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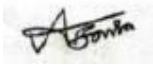

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**TECHNICAL SPECIFICATION for**

Engineering ,Supply, , Civil works, Installation, Testing , commissioning , Trial run , O&M cum CAMC  
till 33kV switchyard end

of TGTRANSCO Substations, Maheswaram Telangana – 187.5MW/750MWH BESS Project

REVISION (00) –	DETAILS:	Prepared by:	Reviewed by :	DATE
		SAR 	VJ 	
		<b>Approved by</b> <b>PM</b> <small>Digitally signed by PUNAM MISHRA  DN: cn=PUNAM MISHRA, o=BHEL, ou=SBD,  email=punammishra@bhel.in, c=US  Date: 2026.01.29 09:51:52 +05'30'</small>		29.01.26  <b>ISSUED</b> <b>PV ENGG</b>



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## PREFACE

Bharat Heavy Electricals Limited (BHEL) is a Central Public Sector Enterprise under the Ministry of Heavy Industries and Public Enterprises, Government of India. It is an integrated power plant equipment manufacturer and one of India's largest engineering and manufacturing companies, with a turnover of approximately USD 2.75 billion. BHEL is a publicly listed company on Indian stock exchanges.

The Solar Business Division (SBD) of BHEL, located in Bengaluru, Karnataka, is actively engaged in the execution of Solar Photovoltaic (PV) , BESS projects. With a diverse portfolio exceeding 1.2 GW, BHEL SBD is a leading EPC player in the Indian solar PV market, with executed projects including ground-mounted, rooftop, canal-top, and floating solar installations.

BHEL SBD invites EPC bids for TGTRANSCO Substations ,Maheswaram Telangana – 187.5MW/750MWH BESS Project. Bidder scope is till LV side of Power transformer and Metering at HT panel Outgoer. PGCIL is BHEL's End customer . PGCIL is Quoting for developer mode BESS tender under VGF scheme.



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## 1.PROJECT INFORMATION

Deployment of Battery Energy Storage Systems (BESS) at ISTS linked power network offers an opportunity for optimum utilization of existing thermal generation and associated transmission infrastructure. By enabling temporal shifting of energy, BESS can help align generation with demand patterns, and provide peak power during non-solar hours, thereby improving overall system efficiency and grid reliability.

In addition, energy storage systems integrated with thermal power stations may contribute in addressing flexibilization challenges of thermal plants due to higher Renewable Energy (RE) penetration in the grid. Such BESS installations may also play a supportive role in mitigating such operational stress by absorbing surplus energy during low-demand periods and supplying it during peak hours. PGCIL is End customer. PGCIL will be Quoting to Developer mode BESS tenders.

### **Telangana Power Generation Corporation Limited (TGGENCO)**

S no	Item	Description
1	Customer	Customer Name: <b>Telangana Power Generation Corporation Limited (TGGENCO)</b> Total Capacity: 187.5MW/750MWh , (BHEL Quoting to End customer) Whether Reverse Auction applicable to PGCIL to Developer mode tender: Yes
2	Project Location	400/220KV Sub-Station Maheswaram: 187.5MW/750MWh
3	Plant Rating	400/220KV Sub-Station Maheswaram: 187.5MW/750MWh Charge/discharge C-rate 0.25
4	Design Life	15 years (minimum)
5	O&M cum CAMC	15 years from trial run successful completion and facilities completion till 33 kV level.
6	Technical Requirements	<ul style="list-style-type: none"><li>• Minimum design life: 15 years</li><li>• Minimum charge/discharge duration: 4 hours (0.25 C-rate)</li><li>• No. of Cycles (Charging/ Discharging)/Per day: 1 Cycle - If on any day, the BESS system cannot be utilized, the same shall be made available for charging and discharging on any day as second charge cycle within 365 days</li><li>• Total Cycles: 6300 - Entire Contract period. Difference between No. of single cycle per day over 15 years and 6300 cycles can be utilized as a second cycle anytime during contract period.</li><li>• <b>Availability (Minimum Annual Average): 95% till 33kV level</b></li><li>• Availability (Monthly): Limited to 95%</li><li>• <b>Round-trip efficiency: 87% RTE without aux (monthly basis) , measured at 33kV HT panel outgoer.</b></li></ul>

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		<ul style="list-style-type: none"> <li>• Degradation per year allowed: 2%</li> <li>• Cooling Time b/w Charge to Discharge: 1 hour. Allowed 1 hour or as stated by the bidder in their offer, whichever is lesser between full charging/discharging. For part charging/discharging cooling time is permitted proportional to the part charging</li> <li>• Recovery time for 1 Cycle: <b>Bidder to specify</b></li> <li>• Interconnection Voltage: 220 kV (Bidder scope till 33kV level)</li> <li>• Aux power to be drawn from separate two no of 33kV feeders ( 2 x 100%) provided by Discoms/Transco.</li> <li>• Land allocation for the Projects shall be under scope of the Customer.</li> <li>• Visual Monitoring System for BESS fitted with High mast Thermal &amp; Surveillance Camera and streaming of the same shall be provided at Control Room of Sub Stations/BESS.</li> <li>• As BESS is prone to fire hazard, the Contractor shall provide suitable means such as fire barrier between switchyard and BESS to avoid fire spread from BESS to switchyard equipment built by employer.</li> <li>• The Contractor shall in general follow “Design Guideline for Substation Connecting Battery Energy Storage Solution” Reference: 869, April 2022, by CIGRE”.</li> <li>• Construction power , other requirements till trial run in Bidder scope.</li> <li>• Availability Spares required for maintaining system Availability more than 95% in Bidder scope.</li> <li>• Scada , EMS will be placed in Customer building. “HT panels shall be suitable for indoor or outdoor installation. In case of indoor installation, the bidder shall be responsible for construction of the HT panel room as per customer requirements.</li> <li>• The O&amp;M-cum-CAMC period shall be 15 years from the date of issuance of the Taking-Over Certificate, till 33 kV level, including all bidder-supplied equipment.</li> </ul>
--	--	---

**Note : Taking over certificate will be issued after successful completion of trial run and successful completion of facilities and acceptance of Discoms/STUs/End customer**

**12 months defect liability period till 33 kV level, including all bidder-supplied equipment from issuance of the Taking-Over Certificate**

**Meteorological data -**

S. No	Station Meteorological Parameters	Reference/Remarks
1	Snow Fall	No
2	Wind Zone	As per National Building Code (NBC) 2016
3	Seismic Zone	As per IS 1893
4	Design Ambient Temperature	50°C
5	Altitude	< 1000 m
6	Coastal area consideration	No



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## 2.SCOPE MATRIX

### Bidder Scope:

S no	Description	Scope	Remarks
1.	Supply of BESS , BMS , EMS , PCS , Spares with mandatory tools	Bidder scope	
2.	Supply of all DC cables , HT cables , AC cables , communication cables , FO cables , DC combiner boxes , All Fire protection systems, DC cable crimping lugs, instrumentation cables , Entire Earthing system , ACDB , Aux power systems ,UPS , Battery charger , Fire alarm panel, Lightning , CCTV , Meters, PMU , Lighting and other associated items till 33kV switchyard end.	Bidder scope	
3.	Supply of , PCS Transformers , Aux transformer – Dry type and oil type , HT panels , Tie Breakers at 33kV level ,	Bidder scope	
4.	Supply of Scada , EMS ,EWS, OWS , PPC , LDC communication hardware's, Historian and related items and commissioning.	Bidder scope	
5.	Unloading ,Storage , Handling , Safety , Security, Erection , wiring , Commissioning of all supplies , connection of HT breaker / Tiebreaker with POI/ Switchyard 33KV end.	Bidder scope	
6.	All civil works including Roads, Drains , Fencing , etc till 33kV switchyard end.	Bidder scope	
7.	Site acceptance tests (till 33kV end , Meters , CCTV , PMUs) , Erection & others support and commissioning	Bidder scope	
8.	Trial run completion , Ensuring RTE , availability , Energy at 33KV level and support till POI	Bidder scope	
9.	Construction power , water and all requirements till Trial run completion	Bidder scope	
10.	Software requirements of EMS , BMS , PCS , MFM , Relays , BESS , Scada,EMS etc till POI till completion of CAMC ( Required details will be provided by BHEL)	Bidder scope	
11.	Co- ordination and Support towards interfacing switchyard SAS CRP Meters with BESS EMS/Scada including laying of FO/communication cable from Switchyard panel to EMS.	Bidder scope	
12.	Supply of all Meters at 33KV level , POI levels and PMUs , LDC communication hardwares , I&C , Warranty till CAMC completion .	Bidder scope	
13.	CCTV (Entire plant) Supply , I&C , CAMC till 15 years O&M completion.	Bidder scope	
14.	Site Establishment for BHEL team including Stay , Food , Office cabins , Transportations, etc till CAMC completion.	Bidder scope	



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15.	Replacement of all defective items till 33kV Switchyard end on immediate basis , maintaining of required spares for smooth completion of trial run , CAMC period (as per scope mentioned).	Bidder scope	
16.	Training to End customer , STU employees and BHEL	Bidder scope	
17.	All approvals , renewals till POI (220kV level) before Commissioning , Trial run	Bidder scope	
18.	All approvals , renewals till POI (220kV level) during O&M	Bidder scope	
19.	System studies inline with CEA , CERC and other regulations requirements till 220kV level and Reactive power compensation Equipment's (if any ) - Supply , Unloading , Erection , Commissioning ,civil	Bidder scope	
20.	O&M including CAMC of all supplies till 33kV for 15 years after Successful trial run and Facilities completions.	Bidder scope	
21.	Supply of Meters, PMU at POI (220KV ) , CAMC till 15 years O&M completion.	Bidder scope	

**Customer Scope:**

S no	Description	Scope	Remarks
1.	Supply , Unloading , Erection , Commissioning ,civil works, CAMC of 33/220KV switchyard Equipment's ,CRP, SAS, all related equipment's ,Tie up transformers , Feeder bays (including spares associated with switchyard, Tie-up Transformers)	Customer	

Bidder's has to perform 15 years O&M and CAMC for of all supplies upto 33 kV LV side of transformer . and Energy guarantee to be maintained as per design till 15<sup>th</sup> year till 33kV -O&M completion . All the supplies to be provided with extended warranty till CAMC completion.

**3. ENCLOSURES TO THIS TENDER SPECIFICATION (TENDER PURPOSE ONLY)**

1. End customer Pre\_Bid\_Clarifications (It will be provided in amendment)
2. Indictive vendor list to be refereed to powergrid site
3. GOI Ministry orders , End customer Quality plan formats
4. System studies Requirements, Formats for connectivity agreement ,
5. Procedure for First time charging
6. Tender Drawings of BESS Plant



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#### 4. LIST OF DOCUMENTS TO BE SUBMITTED ALONG WITH TECHNICAL BID

- 4.1 DC – DC and AC – AC RTE Energy Calculation without auxiliary power **till 33kV level for 15 years** as per loss matrix provided and **at 33kV switchgear level mentioning MWH , RTE**
- 4.2 Total IDT transformer MVA including Aux power.
- 4.3 Basic BESS layout for each Project. (preferably AutoCAD file).
- 4.4 Basic SLD for each project. (preferably AutoCAD file).
- 4.5 Bidder suggestion on Tie up Transformer MVA , EHV cables rating and features.
- 4.6 Battery containers , PCS , EMS , DC, AC cables Dimensions, weight and basic datasheets.
- 4.7 Bidder need to provide the offer in the attached format with Bid.
- 4.8 No deviation certificate wrt technical specification and LD calculations. (Bidder need to sign the Technical specifications , Subsequent amendments)
- 4.9 Declaration that the Bidder/sub vendors will meet the Provenness criteria mentioned.
- 4.10 Technical Writeup , technical datasheets with philosophy , offered solutions , RTE , MWH @ POI , Basic Drawings for BESS projects.
- 4.11 Contractor shall provide (in the bid) following Auxiliary consumption details:
- 4.12 Maximum Auxiliary Consumption (in MW) of BESS during Charging/Discharging operation at rated load of the BESS and at ambient temperature of 50°C.
- 4.13 Maximum Auxiliary Consumption of BESS during idle state (in MW) and at ambient temperature of 50°C.
- 4.14 Manufacturer authorisation form of all major supplies. (Battery , BMS, EMS , Scada, PCS , Transformers, HT Cables , HT switchgears , Meters)

#### 5. PROVENNESS CRITERIA AS PER SPECIFICATIONS ,ATTACHED FORMATS

#### 6. BRIEF DESCRIPTION OF THE SYSTEM WITH DESIGN REQUIREMENTS

The specification is intended for the development of BESS (Battery Energy Storage System) at thermal power stations for optimum utilization of existing thermal generation and transmission infrastructure.

