air Conditioning |
| HVRT | High Voltage Ride Through |
| IBR | Inverter Based Resources |
| ICOG | Incoming and Outgoing |
| IDT | Inverter Duty Transformer |
| IEC | International Electrotechnical Commission |
| IFSC | Indian Financial System Code |
| IP | Ingress Protection |
| ITB | Instruction to Bidders |
| kW | Kilowatt |
| LA | Lightning Arrester |
| LAN | Local Area Network |
| LCOE | Levelized Cost of Energy/Electricity |
| LCOS | Levelized Cost of Storage |
| LDB | Light Distribution Panel |
| LFP | Lithium Iron Phosphate |
| LID | Light Induced Degradation |
| LOA | Letter of Award |
| LOI | Letter Of Intent |
| LV | Low Voltage |
| LVRT | Low Voltage Ride Through |
| MAF | Manufacturers Authorization Form |
| MAT | Minimum Alternative Tax |
| MCR | Main Control Room |
| MDL | Master Deliverable List |
| MFM | Multi-Function Meter |
| MNRE | Ministry of New and Renewable Energy |
| MoEF | Ministry of Environment and Forests |
| MOP | Means of Protection |
| MoV | Metal Oxide Varistor |
| MPLS | Multiprotocol Label Switching |
| MPPT | Maximum Power Point Tracking |
| MSL | Mean Sea Level |
| MV | Medium Voltage |
| MW | Megawatt |

| | |
|---|---|
| MWp | Megawatt Peak |
| MWh | Megawatt Hour |
| NASA | National Aeronautics and Space Administration |
| NEP | National Energy Policy |
| NERLDC | Noth Eastern Load Despatch Centre |
| NGEAL | New and Green Energy of Assam Ltd. |
| NH | National Highway |
| NIB | Notice Inviting Bid |
| NIFPS | Nitrogen Injection Fire Protection System |
| NMS | Network Management System |
| NREL | National Renewable Energy Laboratory |
| NTP | Network Time Protocol |
| OEM | Original Equipment Manufacturer |
| OLTC | On-Load Tap Changer |
| O&M | Operations & Maintenance |
| OPEX | Operational Expenditure |
| OPGW | Optical Ground Wire |
| OTI | Oil Temperature Indicator |
| OTPC | ONGC Tripura Power Company Limited |
| PBG | Performance Bank Guarantee |
| PCS | Power Conversion system |
| PERC | Passivated Emitter and Rear Cell |
| PG | Performance Guarantee |
| PoI | Point of Interconnection |
| PMS | Power Management System |
| PPA | Power Purchase Agreement |
| PPC | Partial Power Converter |
| PPE | Personal Protection Equipment |
| PQM | Power Quality Meter |
| PT | Potential Transformer |
| PTZ | Pan, Tilt, Zoom |
| QA | Quality Assurance |
| QAP | Quality Assurance Plan |
| RBI | Reserve Bank of India |
| RCC | Reinforced Cement Concrete |
| RE | Renewable Energy |
| RLDC | Regional Load Despatch Centre |
| RMS | Root Mean Square |
| RTCC | Remote Tap Changer Controller |
| RTE | Round Trip Efficiency |
| RTU | Remote Terminal Unit |
| SAS | Substation Automation System |
| SCADA | Supervisory Control and Data Acquisition |
| SCC | Special Conditions of the Contract |
| SCIG | Squirrel Cage Induction Generator |
| SERCs | State Electricity Regulatory Commissions |

| | |
|---|---|
| SFMS | Structured Financial Messaging System |
| SLD | Single Line Diagram |
| SoC | State of Charge |
| SOE | Sequence of Events |
| SoH | State of Health |
| SPD | Surge Protection Device |
| SS | Substation |
| STC | Standard Test Condition |
| SWGR | Switchgear |
| TCIV | Transformer Conservator isolation Valve |
| TDS | Tax Detucted at Source |
| UAV | Unmanned Aerial Vehicle |
| UDM | User Defined Memory |
| UE/E | Unearthed/Earthed |
| UPS | Uninterrupted Power Supply |
| VAR | Volt Ampere Reactive |
| VGF | Variable Gap Funding |
| VLAN | Virtual Local Area Network |
| VPLS | Virtual Private LAN Service |
| VRE | Variable Renewable Energy |
| WTI | Winding Temperature Indicator |
| XLPE | Cross Linked Polyethylene |