The proposed Battery Energy Storage System (BESS) is to be installed within the premises of existing End customer thermal power stations, utilizing available land and interconnection infrastructure. The BESS installation shall comprise, but not be limited to, containerized battery modules, Power Conversion Systems (PCS), Inverter Duty Transformer (IDT), Battery Management System (BMS), Energy Management System (EMS), Power Plant Controller (PPC), Supervisory Control and Data Acquisition (SCADA), fire detection and suppression system, HVAC, auxiliary power supply scheme and all other auxiliary systems/facilities required for completion of the BESS system and integration with the existing Substation facilities. Each Battery Energy Storage System (BESS) block shall be connected to a common 33 kV pooling switchgear.



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From this pooling switchgear, suitable facilities shall be provided for interconnection with the existing LV side of the Power transformer

1. Bidder scope is till 33kV switchyard connection end , which also includes Meters at POI metering point , PMU meters , entire plant – supply , I&C , warranty , associated supplies/service .
2. Tie-up transformer , switchyard scope is in customer.

#### SCOPE

1. The Bidder's scope shall include complete design, engineering, manufacturing, testing, supply, packing and forwarding, delivery at site, unloading, handling, customs & port clearance, custom duties & port charges (if any), storage & preservation at site, in site transportation, insurance, complete civil and structural works, installation, Testing & commissioning, trial run/performance testing at site, in line with drawings/documents/test procedures approved by End customer and compliance with statutory requirements and obtaining clearances from statutory authorities, licenses if any), for each of the thermal plants BESS project . The Bidder shall be responsible for identifying and providing all equipment, components, and services necessary to install a fully functional battery energy storage system and its integration with existing facilities of the thermal plant.
2. Bidder scope is till 33kV connection end in switchyard which also includes Meters at metering point , PMU – supply , I&C , warranty , associated supplies/service ,CCTV
3. Tie-up transformer , switchyard scope is in BHEL
4. The BESS capacity ACTIVE power/energy capability which is to be demonstrated at the start of Year-1 (i.e., at Commercial Operation Date – COD), measured at the respective Point of Interconnection (Pol) as defined in Table-1,2. Considering battery degradation over time, the Bidder shall ensure the minimum year-wise dispatchable capacity (MWh), expressed as a percentage of the respective plant's identified capacity, measured at the Pol metering point, as specified in the

#### Telangana Power Generation Corporation Limited (TGGenco) - 187.5MW/750MWh

Year	Minimum Dispatchable Energy at the end of Year (%) of rated (750MWh)
1	98
2	96
3	94
4	92
5	90
6	88
7	86
8	84
9	82
10	80
11	78
12	76



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13	74
14	72
15	70

**Contractor shall also demonstrate, on monthly basis, 100% of the minimum dispatchable Capacity of the BESS as required above.**

5. the BESS as required above To maintain the required minimum dispatchable energy at the metering/delivery point for the respective plant, the Bidder shall undertake any required replenishment or augmentation of the BESS system. However, such replenishment or augmentation shall strictly be carried out at the start of the respective CAMC year only. No capacity addition, replenishment, or augmentation shall be permitted during the Trial run period or in-between any CAMC year, except in the event of an "Interruption of the Trial run Due to Fault/Failure" Monthly/Yearly MW/MWh capacity of BESS should be automatically logged in the configured performance monitoring system/EMS of BESS Plant.
6. **Bidder need to design BESS battery system by considering RTE of min 87% without aux at HT panel outgoer level till CAMC period completion (15 years)**
7. **Bidder responsibility is to maintain availability and performance of all erected equipment's/components during Trial run, CAMC so that min RTE, MWH will be achieved at POI till end of CAMC period.**
8. Complete Electrical system, mechanical systems/auxiliaries including Fire detection & protection system, HVAC system and C&I system as required for the successful completion of the proposed BESS system and its integration with the existing system shall be in the scope of the Bidder. The Fire Detection & Protection system shall comply with the latest Central Electricity Authority (CEA) regulations, relevant safety standards, and all other applicable statutory guidelines and codes for BESS installations, as per the latest amendments. Complete Civil works, structural works/material, supporting structures, foundation, etc. required for all the equipment to be supplied under this package are included in the Bidder's scope of work.
9. The BESS shall include, but not be limited to, of Battery system, Battery Management System (BMS), Energy Management System (EMS) and SCADA, PPC
10. Controller (PPC), Power Conditioning System (PCS), Inverter Duty Transformers, Protection system, Communication System, LT System and , Auxiliary power system along with metering, UPS/Safe AC systems, Monitoring & Control system, temperature scanning systems, Fire Detection & Protection Systems, battery cooling system/HVAC, remote control and monitoring, and all other associated materials and accessories necessary for trouble free operation and maintenance of the BESS system. BESS shall be provided in prefabricated containers specially designed for battery storage solutions, fully assembled and tested as per requirement of relevant codes/standards.
11. **The EMS shall be integrated with Substation of each unit/main control room for coordinated operation and visibility. The Bidder's scope shall include all necessary telemetry, data acquisition, and communication interfaces required to provide real-time data, status, and control signals to the END CUSTOMER's DCS, SAS , customer in turn send signals to Regional Load Dispatch Centre (RLDC), State Load Dispatch Centre (SLDC), and other statutory bodies, as per applicable grid code, LDC requirements. All necessary hardware, software, protocols, and cybersecure communication links required to ensure above interface, performance monitoring, and dispatch control are included in the Bidder's scope.**
12. **Bidders scope includes system studies till 220KV level POI ( including switchyard , Tieup transformer , End customer switchyard network , etc) ,Required data of customer scope till supplies will be provided to bidder.**





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13. CEA and other statutory approvals , regulatory approval and other approvals till POI during initial commissioning , till completion of CAMC period in customer scope. All details with respect to switchyard , Tieup transformer , End customer switchyard network , etc will be provided by BHEL to bidder.

The following clearances will be arranged by bidder for entire plant including 220KV level (in consultation with end customer) .

However, necessary documentations/applications facilitation in bidder scope

SL	ITEM	DETAILS
1	MOEF Clearance	Shall be arranged by End customer, wherever applicable
2	PCB Clearance (SPCB/CPCB)	Application by End customer. Inputs for application & processing to be facilitated by bidder
3	MNRE Clearance	To be facilitated by bidder
4	Chief Electrical Inspector Clearance	To be facilitated by bidder
5	Tree Cutting Permission	To be facilitated by bidder
6	RoW clearance	Application by End customer. Inputs for application & processing to be facilitated by bidder
7	Clearance from Directorate of Factories	To be facilitated by bidder

The Bidder shall be responsible for obtaining and facilitating all other applicable clearances, approvals, and permits required for the BESS installation at Substation, in addition to those specified herein, unless specifically excluded from the Scope of Work

14. Bidder scope includes interfacing EMS/Scada with switchyard -SAS , CRP & other panels and Supporting customer for all communication with LDCs.
15. The configuration and internal layout of the BESS shall provide suitable safe access to all equipment for installation, operation, maintenance, and repair in all weather conditions. Layout shall also adhere to the latest CEA safety regulations/guidelines regarding BESS. All equipment, materials and services, whether explicitly stated or otherwise and that are necessary for the satisfactory operation of BESS and its integration with the existing system as described in the technical specification read in conjunction with the scope of supply and services shall be deemed to be included in the scope of work of the Bidder. The Bidder shall ensure that the BESS and associated systems comply with the latest applicable acts, regulations, and guidelines relating to cyber security, Public Procurement Circulars, and any other requirements as issued by the Government of India/CEA or other Statutory authorities. The system shall comply to IEC 62443 and all the cybersecurity guidelines issued by the GOI for control systems. The Application Software of the Energy Management System (EMS) of the BESS shall be developed indigenously within India in line with the latest requirements issued by Government of India.
16. BESS shall be designed for minimum 15 years life, considering mentioned cycle operation per day for BESS. Year wise BESS round trip efficiency (AC-AC) (RtE) shall be at least 87 % excluding auxiliary consumption till HT panel for the entire BESS life of 15 years.





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17. BESS shall be designed for charging/discharging time of 4 hrs or less (0..25C or higher).
18. The Bidder's scope shall also include the design, supply, installation, testing, and commissioning of the 33 kV pooling switchgear along with all associated equipment and facilities required for interconnection of individual BESS blocks with the 33 kV pooling switchgear and BESS Switchyard. The bidder shall provide necessary systems for earthing, lighting, and lightning protection for all equipment and facilities within their scope of work.
19. A dedicated building will be provided by customer to house the 33 kV pooling switchgear. In addition, a common control room building shall be provided for the BESS installation, which shall accommodate all LT panels, Battery Management Systems (BMS), Energy Management System (EMS), SCADA, communication equipment, UPS and other common auxiliary systems required for operation and monitoring. The control room shall also include Operator Workstations (OWS) and Engineering Workstations (EWS) for local monitoring, control, diagnostics, and facilities/gateways required for integration with the plant's existing control architecture.
20. All control panels associated with BESS and associated system shall be installed in the new BESS control room building. Operator Workstations (OWS) and Engineering Workstations (EWS) shall be provided in the BESS control room building. **Additionally, OWS shall also be provided in Central Control Room (CCR). Control room construction in end customer scope.**
21. The 33 kV pooling switchgear shall be interfaced with the BESS EMS/SCADA system for monitoring, control and metering. All Switchgear panels shall be with MFM meters.
22. Provision shall also be made for signal exchange between the BESS EMS/SCADA and the SAS of the Substation to enable seamless integration and centralized supervision. The list of signals for such interfacing shall be finalized during detailed engineering.
23. Further, necessary provisions for connection and integration with unit controllers— including OWS, Remote Terminal Units (RTU), and AI/AO, DI/DO signal cards, and any other equipment specifically required—shall be made by the Bidder. This shall include supply and laying of required fibre optic (FO) cables and all necessary interfacing accessories.
24. Cabling (including supply of Power, control and instrumentation cables, cable trays and accessories, laying, termination etc.) for interconnection of all equipment in Bidder's scope
25. CCTV System for remote monitoring of the complete project including supply and installation of all accessories like monitoring system at main control room and associated equipment and services at identified location
26. All civil, structural, electrical, mechanical, instrumentation, communication and any other works required for the successful installation, integration, and operation of equipment and systems falling under the Bidder's scope, shall be in the scope of the Bidder. All such works, whether specifically mentioned or otherwise but necessary for the completeness and proper functioning of the system as per the Technical Specifications, shall be deemed to be included in the Bidder's scope of work.
27. Submission of engineering drawings, design calculations, performance test procedures, single line diagrams, electrical layouts, Equipment layout, Drawings/Data sheets of bought out items, Civil Drawings, Operation & Maintenance manuals/instruction manuals etc. to End customer for review/approval.
28. Technical coordination (including participation and arranging technical co-ordination meetings), finalization of drawings/documents, submission of engineering drawing/documents and processing of their approvals by the End customer as per requirement indicated elsewhere in the Technical Specifications



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29. **Submission of list of sub-vendors, manufacturing quality plans and Field quality plans/ material quality plan for approval of End customer.**
30. Conduction of all type, routine, and acceptance tests of the equipment as per relevant codes/standards and relevant chapters of technical specifications.
31. **Submit PSSE and PSCAD model of Inverter/PCS etc. as detailed in Technical Specifications.**
32. Providing warranty of BESS along with its associated equipment's as per technical specification.
33. Providing necessary training to BHEL/END CUSTOMER's personnel.
34. **All preventive and annual maintenance activities, up to and including the 33 kV pooling switchgear, shall be in the Bidder's scope till trial run completion. Thereafter, Comprehensive AMC (CAMC) for a further period of 15 years as mentioned in the Bidder's scope. The scope of CAMC shall be as defined elsewhere in the technical specifications.**
35. Complete unused set of all special tools and tackles, which are necessary or convenient for erection, commissioning and CAMC of any equipment, covered under the scope.
36. Extension of Motorable access/approach from the existing service roads to proposed BESS location (if required).
37. First fill of all oil, lubricants, and consumables (as applicable).
38. Preservative coating, final painting of all structures and equipment under the scope.
39. Any item or works though not specifically mentioned in this specification but needed to complete the equipment & systems to meet the intent of the Specification shall also be furnished, unless specifically mentioned under "Exclusion" in Part-A, of the Technical Specifications.
40. All efforts have been made to provide as much information as available for the existing End customer facilities. However, the bidder may visit the END CUSTOMER's site to acquaint himself with the present facility and collect other data that may be required. Ignorance of site conditions and any data shall not be accepted as a basis of claims of any compensation whatsoever in future. Bidder may submit the request to BHEL for visit to site.
41. **End customer extra general technical, Switchgear, Visual monitoring, Structural and civil requirements is attached in annex – same need to be complied.**
42. **Only after DISCOM and STU acceptance -O&M will commence.**

**SCOPE OF SUPPLY AND SERVICES (BESS, ELECTRICAL & ASSOCIATED SYSTEMS)**

The broad scope of work under this package shall include Electrical works related to but not limited to the following areas. Bidder is advised to visit the site for better understanding of the quantum of electrical work required before bidding.

The Bidder scope shall include design, engineering, manufacturing, type testing, inspection & shop testing at supplier's works, packing, forwarding to site including customs clearance/ port clearance (if required), receipt and unloading, in plant transportation, handling and storage (preservation & conservation of equipment) at site, insurance, erection including associated civil and structural works, earthing, testing and commissioning of the equipment, system and works as indicated in this chapter. The scope includes all interface /interconnection with the systems under this contract as required. Bidder's scope shall also include civil foundation and structural works for transformer, firewall, pipes, cable slit, cable trench, oil retention pit (as applicable), soak pit, cable tray support, NIFPS (Nitrogen



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Injection Fire Protection System) and it's accessories, fencing, rail track, mooring post, jacking pad, etc. as applicable as per statutory and system requirements for all transformers and its associated equipment. The scope of work also includes earthing of IDT Transformers and neutral (as applicable), below and above ground earth mat, earthing pits, gravel filling, pipes, fencing, rail track, mooring post for transformers and its associated equipment along with cable trestle/cable trench/cable slit etc as per system requirement. Bidder shall also provide NIFPS (complete in all respect) for PCS/Inverter Duty Transformer (as applicable as per statutory requirement), details of the same as specified elsewhere.

PCS may be placed outdoor under shed as per OEM standard practice and equipment environmental capability. All other equipment/systems such as HT panel, UPS with Battery bank and auxiliary supply equipment etc. shall be placed indoor.

**The BESS system shall be charged to energy levels, such as 25 % or 50 % or 75 % or 100% (on Employer's discretion) of the full available energy level.**

**BESS, ASSOCIATED SYSTEMS AND INTERCONNECTION UP TO 33 kV POOLING SWITCHGEAR**

BESS for each thermal power location identified in Table-1 shall include the following, but not limited to:


**1. Battery Modules including Containers:**

BESS shall be transportable, containerized energy storage system 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 systems, ac switchgear, Control Systems etc. Any proven battery technology with totally maintenance free characteristic suitable for operation in site-specific climatic conditions and meeting the requirements specified in Part-B of the technical specifications may be used BESS containers shall be suitable for outdoor conditions, diverse climatic conditions and corrosion resistance. Doors, gaskets, and panel construction shall prevent dust, water, and rodents.

**2. Power Conversion System (PCS):**

PCS shall act as an interface between the DC battery system & the AC grid. PCS shall be designed to charge & discharge the BESS battery in coordination with energy management system and battery management system. The PCS shall consist of fast acting solid state electronic switches along with all associated control & protection, filtering, measuring instruments and data logging devices. The PCS shall be bi-directional inverter with four quadrant operation. The PCS output shall always follow the grid voltage & frequency by sensing the grid voltage and phase and the PCS shall always remain synchronized with the grid. The PCS shall use only self-commutated device which shall be adequately rated. Outdoor Duty PCS shall be placed inside shed as per approval during detailed Engineering.

BESS including PCS shall be designed for providing ancillary services (primary, secondary and tertiary reserve ancillary service), reactive power support, synthetic inertia and black start capability. Technical parameters and design of system shall be as per Part B of the technical specifications. BESS system should be capable of extending startup power to the associated thermal unit for restoration

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in case of blackout. Necessary safety provision shall be provided to prevent inadvertent operation in islanded mode. ACB shall be provided between PCS and IDT. PCS with inbuilt fixed type ACB shall also be accepted. PCS may be placed outdoor under shed as per OEM standard practice and equipment environmental capability.

### 3. Inverter Duty Transformers:

Inverter duty transformers shall be provided to ensure galvanic isolation of the PCS/BESS from the grid and to step up the PCS output voltage for interconnection with the 33 KV pooling switchgear. IDT shall be oil immersed transformer suitable for outdoor operation and shall comply with relevant IS/IEC. Muti-winding IDT are acceptable as per standard practice of the bidder. voltage ratio shall be as per system requirements and vector group shall be as per PCS manufacturer recommendation. IDT shall have off Circuit Tap Changer with range of +/-5% in steps of 2.5%. One number IDT with same rating shall be provided as spare for EACH location. Necessary transformer maintenance and monitoring equipment's shall be provided. Supply of 5% of total volume of Oil for all transformers shall also be in bidder's scope.

### 4. Auxiliary transformer

Adequate number of auxiliary transformers shall be provided as required to meet the total auxiliary power demand of BESS system. Auxiliary transformers may be fed from 33kV pooling switchgear or LV side of the Inverter Duty Transformer as per standard practice of the system Integrator. Oil filled transformer with outdoor application OR Dry type transformers with indoor application shall be acceptable. Necessary redundancy shall be maintained such that there is no loss of auxiliary power supply in case of outage of Single Auxiliary Transformer.

### 5. Battery Management System (BMS):

The BESS shall be equipped with a comprehensive Battery Management System to ensure safe, efficient, and reliable operation of the battery throughout its service life. The BMS shall provide multilevel (module/rack/system) monitoring and control, including real time measurement and logging of key parameters such as SoC (State of Charge), SoH (State of Health), voltage, current, temperature, charge/discharge cycles etc. It shall be capable of automatically isolating faulted cells or strings under abnormal conditions (e.g., over/undervoltage, overtemperature, imbalance, or internal faults) and shall incorporate redundancy to avoid single-point failures. The BMS shall interface seamlessly with the EMS/SCADA using open and standard communication protocols, thereby enabling coordinated control and system-level optimization.

**6. Energy Management System:** The EMS along with the Power Plant Controller (PPC) shall provide real time monitoring and control of BESS, with provision for standalone operation (independent of thermal generation) as well as coordinated operation with the host thermal plant. It shall coordinate charging from Renewable Energy (standalone mode) or Unrequisioned Surplus (URS) power, considering TML, generation schedule, and State of Charge (SoC), to optimize readiness for peak discharge. The EMS, PPC shall interface with host thermal plant existing DCS for coordinated operation of thermal plant and BESS.



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Provision for interconnection of EMS with thermal plant AGCs shall also be provided. EMS, PPC shall also enable standalone AGC and interface with RLDC for independent BESS operation. EMS shall be capable for BESS functionalities as detailed in Part B of the technical specifications. EMS control shall follow a layered structure—system level (grid interface, scheduling, ancillary services), supervisory (SoC management, system health), and device level (PCS, BMS, auxiliaries, fast grid response). Standard communication protocols (IEC 61850, IEC 608705101/104, OPC, etc.) with redundancy and cybersecurity provisions shall be adopted.

Protection, control, and SOE data for associated 220/33 kV system shall be integrated with EMS of the system. Following minimum equipment shall be included for EMS interface:

Sl No	Description	Quantity
1	Engineering cum Operator work station (EWS+OWS) (Server with 29 inch Monitor)	2
2	Operator work station (OWS) (Server with 29 inch Monitor) *	1
3	Portable (laptop based) EWS	1
4	Gateways	2
5	Historian (Desktop)	1
6	50 Inch LED display	1
7	Time Synchronization equipment*	1
8	Control Desk	1
9	Chairs for Control Desk	4
10	Laser Printer(A4)	1

\*- the same shall be placed at END CUSTOMER's existing main plant control Room. However exact place shall be decided during detailed engineering.

**7. AC and DC Cables for Interconnection of BESS:** All AC and DC power and control cables required for interconnection within the BESS system and all equipment in the Bidder's scope shall be provided.

DC cables between the battery system and PCS shall be of suitable grade to withstand the maximum DC voltage of the battery strings and shall not be less than 1.5 kV (DC) grade. In case a 1500 V DC system is offered, 3.3 kV (E) grade cables shall be provided. DC power cables shall be of compacted aluminum/copper conductor, XLPE insulated, PVC inner sheathed (as applicable), armoured, and FRLS PVC outer sheathed, conforming to IS: 7098 (Part2) or equivalent standards. The insulation grade shall comply with the PCS manufacturer's recommendations based on the DC side waveform. Power cable from PCS to IDT shall be 3.3 kV (E) grade, XLPE insulated, PVC inner sheathed, armoured with compacted aluminum conductor.

Sizing of all AC and DC cables shall be carried out by the Bidder during detailed engineering, considering current-carrying capacity, derating factors (temperature, grouping, soil conditions, etc.), and voltage drop requirements. The sizing calculations shall be submitted to the End customer for review and approval.

All cable construction parameters shall conform to the relevant IS/IEC standards and the requirements specified in the applicable chapters of Part B of this specification



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#### 8. LT Switchgear for BESS Auxiliaries:

The Bidder shall provide LT switchgear and associated systems for powering all auxiliary loads of the BESS, including HVAC, fire detection and suppression, lighting, control systems, communication systems, and other ancillary loads. The complete auxiliary power supply for the BESS installation shall be sourced through BESS Tie Transformer itself with no dependency on external auxiliary supply. Auxiliary supply for BESS shall be drawn from electrical system of BESS and NO separate supply shall be provided by End customer

The auxiliary power system shall include energy metering capable of measuring and electronically recording real-time auxiliary power consumption (at the actual tapping point) in EMS, independently of the operation of the PCS or the net active/reactive power flows to and from the battery system.

Additionally, the auxiliary and/or control system design shall ensure provision of necessary emergency backup power to enable safe and orderly system shutdown during abnormal conditions, including total loss of grid power.

The auxiliary power system shall be designed with adequate redundancy such that failure of any single BESS container/PCS shall not affect the continuity of auxiliary power supply.

The scope of work includes the following (as applicable) for feeding all the LV Loads as required. The design and sizing criteria of the Switchboards shall be as detailed in relevant chapter of part B of the specification

- 415 Volt Switchgears
- 415 Volt AC Distribution Boards
- 415 Volt AC MCCB Boxes
- 220 Volt DC MCCB Boxes (if applicable)
- Local Motor Starters -for ventilation fans (up to 5.5 KW)
- Local Emergency Push Buttons (EPB)
- 220 V DC/110 V DC Distribution Boards (if applicable) Telescopic Trolley for Breaker Handling MLDB with Lighting Transformers (2 no's of MCCB both at Primary and Secondary End of Transformer shall be provided)
- Wall mounted Power Distribution Board.
- LV Bus ducts & Associated Support Structure
- UPS/Safe AC DB

**Spares (MCCB Modules less than 100 A and MPCB Modules):** All Switchgears, Motor Control Centres (MCCs) & AC/DC distribution boards, etc. shall have at least twenty per cent (20%) or minimum two (whichever is higher) fully equipped MCCB/MPCB modules of each rating as spares which shall be uniformly distributed over different vertical sections.

**Spares (MCCB modules—100A and higher—Starter/DAE-OG/DM Modules):** In addition, all Switchgears, MCCs and AC distribution boards shall have as spares at least twenty per cent (20%) of starter modules/MCCB/DAE-OG/DM modules or at least one module (whichever is higher) of each rating range





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of the selection table, equipped for the rating of the largest auxiliary fed from that range. Bidder's scope also include supply and laying of the Insulating mat in front of LT Switchgears in switchgear rooms.

#### **9. MV Switchgear (33 kV Pooling Switchgear):**

The scope shall include Switchgear boards as required (as per typical key single line diagrams of various projects enclosed in Tender drawings). The design and sizing criteria of the Switchboards shall be as detailed in the specification.

The switchgear(s) shall be suitably rated to handle the total BESS capacity and configured with the required number of feeders based on the system requirements and as indicated in tender SLD's.

For all the Switchboards, each section shall have minimum 1 nos. of spare modules [O/G transformer] in addition to future module indicated in the SLD. It is preferable to supply MV Switchgear from a single manufacturer. Bidder's scope also includes the implementation of dielectric epoxy-based coating as indicated in relevant chapter of Part-B of the specifications.

It is to be noted that control and supervision of all circuit breakers shall be envisaged through SCADA on dual redundancy network over IEC -61850 network. Same network to be used for integrating BESS SCADA. All the processors used for SCADA shall be of industrial grade server-based processor only.

DC Supply shall generally be used for control and protection system of switchgear. However, In case AC supply is considered for auxiliary control and protection supply for switchgear, then suitably rated UPS shall be used to meet the control supply requirement of switchgear panels.

#### **10. Switchgear /Numerical Relay Networking**

The Bidder's scope of work shall include the following for all the 33KV and LV Switchgears under this package. The communication architecture and design criteria have been explained in part B of the specification.

The Bidder's scope of work shall include complete design, engineering, supply, installation, testing and commissioning of the following:

- a. Communicable Numerical Relays (with IEC 61850) in all MV Switchgears & LV Switchgears.
- b. IEC 61850 Ethernet switches in Switchgear panels – Sufficient quantity of Ethernet switches as per requirement for all boards. At least 2 ports per switch shall be kept as spare ports.
- c. Cat5e Ethernet cable / FO cable for connection of Numerical Relays to Ethernet switches in all Switchgears.
- d. Optical Fibre Cable with fire-retardant outer sheath as required for the complete numerical relay network.
- e. Optical Fibre Cable termination equipment such as LIU, patch cord, etc. for the complete network.
- f. suitable arrangement for integration to BESS DCS/EMS.
- g. All other equipment required to meet the intended specification.
- h. Relay Test Equipment. 1 Nos.



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For control/Aux supply to 33KV MV switchgear including breaker circuit, spring charging motor, numerical relays, Data Concentrator, SCADA, HMI, GPS clock, Energy meters etc 220V AC or 220 DC both are acceptable.

1) For 220V DC, 2x100% redundant DC sources to be provided with sealed maintenance free batteries for at least 30 minutes back-up and SMPS based charger with input current harmonic less than 5%. The power output shall be distributed by 220V DCDB of suitable fault rating with 2 incomer and 1 bus coupler arrangement. Charger should have the facilities of online monitoring in SCADA.

2) For 220V AC supply, Online UPS (2x100%) with remote monitoring having a battery backup of at least 30 min to be provided. The batteries for UPS System shall be Sealed Maintenance Free type. The power output shall be distributed by 220V AC UPS with 2 incomer and 1 bus coupler arrangement.

3) Both UPS and DC system must have a margin of at least 20% of the connected load and designed accordingly. The system shall be designed for indoor mounting with ambient temperature of 50-degree C. The AC source for both Charger/UPS shall be wired to LT switchgear/ACDB which is under bidder's scope. All equipment's shall comply to relevant IEC/IS standards.

## 11. BESS SCADA System:

The SCADA system shall provide real-time monitoring, control, and data acquisition of all BESS subsystems including battery modules, PCS, transformers, auxiliaries, 33KV Pooling Switchgear and protection systems. It shall record and display alarms, events, and trends with secure remote access and redundancy. The system shall use standard open protocols (IEC 61850 / IEC 60870-5-101/104 / OPC etc.) and interface with existing thermal plant DCS, BESS EMS, and RLDC as required, ensuring seamless visibility and reliable operation

## 12. CABLES: HT Power Cables

HT power cables required for all feeders as indicated in typical key single line diagrams along with necessary termination, lugs and glands.

### LT Power and Control Cables


Supply of LT Power and Control cables required for all feeders along with interplant control and protection as indicated in typical key single line diagrams along with necessary termination, lugs and glands.

## 13. Cabling

The scope of the Bidder for all areas including building, equipment's etc. covered under this package: -

- (a.) Supply and installation of Laying of EHV, HT power, LT power and control cables.
- (b.) Supply and installation of Cable trays, fittings, and their accessories, along with support system
- (c.) Supply and installation of cable glands and lugs for all the cables in its scope of supply



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- (d.) Supply, installation of Straight-through jointing kits for, HT XLPE power cable, LT power and control cables.
- (e.) Supply and installation of Cable termination kits for, HT XLPE power cables.
- (f.) Supply and installation of Welding receptacles.
- (g.) Supply and installation of Trefoil cable clamps.
- (h.) Supply and installation of Junction boxes.
- (i.) Supply and installation of Galvanized steel pipes/ HDPE/ Hume pipes/ PVC pipes
- (j.) Supply and installation of Miscellaneous items like M.S. sections etc. as required (k.) Not used
- (l.) Bidder shall design, supply, and erect all cable tray (as applicable), interconnection of PCS/IDT/switchgear room etc.
- (m.) The detail cable tray layout includes tray layout of different platforms, floors, cable shafts, inter connection of buildings/interplant cable tray layout for feeding all the electrical loads etc. The cable tray layout comprises of sufficient/exact number of cable trays, size, elevation, distances, clear view, sectional detail, cable tray numbering etc. as per the requirement of Electrical/C&I loads of this package.
- (n.) Complete cable erection includes supply and erection of all the accessories such as rigid/flexible conduits, fittings, junction boxes, tying materials, cable tags, and markers, support structures, cable trays, cable termination, junction boxes etc. shall be under the scope of Bidder.
- (o.) Bidder shall furnish the cable schedule.
- (p.) Control interconnection charts/ diagram/equipment layout/layout for cables between Bidder's equipment's shall also be prepared by bidder
- (q.) Cable dressing for all cables laid by bidder along the complete length of the cable shall be under bidder's scope

For Tanda projects, All components and equipment (oil filled Transformers, all cables, cable tray/trench/trestle and support arrangements, accessories, JB, Lighting Panels, Lighting Tower/mast, structural items, hardwares etc) shall be designed and galvanised/painted (as applicable) suitably for corrosion protection of C5-I class in accordance with ISO and other International Standards/Practices for selecting the Coating Systems for bare steel surfaces exposed to atmosphere

All cables upto 33kV Pooling switchgear shall be laid in cable trenches. Cables beyond 33kV pooling switchgear upto identified Pol may be laid in buried arrangement.

#### 14. Earthing and Lightning Protection:

Below and above ground earthing mat/Grounding and lightning protection for the complete buildings, structures, foundations, and equipment's is in the Bidder's scope including development of layout drawing.

Bidder's scope shall also include interconnection of Earth grid at various locations and with the Owner's main plant earth grid and below ground earth mat (along with earth pit) for the Tie transformer, PCS/Inverter Duty transformer, Auxiliary Transformers, Neutral Earthing, lightning arrestor, cable sealing end, bus post insulator, accessories etc.

All earthing pits shall be treated earth pits as per latest Indian Standard and IEEE guidelines.

Earthing of Battery/PCS shall be as per OEM recommendation.

#### 15. Illumination System



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- a) Design and Supply of Station lighting system for the plant, buildings and equipment under Bidder's area.
- b) Lighting fixtures complete with lamps & accessories, LED lighting fixture complete with driver circuit & accessories, Lighting Panels, Receptacles, Switch boxes, Conduits. Lighting Wires, Ceiling fans or Wall mounted fans with regulators, lighting poles, Lighting masts, Earth wires and rods, Junction boxes, Battery operated automatic self-contained lighting fixture, Maintenance ladders as required.
- c) Scope shall also cover all interior and exterior lighting such as area lighting, street lighting, security lighting etc.
- d) LED type lighting fixtures shall be provided for Lighting Mast.
- e) Flame proof fluorescent fixtures shall be provided for hazardous areas.
- f) Normal lighting of the plant will operate with the normal AC supply. About 20% of these fixtures will also have arrangements for being fed from UPS/DC system on failure of the station AC supply. Self-contained rechargeable type fixtures shall be employed at important locations. Bidder shall provide indoor and outdoor emergency lighting at each inverter room, main control room, security room and main gate.
- g) Bidder shall prepare complete lighting layout drawings of all the areas covered under this contract. Mandatory spare parts and maintenance equipment as required.

#### 16. CONSTRUCTION POWER

All necessary statutory requirements for charging construction power bidder's network shall be in the bidder's scope.

#### 17. Fire Detection and Protection System:

Fire detection & protection system for BESS including automatic **clean agent (FK-5-1-12)/AEROSOL** fire protection system with cylinders, piping, fire/gas detectors, fire control panel, fire dampers, manual call points, abort & emergency release switches, cabling & integration with fire alarm panel provided in BESS control room along with trays, switches & racks. Fire detection & protection system shall be provided as per **relevant applicable codes/standards (BIS/NFPA/IEC/ Equivalent)** compliance and as per proven & standard practice of industry/OEM meeting statutory/regulatory requirements in India.

Fire Detection & Protection System for BESS Control Room, Switchgear Room, etc. comprising of multi-sensor detectors, Manual Call Points, hooters, Fire Alarm panel, Cabling, portable fire extinguishers, etc. as detailed out in Part-B of Technical Specification.

Further, Nitrogen Injection Fire Prevention & Extinguishing System (NIFPES) shall be provided for all oil filled transformers/reactors of rating 10MVA/10MVR & above.

#### 18. HVAC System:

The BESS shall include HVAC/Cooling system designed to maintain battery temperatures at levels acceptable to the Battery Manufacturer's normal Battery warranty conditions, conducive to acceptable battery life, and as required to maintain battery capacity for all seasons/climatic conditions at the site. The



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HVAC/Cooling System shall be designed to ensure temperature uniformity within the battery. The HVAC/Cooling system shall be designed as per applicable codes/standards for such applications and in line with relevant CEA regulations (as applicable)

Further, mechanical ventilation system (comprising of supply air fans & exhaust air fans, etc.) shall also be provided for switchgear rooms, pantries, toilets, etc. Air Conditioning System comprising of ductable/non-ductable air conditioners shall be provided in Control Room, office space, etc.

**19. Typical Interconnection Control Philosophy (Between EMS/DCS/ Switchyard/GRID):**

The BESS control system shall interface with the thermal plant existing DCS, EMS system and Switchyard Substation Automation System (SAS) through standard protocols /hardwired with suitable cyber security provisions meeting cyber security norms/regulations (the same shall be decided during detail engineering). Unit wise DCS shall exchange necessary available signals with BESS EMS for coordinated charging from URS power. A separate AGC shall also be provided and configured for standalone BESS operation. The necessary cable and cabling/ up to existing system shall also be in the scope of the Bidder.

For meeting intent of the specification, any Additional equipment/system (if any) for required interface shall be provided by the Bidder.

The typical system configuration for existing system interface refers part-E interconnection configuration drawing. shall be designed as per relevant codes for fire safety, ventilation, and accessibility, with provision for cabling, earthing, lightning protection, illumination etc.

**20. Auxiliary building including Control Room:**

In Customer scope only for Scada , EMS.

**CCTV:**

A CCTV surveillance system shall be installed to cover all critical areas of the BESS installation including container yards, switchgear rooms, and auxiliary buildings. The system shall support remote viewing, recording, and storage with redundancy. The minimum quantities of CCTV cameras shall be 15 of which 5 cameras shall be of PTZ type. The exact location shall be finalized at site during detail engineering/commissioning. The CCTV system shall be integrated with EMS system. The bidder's scope includes providing CCTV coverage in the switchyard, BESS plant, and associated locations. . Further, the feed of the CCTV system shall be displayed on a separate 55-inch LED Screen in the control room.

**21. Time Synchronization Equipment and Cybersecurity Measures:**

The Bidder shall provide GPS-based or equivalent time synchronization equipment to ensure event/time stamp accuracy across all BESS subsystems and SCADA. Cybersecurity measures shall be implemented in compliance with CEA/Govt. guidelines, including firewalls, intrusion detection, user authentication, encrypted communication, and remote access control.

**22. UPS and / or DC system:**



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UPS system(s) and / or DC system of suitable rating shall be provided for the entire Battery Energy Storage System (BESS) plant in the auxiliary/control room building. The UPS/DC shall be configured for full redundancy (2×100 %) to ensure that each unit can independently support the entire critical load in the event of failure of the other, enabling uninterrupted control power supply for critical systems of BESS, 33 kV Pooling switchgear, relays, and emergency lighting. UPS sizing including battery runtime, overload capacity etc. shall be finalized during detailed engineering based on actual critical loads, ambient conditions, and project requirements.

UPS system shall comprise of 2 x 100% UPS with 30 minutes backup.

Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing required backup as above. Bypass Line static switch, manual. bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories.

In place of UPS, bidder can provide DC supply system if the auxiliary power supply requirement of the loads is in DC. In case of DC system, Each Battery with charger system shall consist of 1 x 100% charger and 1 x 100% Battery bank for required back up, but 30 minutes minimum) and 1 x 100% DCDB, and other necessary protective devices and accessories. DC supply system voltage shall be 220V DC.

### 23. Operation & Maintenance Operation & Maintenance

The contractor shall carryout Operation and comprehensive maintenance of complete BESS part under its scope from date of commissioning of full project capacity. Operation & Maintenance shall start from date of full commissioning. Additionally, bidder to refer commercial portion of bidding document for details regarding O&M of part capacity commissioned. During O&M period, Employer personnel / Employer's authorize representative shall have unrestricted entry to the BESS plant and Control Room any time. Employer may suitably depute its personals to associate with O&M activities. Contractor shall assist them in developing expertise through their day-to-day O&M activities. All records of maintenance must be maintained by the contractor which can be accessed by Employer on demand. These records are to be handed over to Employer after the O&M period of contract.

The Contractor shall be responsible for supply of all spare parts, repairs / replacement of any defective equipment at his own cost as required from time to time during the O&M period.

The contractor shall be responsible for the Operation and Comprehensive Maintenance of the entire BESS plant under its scope during the O&M period. The brief scope of works is listed below. The details shall be further elaborated by the contractor in the O&M manual to be submitted to Employer for approval.

- Ensuring successful operation of BESS Plant for optimum Charging/discharging operation/duty/Availability.
- Charging/Discharging & Operation of the system as per the requirement of SLDC/DISCOM/Employer of the system
- Ensuring Breakdown maintenance, Preventive maintenance overhauls, arranging visit of O&M experts (when required) to maximize the availability of the BESS plant.



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- Daily work of the operators involves logging important parameters of the BESS system.
- The operator shall record monthly performance parameters as defined in the specification and reports shall be prepared on performance of BESS plant.
- Submission of periodical reports to the owner on the operating conditions of the BESS
- Ensuring Safety and protection of the plant by deputing sufficient security personals
- Monitoring, controlling, troubleshooting, maintaining of records, registers.
- Supply of all type of maintenance spares, consumables and fixing / application of the same. In order to meet the emergent requirements, contractor, with the permission of Employer can utilize the mandatory spares being supplied under the contract. However, the used spares shall be replenished by the contractor within reasonable time.
- Cleaning of the plant including Battery yard on regular basis and as and when required.
- Cleaning of drains, cable trenches, box culverts etc in BESS area.
- Herbicide spray and grass cutting on a periodic basis.
- The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
- The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his employees or his Co-contractor's employees.
- The Contractor shall immediately report the accidents, if any, to the Engineer In charge & to all the concerned authorities as per prevailing laws of the state.
- The Contractor shall comply with the provision of all relevant Acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Employees State Insurance Act 1948, Contract Labor (Regulations & Abolishment) Act 1970 or any modification thereof or any other law relating whereto and rules made there under from time to time.
- In order to ensure longevity, safety of the core equipment and optimum performance of the system the contractor should use only genuine spares of high-quality standards.
- Deployment of Plant in Charge, adequate number of technical support staff and other supporting personnel during the O&M period
- Contractor is required to maintain adequate O&M spare during the O&M contract period of the BESS system with the view to maximize availability and operation of the plant.
- Safety Engineer and Supervisor need to be also present during O&M.
- Wages shall be as per State/Central govt regulations/circulars.
- At the time handing over of the plant by the contractor to Employer, the contractor shall handover equipment and spares in healthy condition.
- Contractor must take Comprehensive Annual Maintenance Contract (AMC) from Original Equipment Manufacturer (OEM) **or OEM authorized service provider** for the following components:



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- ✦ PCS System
- ✦ EMS/SCADA
- ✦ Battery and BMS System

- The AMC document has to be submitted before completion of trial run. Replacement of equipment/spare parts/ updating of software's being phased out or not being supported by OEM's is also included in bidder's scope.
- Contractor shall be responsible to carry out all test and work as required by statutory regulation in effect as on date of Techno- commercial bid opening during O&M period.

**Other Requirements**

The contractor shall be fully responsible for:

- a. Ensuring that the BESS is integrated with the existing power system network to have trouble-free operation of complete A.C. network.
- b. Ensuring strength of all parts, material and equipment to withstand all stresses including electrical, mechanical, seismic and other forces which may be normally experienced or expected during long term station operations as well as those stresses caused by faults, switching operations and abnormal A.C system conditions.
- c. Ensuring correct application, satisfactory and proper performance of all material, equipment, structures, systems and auxiliary station services under all specified operating conditions without signs of undue strain and without breakdown, damage or deterioration of any of the equipment due to faulty or unsuitable material, equipment, workmanship, design, construction, installation, and commissioning.
- d. Transportation of all temporary and permanent materials, equipment and apparatus from the places of manufacture to the Site.
- e. Supply of complete documentation including drawings, simulation models, study reports, operating and maintenance procedures and manuals for all works.
- f. Only after STUs/Discom acceptance – O&M will commence.
- g. During O&M – All approvals , renewals , co ordinations with LDC , STU's in bidders scope.

**24. INTERCONNECTION FROM BESS TO Pol /Switchyard IN EXISTING THERMAL PLANT**

**Scope of supply and services for interconnection from the 33 kV Pooling Switchgear/ Tie breaker to the Point of Interconnection (Pol) and from the 33 kV Pooling Switchgear to switchyard connection end**

**All meters at metering point -33kV level and 220KV level ,PMU , Overall plant CCTV- supply , I&C , panel works ,associated warranty , testing , approvals, connections with switchyard and other related requirements is in Bidder's scope.**

- Bidder scope is till 33kV connection end in switchyard which also includes Meters at metering point , PMU – supply , I&C , warranty , associated supplies/service ,CCTV.
- Tie-up transformer , switchyard scope is in customer.



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Bidder shall provide metering arrangement at following locations as per the relevant CERC/ TGERC Regulations, Grid Code and Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 as amended and revised from time to time.

- 33kV Delivery Point at Employer Substation
- Inter - connection point/ Delivery/Metering Point at TGTRANSCO Substation

Metering arrangement in all respect including ABT & PQ Meters, Metering CT & PT/CVT and communication system as TGERC/SLDC/DISCOM/CERC requirement.

## 25. Relay Settings & Configuration Files

Recommended relay settings, including calculation files, software (if any), and SCD/ICD/SCL files, shall be submitted for the BHEL/End customer review and approvals. Necessary Relay , meters , EMS ,BMS , PCS and other equipment's software & licenses till 15 years (completion of CAMC) to be installed in supplying Laptop.

## 26. PAINTING FOR ELECTRICAL EQUIPMENT

Unless explicitly stated in relevant chapters of the specification, the painting of all electrical equipment shall be as follows:

The thickness of finish coat shall be minimum 50 microns (minimum total DFT shall be 100 microns). However, in case electrostatic process of painting is offered for any electrical equipment, minimum paint thickness of 50 microns shall be acceptable for finish coat. In case procedure is not indicated, Epoxy based paint with suitable additives shall be used. Paint shade for various Equipment shall be as follows:

Sl no.	Item Description	Procedure	Paint Shade
1.	Transformers and Oil Tanker	a) Inside of Tank and Accessories-Oil and Heat Resistant b) External surface of transformer and accessories-Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint.	Full Glossy White  RAL 5012
2.	Transformers-Radiators	a) External surface- ISO 12944-5:2018, Table D.1, System no. G5.05 b) Internal surface- Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	RAL 5012  NA





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3.	Transformer marshalling Box	-	SS No painting
4.	MV and LT Switchgear,	a) Front and Rear b) Extreme ends c) AC and DC MCCB Box d) Local Push Button Stations e) Lighting and Welding trf	RAL 9002 RAL 5012 RAL 9002 RAL 9002 RAL 9002

## 27. TYPE TEST

Bidder shall meet the requirements of type tests on electrical equipment's as stipulated in relevant chapters of technical specifications.

1. The Contactor shall carry out the type tests as listed in the specifications of respective equipment.
2. The type tests shall be carried out in presence of the END CUSTOMER's representative, for which minimum 07 days' notice shall be given by the Contactor. The Contactor shall obtain the END CUSTOMER's approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.

3. In case such specified type test(s) have been conducted earlier, Bidder may submit the type test reports to the BHEL/End customer during detailed engineering for waiver of conductance of such test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.


The validity period of such type test reports shall be as specified in the **"CEA guidelines on Validity Period of Type Test(s) conducted on Major Electrical Equipment"** on the date of techno commercial bid opening unless explicitly stated otherwise in relevant chapters of the specification

4. However if the Contactor is not able to submit report of the type test(s) conducted or in the case of type test report(s) are not found to be meeting the specification requirements, the Contactor shall conduct all such tests under this contract at no additional cost to the BHEL/End customer either at third party lab or in presence of client/END CUSTOMERs representative and submit the reports for approval.

## 28. MANDATORY SPARES

Bidder's scope shall include Mandatory Spares of all equipment's as mentioned in the relevant portion of Technical Specification



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Electrical simulation studies to be carried out by Bidder on BESS Network. The Bidder shall submit the soft copy of the Electrical simulation files along with all required background data files and libraries for review and record of the End customer.

## 29.Commissioning of System / Trial run under Bidder's scope

The Bidder shall submit commissioning / Trial run procedure for BHE/End customer approval during detailed engineering.

### Telangana Power Generation Corporation Limited (TGGENCO)

S no	Item	Description
1	Customer	Customer Name: <b>Telangana Power Generation Corporation Limited (TGGENCO)</b> Total Capacity: 187.5MW/750MWh , (BHEL Quoting to End customer) Whether Reverse Auction applicable to PGCIL to Developer mode tender: Yes
2	Project Location	400/220KV Sub-Station Maheswaram: 187.5MW/750MWh
3	Plant Rating	400/220KV Sub-Station Maheswaram: 187.5MW/750MWh Charge/discharge C-rate 0.25
4	Design Life	15 years (minimum)
5	CAMC	15 years from trial run successful completion – BESS , PCS , EMS 05 years from trial run successful completion – all other Items excluding BESS , PCS , EMS till 33 kV level.

## 30.Functional Guarantees (Performance/Demonstration Test)

The functional guarantee shall be as per the requirements specified in specifications.

### Comprehensive AMC of the Plant

- Maintaining the guaranteed availability of the BESS plant
- Carrying out preventive and breakdown maintenance as per OEM recommended practices
- Supply of all spare parts and consumables, and replacement/repair of faulty or damaged components
- Ensuring the required year-wise battery capacity and maintaining sufficient spares on site for continuous operation
- Periodic visits by OEM/service support (at least once in one months , if required every week), software upgrades, and monitoring the health of BESS**
- Safe and compliant disposal of end-of-life components, including batteries, in accordance with the latest E-waste (Management and Handling) Rules and applicable statutory guidelines.
- During Breakdowns , immediate response /visits to site by OEM with necessary spares need to be ensured and corrective actions to taken in war foot basis.**



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- h. Metering for BESS is proposed at Pol. metering panel shall be placed in AC Kiosk or switchyard control room as decided during detailed engineering.
- i. **Forecasting, Scheduling and Deviation Settlement shall be in the scope of the bidder.**

As part of the Forecasting, Scheduling and Deviation Settlement the following shall be carried out:

- j. Scheduling of Charging and Discharging of the system will be under the scope of SLDC/DISCOMs. Employer/State DISCOMs will provide required power for charging BESS considering minimum 'system efficiency' under the contract document.
- k. The contractor shall comply with the all the applicable CERC/TGERC
- l. Regulations including on Forecasting, Scheduling and Deviation Settlement as applicable from time to time.
- m. The scheduling of the power to/from the project as per the applicable Regulations shall be decided by DISCOMs/SLDC. However, any Deviation Settlement Mechanism (DSM) penalties due to violation of the schedule of charging or discharging of the BESS at BESS end shall be to the account of the Employer.
- n. In order to remove potential discrepancies and ambiguities, the Contractor are hereby instructed that, as part of scheduling of power to/from the Project, they will be required to punch-in their respective schedules and subsequent revisions

Category	Definition	Resolution Time
Severity 1 (Urgent)	Complete system failure, severe system instability, loss or failure of any major subsystem or system component such as to cause a significant adverse impact to system availability, performance, or operational capability. Failure of application software, cyber security issues shall also come under this category.	24 Hours
Severity 2 (Serious)	Degradation of services or critical functions such as to negatively impact system operation. Coverage under this severity would not affect complete system but subsequently could result into Severity-1 category problem.	48 Hours
Severity 3 (Minor)	Any other system defect, failure, or unexpected operation not covered in severity 1 & 2.	72 Hours
Severity 4 (General / Technical Help)	Request for information, technical configuration assistance, "how to" guidance, and other requests.	48 Hours

The CAMC scope covers all equipment up to and including 33 kV termination point in switchyard/metering point, including but not limited to the battery system, Battery Management System (BMS), Energy Management System (EMS) and SCADA, Power Plant Controller (PPC), Power Conditioning System (PCS), inverter duty transformers, protection and communication systems, auxiliary power systems, UPS/SA systems, monitoring & control systems, temperature scanning systems, fire detection & protection systems, HVAC/battery cooling systems, and all associated materials and accessories necessary for trouble-free operation.



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The Bidder shall maintain the required year-wise battery capacity for each CAMC year. **Replenishment or augmentation of BESS capacity shall be permitted only at the start of each CAMC year to meet the guaranteed performance, and no additions or replacements shall be allowed during the CAMC year.**

- Only genuine, high-quality spares shall be used to maintain longevity, safety, and optimum performance of the core equipment and the complete BESS system.
- Replacement of equipment/spare parts/ updation of software that is phased out or no longer supported by OEM is also included in bidder's scope.
- The bidder must ensure that the Battery and all other BESS components, upon reaching their 'end of life' (when they become defective, non-operational, or nonrepairable), are disposed of in accordance with the latest amendment of the 'E-waste (Management and Handling) Rules, notified by the Ministry of Environment, Forest, and Climate Change. The disposal of the plant/system/sub-system shall be carried out by the bidder as per the procedure approved by the BHEL/End customer during the , CAMC period.
- At the end of the contract period, the Bidder shall hand over the plant and equipment back to the owner in completely safe and healthy condition and without any pending defect. After CAMC period, BHEL/End customer may at its discretion, decide to extend the existing CAMC contract on mutually acceptable terms & conditions or undertake the maintenance of the Plant on its own.
- The Bidder shall be allowed to use the initial spares supplied along with the main supply as listed in Technical specification on a replacement basis during the Trial run and CAMC period. Up to the end of the Defect Liability Period, any spare used for the entire plant shall be replenished by the Bidder at no additional cost within timelines agreed between the Bidder and the End customer. Thereafter, from the expiry of the Defect Liability Period up to the end of the CAMC period, any spare used for BESS equipment, up to and including the 33 kV pooling switchgear, shall likewise be replenished by the Bidder at no additional cost within timelines agreed between the Bidder and the End customer.

#### Painting

- The bidder's scope of work includes painting of all equipment and structures as per the BHEL/End customer standard color-coding scheme. The painting shall include required application of finish paint indicated elsewhere in the Technical Specification.

#### TESTING

- During detailed engineering, the bidder shall submit for BHEL/End customer approval the reports of all the type tests as in the technical specifications. Unless specified, the type test should have conducted within last ten years from the date of bid opening. These reports should be for the test conducted on equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- However, if the bidder is not able to submit report of the type test(s) conducted within applicable period or in the case of type test report(s) are not found to be meeting the specification requirements, the bidder shall conduct all such tests under this contract at no



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additional cost to the owner either at third party lab or in presence of owner's representative and submit the reports for approval.

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

## 7. Efficiency Matrix for RTE , MWH Calculation

S no	Level	Min Efficiency (%) to be considered till 15 years completion
1	33kV outgoer to LV side of power transformer HT panel	87% without aux

1. Bidder scope is till 33kV connection end in switchyard which also includes Meters at metering point , PMU – supply , I&C , warranty , associated supplies/service, Entire plant CCTV.
2. Tie-up transformer , switchyard scope is in customer.

## 8. FUNCTIONAL GUARANTEES, LIQUIDATED DAMAGES

### GENERAL

- The term “Performance Guarantees” wherever appears in the Technical Specifications shall have the same meaning and shall be synonymous to “Functional Guarantees”. Similarly, the term “Performance Tests” wherever appears in the Technical Specifications shall have the same meaning and shall be synonymous to “Guarantee Test(s)”.

### PERFORMANCE GUARANTEES / PERFORMANCE TESTS—GENERAL REQUIREMENTS

- The bidder shall guarantee that the equipment offered shall meet the rating and performance requirements stipulated for various equipment covered in the specifications.
- The guaranteed performance parameters furnished by the bidder in his offer, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures. No tolerance or allowance on the test result will be permitted for instrument errors or inaccuracy, the method of testing or any other causes.
- The bidder shall demonstrate all the guarantees covered herein during demonstration tests / Trial run. The various tests which are to be carried out during demonstration tests are listed in the specification.
- All costs associated with the tests including cost associated with the supply, calibration, installation and removal of the test instrumentation shall be included in the contract price.
- The guarantee tests shall be conducted by the bidder at site in presence of End customer. Trial run procedure as per the technical specifications shall be submitted by the Bidder and approved by End customer. It shall be responsibility of the Bidder to make the plant ready for the performance guarantee tests.

**Commencement of trial Test:** Contractor should successfully demonstrate all the control function of Power Plant Controller (PPC)/EMS/SCADA of BESS. Bidder shall submit the detailed procedure for conducting trial run during detail engineering for approval Trial run shall be conducted for all BESS



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design parameters as per IEC 62933-2-1 including ramp rate, response time etc. All functional testing shall be done for different application as defined in EMS as per functional requirement mentioned in specification with in BESS design parameters. The trial Test shall commence only upon the Bidder successfully demonstrating the following at the point of interconnection (Pol):

- (i) Power output capability (MW) and energy storage capacity in MWh as per technical specifications.
- (ii) Frequency response of BESS.
- (iii) Ramping capability as per design.
- (iv) Reactive power at the 220KV/ Higher level as specified in technical specifications.

**A. Following paramters shall be demonstrated for each plant during the trial run and every month**

- i. Annual Capacity Degradation
- ii. Round Trip Efficiency (RtE) – every month
- iii. Cumulative BESS Availability – every month

**B. Following paramters shall be demonstrated for each plant during the trial run and every month during Comprehensive AMC Period (At the end of each CAMC Year):**

- i. Annual Capacity Degradation - every year beginning
- ii. Round Trip Efficiency (RtE) – every month
- iii. Cumulative BESS Availability – every month

**Remarks**

1. Bidder has to provide detailed RTE , MWH calculation excluding aux power at 33kV switchgear end yearly along with bid submission.
2. The bidder shall provide the minimum MWh capacity for at least 420 cycles, considering the applicable degradation for the respective year.
3. Bidder responsibility is to maintain availability and performance of all erected equipment's/components till 33kV switchyard end during trail run , CAMC so that min RTE, MWH , availability will be achieved at POI till end of CAMC period.
4. If any issues arise in customer supplies or I&C, BHEL will rectify them, and no LD shall be levied on the bidder. Suitable availability, RTE, and MWh compensation will be mutually determined for issues attributable to BHEL.

**a. Annual Capacity Degradation:**

For each plant, the Annual Capacity Degradation shall be carried out to verify that the respective BESS plant meets the guaranteed limits on capacity degradation over time, using the baseline capacity



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established at the commencement of Year-1 The capacity test shall be repeated at the end of Year-1 and capacity shall be measured at the 33kV level. The annual capacity degradation shall be calculated based on the difference between the BESS capacity measured at the start of Year-1 and the BESS capacity measured at the end of Year-1

- **The capacity testing of the BESS system shall be conducted as per the procedure approved during detailed engineering. During the testing, the BESS system shall be discharged to its minimum available energy level (design depth-of-discharge (DOD) level), and then the BESS shall be charged at rated power to its full available energy level (upper design state-of-charge (SOC) level). After charging, the BESS shall be discharged to the minimum available energy level (design DOD level), to obtain the BESS capacity.**
- All required and important measurement parameters such as active power, reactive power, energy, current, voltage, battery SOC, battery DOD, reference power etc. shall be recorded in the EMS SCADA system during entire test periods. During the BESS capacity test, the operating SOC range/window (BESS designed lower SOC level to designed upper SOC level) shall be recorded. Bidder needs to ensure that during normal operation of the BESS plant, the same BESS SOC range/window (as demonstrated during the Trial run) with rated MWh discharge capability shall be available.
- No replenishment, augmentation, or replacement of battery modules/cells shall be permitted during the trial run , except in the event of an “Interruption of the trial run Due to Fault/Failure” as defined in specification.
- In case the measured degradation of BESS capacity at the end of Year-1 exceeds the guaranteed annual degradation limit, the bidder need to augment.
- If the BESS does not achieve the Minimum Capacity Threshold, Contractor shall at its expense replenish, adjust and modify the system incl. equipment to enable the BEES to achieve the Minimum Capacity Threshold; and
- Arrange and repeat the Performance Test at Bidder’s cost within 5 business days of the completion of all adjustments and modifications.

**b. Round Trip Efficiency (RtE):**

- For each plant, the Bidder shall ensure that the **minimum annual Round Trip Efficiency (RtE) -87%** of the complete system under the Bidder’s scope (BESS and associated system up to the 33KV HT outgoer level) meets the guaranteed value specified in the technical specifications. The RtE shall exclude auxiliary power consumption of the system and all losses upto the 33KV HT outgoer level
- Measurement of incoming and outgoing energy shall be carried out at the metering/delivery point of respective plant (33 kV HT outgoer level).
- **RTE will be measured monthly.**

**Calculation of RtE**



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*AC to AC Round trip Efficiency of BESS*

$$= \frac{\text{Sum Total of Actual Injection/Discharging MU}_{sj} \text{ in a month (C)}}{\text{Sum Total of Actual Drawal/Charging MU}_{sj} \text{ in a month (D)}}$$

Where,

j refers to the jth month in a year;

D ≠ 0;

$D \leq 2 \times E_{\text{bess}} \times (\text{MD}_{n-1} - (\text{MD}_{n-1} - \text{MD}_n) \times j/12)$  x No. of days in jth month)/RtEg;

E<sub>bess</sub> refers to Energy Rating of BESS in MWh;

MD<sub>n-1</sub> refers to minimum guaranteed dispatchable energy at the end of the previous year (as a % of Capacity at the COD specified);

MD<sub>n</sub> refers to minimum guaranteed dispatchable energy at the end of the current year;

RtEg (Guaranteed Round-Trip Efficiency) = 87%;

**C and D shall be as per the DSM/UI Reports published by the SLDC or measurement at the Main ABT Meter at the Point of Delivery Point.**

Auxiliary power consumption of BESS shall not be part of RtE calculation. Separate metered connection for the Auxiliary Power load of BESS is detailed in forthcoming section.

If the monthly RtE as determined by the test is less than 87% for the BESS, then the corresponding BESS shall not have met the Guaranteed RtE, and Contractor shall:

- Pay liquidated damages to Employer as per corresponding section of this specification.
- Promptly remedy the failure to ensure that the BESS meets the Guaranteed RtE in subsequent month.
- **Till 33KV , as per above RTE formula – to the bidder the RTE will be calculated.**

**b. Cumulative BESS Monthly Availability:**

The availability guarantee shall commence from the date of commissioning of the system and shall be calculated as below:

*Monthly System Availability = Mean of the System availabilities of all time-blocks during the month in which the off-taker has scheduled power for charging/discharging the BESS.*

LD for shortfall in System Availability (in ₹) = (A – B) x 0.019 E

where,

A is Guaranteed system Availability-95%

B is Actual Annual System Availability,



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E is Evaluated cost (₹) to be quoted by the Contractor = EPC cost + O&M cum Comprehensive Maintenance cost.

The LD calculation for shortfall in System Availability shall be applicable only for  $A > B$ .

- Till 33KV , accordingly as per above formula – to the bidder the system availability till 33kV level will be calculated.

Measurement of the Availability shall be recorded each Month by the Contractor and retrievable from Contractors remote monitoring system, together with Contractor's inspection and maintenance log.

- For each plant, the Bidder shall ensure a minimum annual availability of 95% for the BESS (up to and including 33kV HT outgoer level) , monthly. The unavailability of the system (beyond 33 kV LV side of transformer ) shall not be imposed upon the Bidder for calculation of availability.
- Availability shall mean the capability of the BESS to perform its intended charging and discharging functions, as per the scheduled operation, whenever called upon by the End customer, measured at the Point of Interconnection (POI). The EMS of BESS each Plant should have the facility to calculate availability of the BESS. The Bidder shall make the BESS available for 2 operational cycles on certain days as per requirements.
- If the monthly Plant Availability Factor falls below 95%, the Bidder will be subject to Liquidated Damages (LD).

**A. During trial Test**

Sl. No.	Guaranteed Parameters	Guaranteed Figures
1	Annual Capacity Degradation.	Measured yearly as per requirement
2	Round Trip Efficiency (RTE) monthly	Not less than 87% without aux at 33kV HT outgoer level
3	Cumulative BESS monthly Availability	Not less than 95%

In case of shortfall from the guaranteed figures indicated above as established after conducting the trial tests, Bidder has do necessary correction and make sure that trial run is successful

**B. During CAMC Period (at the end of each CAMC Year)**

Sl. No.	Guaranteed Parameters	Guaranteed Figures
1	Annual Capacity Degradation.	Measured yearly as per requirement





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2	Round Trip Efficiency (RTE) monthly	Not less than 87% with aux at 33kV HT outgoer level
3	Cumulative BESS monthly Availability	Not less than 95%
4	Aux consumption charges – monthly	As quoted by Bidder

#### Test Instrumentation and their Calibration

All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test Institute approved by the BHEL/End customer and submit the same to BHEL/End customer prior to commencement of test. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subject to the approval of the BHEL/End customer prior to commencement of test.

All tools and tackles, instruments/devices and any special equipment required for the successful completion of the tests, shall be provided by the Bidder free of cost.

The Performance test shall be carried out as per the agreed procedure. The detailed Trial run procedure shall be submitted for BHEL/End customer approval.

The Bidder shall submit for BHEL/End customer approval the detailed Performance Test procedure.

#### Test Reports

After the conductance of Performance test, the Bidder shall submit the test evaluation report of Performance test results to BHEL/End customer promptly but not later than one month from the date of conductance of Performance test.

#### AMOUNT OF LIQUIDATED DAMAGES (LD)

The rate of liquidated damages and acceptable shortfall limits with LD for different guarantees shall be as under and such liquidated damages shall be deducted from the Contract Price of the project.

Customer Name: **Telangana Power Generation Corporation Limited (TGGenco) -187.5MW/750MWH**

**Formula for calculating LD due to RtE condition:**

#### LD for not meeting RtE

a. For  $RtE < 72\%$ , there shall be a liquidated damage @ APPC tariff of previous financial year of the Discoms of excess conversion losses considering system  $RtE = 87\%$  and tariff payment for the corresponding month shall not be made to the BESSD;

b. For  $72\% \leq RtE < 87\%$ , there shall be a liquidated damage levied @ APPC tariff of previous financial year of the Discoms of excess conversion losses considering system  $RtE = 87\%$ .

*Formula*



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*System Round Trip Efficiency = [Sum total of actual injection/ discharging MUSj in a month (C)] / [Sum total of actual drawal/ charging MUSj in a month (D)]*

*Where,*

*j refers to the jth month in a year;*

*D ≠ 0;*

*D ≤ 2 × Ebess × (MDn-1 – (MDn-1 – MDn) × j/12) × (Number of days in the jth month) / RtEg; Ebess refers to Energy Rating;*

*MDn-1 refers to minimum guaranteed dispatchable energy at the end of the previous year (as a % of Capacity at the COD);*

*MDn refers to minimum guaranteed dispatchable energy at the end of the current year;*

C and D shall be as per the DSM/UI Reports published by the SLDC or measurement at the Main ABT Meter at the Point of Delivery Point.

**In RTE calculations – Availability will not be factorised.**

**LD for shortfall wrt Guaranteed system availability**

**LD for shortfall in meeting Performance Criteria**

*Liquidated damages = (A – B) × 0.019E*

*where,*

*A is Guaranteed system Availability.-95%*

*B is Actual Annual System Availability,*

E is Evaluated cost (₹) to be quoted by the Contractor = EPC cost + O&M cum Comprehensive Maintenance cost.

The LD calculation for shortfall in System Availability shall be applicable only for A > B.

**Differential Price Factors for Evaluation (Capitalization of Losses for Auxiliary System for BESS)**

The actual Auxiliary Consumption of BESS during Charging/Discharging operation and idle state shall be measured during performance guarantee stage (trial run), and if the actual consumption is found to be more than that allowed consumption then the applicable LD amount (one time) shall be calculated with following formula:

Sl. No	Equipment	Parameter to be taken for applying differential price factor (F)	Value of F in Indian Rupees of parameter differential per KW
1	Auxiliary System for BESS	Differential Guaranteed Auxiliary Consumption losses of BESS during Charging/ Discharging (KW) at rated Load	<b>{Actual Loss (in kW) – 1.8% of BESS Power Capacity (in kW)} × INR 2,24,047/-</b>
		Differential Guaranteed Auxiliary Consumption losses of BESS during idle state (KW)	<b>{Actual Loss (in kW) – 0.2% of BESS Power Capacity (kW)} × INR 3,12,714/-</b>



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## 9. MANDATORY SPARES

MANDATORY SPARES listed in the table below are minimum spares required to be provided with each BESS project .The list below is indicative, and Bidder may provide additional items to ensure availability, operability, maintainability and the reliability of the BESS plant during Trial run and O&M/CAMC period. Bidder shall submit the spare list for BHEL/End customer review and approval during detailed engineering.

### LIST OF MANDATORY SPARES (for each project)

#### Dry Type Transformers (as applicable for each project)

S. No.	Components	Quantity (for each type and rating of transformer)
1	HV Bushing	1 No.
2	LV Bushing	1 No.
3	LV Neutral Bushing	1 No.
4	Complete Winding Limb (HV and LV)	1 No. (HV) 1 No. (LV)
5	WTI (if applicable)	1 No.
6	Set of RTD with associated leads complete for one transformer	1 Set

Note: 1 set consists of quantities required for 1 complete transformer. Dry type transformer will be as applicable.

#### Mandatory Spare for 33KV MV Switchgear , Scada

Sl no	Description	Quantity
1	33KV Vacuum Circuit Breaker	1 nos of each rating
2	Numerical Relays & Auxiliary relays	2 nos. of each type, make, model and rating
3	Current Transformer	3 nos of each type and rating
4	Line & Bus PT	3 nos of each type and rating
5	Ethernet Switch	2 nos of each rating
6)	FO cable	5 km
7)	Fuses	20 No. of each type and rating
8)	ABT Energy Meter switchyard end	2 No. of each type
9)	PMU at switchyard end	2 No. of each type



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**Mandatory Spare for HV cable and Accessories [ as applicable for respective projects]**

Sl no	Description	Quantity
1	HV cable	1000meters incl. steel drum
2	Cable jointing kits	2 nos.
3	Current Terminations	2 nos.


Ratings and technical parameters of spare indicated above shall be same as that equipment supplied in each project

**BESS Auxiliary System (Spares identified are for each plant)**

<b>1.</b>	<b>LT Switchgear</b>	
	(i) ACB	1 no.
	(ii) MCCB	2 nos.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Relay	2 nos.
	(vi) Meter	2 nos.
	(vii) Current Transformer	2 nos.
	(viii) Voltage Transformer	2 nos.
	(ix) Contact Assembly	2 sets
	(x) Indicating lamp	10% of total supply
	(xi) Rotary switch	10% of total supply

**MANDATORY SPARES FOR FIRE DETECTION AND ALARM SYSTEM FOR  
EACH BESS PROJECT AT RESPECTIVE THERMAL PROJECT**

Sl. No	ITEM DESCRIPTION	QUANTITY
1.0	<b>FIRE DETECTORS</b>	
1.1	Multi sensor detectors (Addressable)	5 nos.
1.2	In Indicators assembly for multi sensor detectors provided in false ceiling (Response indicator)	2 nos.
1.3	Manual pull stations	2 nos. of each type
1.4	Hooters	2 nos.
2.0	<b>FIRE ALARM PANEL</b>	
2.1	Power supply modules	1 No. of each type & rating

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2.2	Processor modules, Control modules, loop cards modules, isolator cards	1 No. of each type
2.3	LCD display of each type unit of panel	1 No.
2.4	Interface unit / modules for non-addressable devices, auxiliary / output relay modules, control modules, supervisory control modules and any other electronic modules	1 Nos. of each type
3.1	<b>CABLES</b>	
3.1.1	Control Cable 2Cx1.5 sqmm	200 mtr
3.1.2	Control Cable 2Cx2.5 sqmm for power supply	50 mtr

## 10.GENERAL REQUIREMENTS OF BESS

### System Level Design and Performance Requirements

The major equipment items shall include but not limited to a battery, battery management system (BMS), PCS, and EMS/SCADA, PPC which is to be integrated with BOS system/PCS Transformers/33kV 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 of 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. The prudent design of the BESS should include careful consideration of resonance and Ferro resonance.

It shall be possible to fully remove, repair, and replace in the field any failed or poorly performing component. This capability shall be demonstrated in the factory acceptance test (FAT) for unit batteries and other key components.

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

### Operational Window

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 Bidder 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) Grid Outages (duly certified to this effect by the Grid Operator)



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- c) Planned Maintenance Outage duly informed by the Bidder to the BHEL/End customer with at least one month's prior notice, subject to total no. of planned outage period being not more than 200 hours in the year.

It shall be the responsibility of the Bidder 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 (End of CAMC Period). Outage time as a result of replacement will also be counted as an "Accountable BESS Outage" for the purpose of computing BESS Availability.

#### **Auxiliary Power**

The BESS shall include an auxiliary power system with metering so that auxiliary power consumption can be measured and electronically recorded in real time, independently of operation of the PCS or of net power flows to and from the battery. All drawl ( BESS system) for any purpose shall be covered under aux power.

The auxiliary power system and/or control system design shall provide for whatever emergency power is necessary for an orderly system shutdown during abnormal conditions such as a loss of grid power.

#### **Mechanical Design**

- a.) All exposed surfaces of ferrous parts shall be thoroughly cleaned, primed, and painted or otherwise suitably protected to survive outdoor conditions for at least design life of the system.
- b.) Outdoor enclosures shall be weatherproof and capable of surviving intact under the site environmental conditions specified. Outdoor enclosures shall be equipped to prevent condensation.
- c.) Components mounted inside enclosures shall be clearly identified with suitable permanent designations that also shall serve to identify the items on drawings provided.
- d.) The site temperatures and the effect of temperature on component life shall be considered in developing the thermal design for all components, including the battery and PCS. Irrespective of the heat-removal system design the final rejection of all waste heat from the BESS shall be to the ambient air.

Air-handling systems shall include filters to prevent dust intrusion into the BESS.

- e.) The BESS shall include an HVAC or ventilation system designed to maintain battery temperatures at levels acceptable to the Bidder's normal Battery warranty conditions, conducive to acceptable battery life, and as required to maintain battery capacity for all seasons/climatic conditions at the site. The air handling/distribution system shall be designed to promote temperature uniformity within the battery.

#### **Other Design Requirements**



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#### **Fire Protection:**

The Bidder shall design and install a fire protection system that conforms to national and local codes, good engineering practice and latest CEA guidelines. The fire protection system design and associated alarms shall take into account that the BESS will be unattended at most of the times. If required by the type of fire protection system provided, the Bidder 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 Bidder shall also provide thermal runaway characterization of the battery storage systems.

#### **Toxic Materials:**

If any toxic substance can be emitted from the equipment during a failure, fire, or emergency or protective operation, description of the toxic nature of the substances as well as treatment for exposure to it shall be included in the O&M manual. Their treatment and disposal shall be in accordance with the New Hazardous Waste Management Rules 2016/latest guidelines notified by the Central/State Government authorities

#### **Maintenance and Repair**

The Bidder shall supply all equipment, and materials and deploy manpower needed to maintain the BESS performance and safe operation, including all maintenance required to satisfy the operation performance and warranty terms and conditions.

The Bidder shall list all maintenance activities to be carried out under the maintenance contract. For each maintenance item, the list shall include a description of the item, the expected frequency (maintenance interval), the time required to perform the maintenance, any anticipated parts replacement, and any potential problems in carrying out the maintenance. CAMC (Comprehensive AMC) scope shall be as defined in Part A of the technical specifications.

#### **Factory Acceptance Testing of BESS**

The Bidder shall develop and submit to the BHEL/End customer for its review and approval a comprehensive FAT plan that shall demonstrate that the BESS will meet the requirements of the specification. The BHEL/End customer shall have the right to request reasonable changes to the test plan.

Where full-scale testing of larger systems at the factory may be difficult or impossible due to the large system, the FAT shall be carried out at a subsystem or module level and shall consist of tests of 100% of the subsystems or modules that comprise the complete BESS, to the extent possible. In the FAT plan, the Bidder 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.





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After the Bidder determines that the BESS is fully operational, the Bidder shall conduct a FAT in which the Bidder shall demonstrate to the BHEL/End customer that the BESS is fully operational and performs as specified. This includes but is not limited to the following:

- Visual inspection of all provided equipment, including dimensions and overall design.
- Verification of proper mechanical construction such as electrical connection torques.
- Verification of sensors, metering, and alarms.
- Verification of all control functions, including remote control and monitoring, and communications interfaces.
- Verification of BESS performance at full and partial power and energy ratings
- Verification of maintenance and replacement features for unit batteries and other key components.
- Verification of compliance with specifications

During the FAT, the BESS shall meet the following

- Be operated and function as specified and designed in all the operating states, use cases, and duty cycles specified herein.
- Meet the power and energy requirements specified herein
- Be demonstrated to meet the safety and response to catastrophic failure requirements specified herein.
- Have the efficiencies, response capabilities, and other features specified herein and/or proposed by the Bidder.

Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local (control console), and remote operation of the controls shall be demonstrated.

Factory testing shall, if required, demonstrate operation at expected temperature extremes at the independent laboratory. Certification of operation of critical components and subsystems in the battery, PCS, and control systems shall be submitted at the time of the FAT. The Bidder shall submit to the BHEL/End customer for approval, 90 days before the FAT, a list of components and subsystems for which independent lab testing certification will be sought.

The Bidder shall perform any and all system modifications required during start-up and testing. The testing may be suspended as a result of a BESS malfunction and resumed only on rectification of problem items. Such suspension and resumption will occur at the sole discretion of the BHEL/End customer .

The BESS will not be accepted for shipment until all FATs have been successfully completed. In addition, the BHEL/End customer 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. **Warranty**



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The Bidder shall provide warranty for the entire BESS and its constituent equipment as per standard warranty conditions of the respective equipment. However, warranties for Battery and associated system is envisaged for complete life of project (15 years) as per desired operational requirement.

Bidder 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.

For the battery storage (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.

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.

Additional Warranty Requirements are as follows:

- The warranty shall specify the terms and conditions of the warranty, including operating conditions requirements, procedures that must be followed, and all maintenance requirements. The warranty terms shall be easy to understand and shall be clearly stated.
- The warranty shall provide an explicit statement as to the warranted cycle life and the warranted calendar life of the battery.
- The warranty shall include a simple and easy to understand proration formula, if any, to be used in crediting the BHEL/End customer for unused life or capacity of equipment replaced or repaired.
- The warranty shall include the scope of service associated with software updates.
- The warranty shall include all labor, materials, shipping charges, and any other applicable expenses.
- The warranty 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 Bidder that the BESS has failed to meet the performance requirements.

## APPLICATION REQUIREMENTS

The BESS shall be deployed at BHEL/End customer thermal power stations with provision to charge both from Un-Requisitioned Surplus (URS) power of thermal generating units as well as tie-up of renewable energy (RE) power (Stand alone Operation). The following operational requirements shall apply:

### 1. Measurement & Integration

- The BESS scope shall include provision for measurement of active and reactive power at the 220 kV interface point with the thermal plant switchyard using 0.2 class transducers/meters.



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- Data shall be integrated into the BESS EMS/SCADA.

**2. Operational Modes:**

- For charging from URS, the EMS shall schedule charging considering Technical Minimum Loading (TML) of the generating units, the generation schedule, and the State of Charge (SoC), so as to ensure optimal readiness for discharge during peak demand periods and effective utilization of surplus power.
- For charging from RE tie-up, the BESS shall operate in standalone mode irrespective of thermal plant operation.

**3. Control Philosophy and Integration**

- The existing unit-wise DCS of the thermal plant shall interface with the EMS of the BESS system. Based on aggregated plant power, TML, generation schedule, and SoC, the EMS shall determine the charging power for BESS.
- For this URS-based operation, the interface between RLDC and BESS shall be through the existing AGC/DCS of the thermal plant.
- For standalone operation (RE tie-up mode), a separate AGC for BESS shall be provided to communicate directly with RLDC.
- Provision shall also be kept for interlinking Unit AGCs with the BESS EMS.

**4. Schedule-based Charging and Discharging**

- The BESS shall be provided with scheduled charging and discharging facility, both from URS thermal power and from RE tie-up power.
- Scheduling shall be possible for complete one day with 15-minutes time block interval.
- Schedule revision and overwriting shall be possible as many times as required during operation

**5. Manual Control**

- In this mode, the BESS shall be able to charge and discharge its battery through manual setpoints given via BESS SCADA HMI.
- BESS SCADA shall also have the facility to receive charge/discharge setpoints from RLDC/LDC and BHEL/End customer control center

**6. URS/RE Power Time Shifting**

- BESS shall automatically charge with URS/RE power during surplus periods and discharge to the grid during peak load demand or as per BHEL/End customer requirements.
- EMS shall ensure charge/discharge scheduling in line with SoC, availability of URS/RE, and grid requirements.

**7. Ancillary Services & Grid Support**

- The BESS shall support provision of PRAS, SRAS, TRAS, as well as black start capability, reactive power control and synthetic inertia response, as per grid requirements and latest CEA guidelines/CERC regulation.



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#### BESS Functional requirement

1. **Reactive Power Control:** The BESS shall be required to provide reactive power (capacitive and inductive) support to the grid for voltage regulation purposes. BESS operator shall be able to provide reactive power/power factor set point through BESS SCADA HMI (manual intervention). BESS SCADA shall also have the facility to receive the reactive power setpoint from RLDC/LDC and BHEL/End customer control center.
2. **Black Start Capability:** BESS shall set and automatically control the grid voltage and frequency within the acceptable limit and shall discharge the battery based on load requirement. BESS shall have all the required hardware, control, and protection features for the safe operation during operation in Black Start mode.
3. **Ancillary Services:** For participation in the ancillary services market based on CERC Ancillary Services Regulations, the BESS shall be provided with all required control logic and facility/provision for the following types of Ancillary Services, namely:
  - Primary Reserve Ancillary Service (PRAS);
  - Secondary Reserve Ancillary Service (SRAS);
  - Tertiary Reserve Ancillary Service (TRAS); and
  - Such other Ancillary Services as specified in the Grid Code.

For this, the bi-directional communication system with RLDC, as per the requirements, shall be provided. Provision shall be provided to select the operation mode in the BESS SCADA HMI. At a time, only one operational mode shall be selected.

4. **The Automatic Generation Control (AGC):** BESS shall have capability to operate in AGC. The details regarding AGC signals required but not limited to, are given in Grid India website. BESS shall be able to operate in AGC and be able to comply with the requirements desired by system operators. Some of the BESS signal list for implementation of AGC shall be as follows (list is indicative only):
  - a. Maximum MW permissible (dynamic or user entry)
  - b. Minimum MW permissible (dynamic or user entry)
  - c. Ramp rate up permissible (dynamic or user entry)
  - d. Ramp rate down permissible (dynamic or user entry)
  - e. Actual MW
  - f. Actual MVAR
  - g. Auxiliary Consumption MW
  - h. Scheduled MW (dynamic or user entry)
  - i. BESS Temperature (for monitoring and correlation)
  - j. Ambient Temperature (for monitoring and correlation)
  - o. Cycle limits (0-100%) per day (user entry)
  - l. Circuit breaker status
  - m. Local/Remote status
  - n. AGC Set Point MW from LDC to BESS
  - o. Voltage (kV) at grid level
  - p. Voltage (V) at BESS LV side



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**5. Capability to Provide Synthetic Inertia:** The Battery Energy Storage System (BESS) to be deployed at thermal power stations shall have the capability to provide synthetic inertia to support grid frequency stability during sudden disturbances or generation-loss events. BESS shall be equipped with advanced control algorithms within the Power Conversion System (PCS)/EMS to detect the Rate of Change of Frequency (RoCoF) and respond by rapidly injecting or absorbing active power. This response shall emulate the inertial behaviour traditionally provided by synchronous generators.

Key capabilities shall include:

- Required Synthetic inertia response, depending on system RoCoF and state-of-charge (SoC).
- Operation in grid-forming mode, enabling the BESS to act as a controlled voltage source and support dynamic system behavior during grid events.
- Real-time RoCoF monitoring and control logic to proportionally modulate active power output during frequency deviations.
- Provision for reservation of a defined portion of BESS capacity for inertial support, for ensuring availability during transient events.

The synthetic inertia capability shall be designed to arrest frequency decline, improve frequency nadir, and reduce system RoCoF. When integrated with thermal units operating in flexible or part-load modes, this functionality shall enhance the station's ability to contribute to fast frequency response and system stability under high renewable penetration and declining system inertia

**Other Requirements of BESS:**

- a. BESS shall be capable of operating in the frequency range of 47.5 Hz to 52 Hz and be able to deliver rated output in the frequency range of 49.5 Hz to 50.5 Hz.
- b. BESS shall be capable of operating when voltage at the interconnection point on any or all phases dips/rises to the high or low levels. The levels applicable for wind/solar inverter-based generation shall be referred as available in Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations.
- c. The safe and reliable operation of power system is ensured by frequency control as well as voltage control. BESS to be implemented shall have provisions for Primary frequency control with a droop which can be set as per system requirement between 1-3 percent. The BESS performs regulations in one or several pre-defined ways (e.g. regulating its own output power according to the orders given by EMS/SCADA system) to achieve an active power balance between generation and demand to maintain the power system frequency within a reasonable range.
- d. BESS shall operate to maintain voltages as per specified voltage ranges in Grid standards. BESS shall have feature to detect the voltage of interconnection point and regulate voltage independently. The response time of the BESS shall not exceed the value specified in relevant standards or grid codes.
- e. BESS shall operate in a manner to promote the power system reliability and improve the power quality. When power quality problems, such as voltage dip, flicker, unsatisfactory power factor, etc., occur in power system, the BESS shall be able to eliminate these problems by flexible active and reactive power output in this function.



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- f. The BESS shall provide reliable protection and not be limited to as an overvoltage/under-voltage protection, overcurrent protection, low- temperature/over- temperature protection of battery, DC insulation monitoring, etc.
- g. BESS is required to have the following basic functions:
- i. Monitoring: Monitor operational parameters, equipment status and communication status, alarm and faults of main equipment and BESS system, etc.
  - ii. Information exchange: Receive and process information with RLDC including operation parameters, switching information various alarms and alerts, protective action signals, control information, etc.

Control: Including control mode and parameter setting with RLDC/NLDC.

## 12. BATTERY AND BATTERY MANAGEMENT SYSTEM

### Provenness criteria

The battery manufacturer must have manufactured and supplied at least 50 MWh of batteries (of the technology which has been offered in the bid) cumulatively during last three (3) years in stationary grid applications as on BHEL prebid tender opening date.

### **CODES AND STANDARDS**

The BESS shall conform to all applicable IEC and UL standards. Where an applicable IEC/UL standard is not available, IS/ any applicable international standard shall be referred to as best practice. BESS shall meet all the latest CEA/CEIG and local statutory requirements for interconnection with grid at the required Voltage level.

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

IEC 61850/ DNP3	Communications networks and management systems. (BESS control system communication).	
UL 1973 battery) or (IEC 62619 (battery)+ IEC 63056 (battery))	Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications / Secondary cells and batteries containing alkaline or other nonacid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Either UL 1642 or UL1973 or (IEC 62619 + IEC 63056) for the Battery level



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UL 1642 or UL 1973, Appendix E (cell) or IEC 62619 (cell) + IEC 63056 (cell)	Secondary cells and batteries containing alkaline or other non-acid electrolytes -Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Required for Cell
IEC 62933-2-1	Electrical Energy Storage (EES) systems-Part-2-1: Unit Parameters and Testing methods-general Specification	Tests for Class B application: 1.Duty cycle round Trip Efficiency test 2.Equipment and basic Function test. 3. Available Energy Test 4. Insulation Test
IEC 62281 / UN 38.3	Safety of primary and secondary lithium cells and batteries during transport: Applicable for storage systems using Lithium Ion chemistries	Required for both Battery and Cell
UL 9540 or (IEC TS 62933-5-1 + IEC 62933-5-2)	Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid integrated EES systems – General specification/ Standard for Energy Storage Systems and Equipment	Either UL9540 or (IEC 62933-5-1 + IEC 62933-5- 2) is required for BESS system level
IEC 61427- 2/IS 16270	Secondary cells and batteries for renewable energy storage for On grid applications - General requirements and methods of test	Required for Cells and Battery Modules
UL9540A	Standard for Thermal runaway	Required for BESS system level


#### **BESS General Requirements**

BESS shall be transportable, containerized energy storage system 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), PCS, Inverter duty transformers, auxiliaries, such as HVAC and fire detection and protection systems, LT switchgears, Control Systems etc.

#### **BESS Parameters**


The BESS capacity for a given year shall be maintained consistently throughout the year under ambient temperature conditions ranging from 0°C to 50°C, as well as under other extreme ambient conditions. The Bidder shall be responsible for providing suitable HVAC systems and any other



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**necessary equipment to ensure that the required BESS capacity is maintained. The BESS parameters indicated in the table below specify the minimum requirements to be complied with by the Bidder.**

Item Description	Requirement
Battery Technology	Any battery technology suitable for operation in site-specific climatic conditions can be used.
Project Capacity	MW/MWh for each shall be as per specification..  Bidder to ensure that battery life cycle/degradation etc. are duly considered as per Battery OEM guidelines.
Cycle Life/Project Life	Project Life shall be 15 years from trial run of the Project
Depth of Discharge (DOD)	The Bidder shall decide on the suitable battery storage DOD as per the offered battery technology. During the detailed engineering stage, the Bidder shall specify the BESS Battery maximum 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 so that the above maximum DOD level is not violated under any operating conditions/ circumstances during operation Bidder shall provide suitable calculation/document in this regard during detail engineering. DoD shall be defined at C/2 Rate of Discharge
Round-Trip ac-dc-ac efficiency at POI	Round trip AC/AC Efficiency (%) of BESS system at Metering Point shall be considering the energy loss (including auxiliary power requirement) of BESS.  Annual average round trip AC/AC efficiency (including aux. consumption) in any year shall not be less than 87% for entire design life of BESS i.e., 15 years without aux consumption at 33kV outgoer level.

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Use case requirements.  (Any other control/application mode if required during CAMC shall be configured by Bidder.	a. Peak Management b. Grid Ancillary services c. VAR support to Grid / voltage Regulation d. Black Start capability e. Frequency Regulation /Grid support f. Energy Arbitrage/energy shifting operation/Solar Smoothing g. Ramp rate support h. Power Quality mitigation to Grid i. Interaction on real-time with IEX for schedule of charging and discharging. j. Emergency Back-up k. Electric Energy Time-shift:
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.
Charging/ Discharging rate/ Ramp rate /Response time	Suitable for Application requirement.
Power Factor range at POI (minimum)	As per CEA connectivity regulation when it is charging/discharging condition
VAR support to Grid facility	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
Identification and traceability	Battery Cells/Racks/Packs assembly shall meet the seismic requirement for the plant location of the BESS. Labeling of cells/batteries shall include manufacturer's name, cell type, name-plate rating, date of manufacture and date of expiry of parts and warranty details

- Only cells that are commercially available or for which suitable (not necessarily identical) replacement cells can be supplied on short notice will be allowed. For both premature cell failures and end-of-battery-life replacement, the Bidder 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 BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the BHEL/End customer and approved prior to dispatch.



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- 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 the purpose of addressing safety issues.
- Battery shall not produce any gases and shall be free from fire hazards.
- 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 Bidder to suit the PCS and battery efficient and safe operational requirement.
- 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
- 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.
- 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.
- DC wiring shall be adequately braced to withstand the available fault currents. Protection shall be provided through a DC breaker, fuse, or other suitable current-limiting device on the battery bus, coordinated with the PCS capabilities and battery string protection. The Bidder shall carry out a detailed fault analysis and protection coordination study for the battery DC subsystem during final design. Shipment of the BESS shall be subject to satisfactory completion and acceptance of this fault analysis by the BHEL/End customer .
- 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.
- 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 Bidder shall have overall responsibility for the safety of the electrical design and installation of the battery, as well as all aspects of the BESS.



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- 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.
- 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.
- 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 Bidder 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
- Type test reports for battery system as per requirement of relevant IEC/applicable standard shall be submitted during the detailed engineering. The type tests reports shall be as per the requirements identified in Part A of the technical specifications.
- The Bidder shall design and install a fire protection system that conforms to national and local codes, good engineering practice and latest CEA guidelines. The fire protection system design and associated alarms shall take into account that the BESS will be unattended. The Bidder 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 Bidder shall also obtain thermal runaway characterization of the battery storage systems.
- Provision shall be made for future Augmentation/Replacement by keeping Spare Racks for accommodating Battery Stack Modules capacity.
- The design of all modules and racks shall specifically account for the anticipated vibrations and shocks associated with the transportation of the BESS.
- 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.



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- The Contractor will comply with the requirements under Hazardous & other Waste (Management and Trans boundary Movement) Rules, 2016, as amended from time to time, as applicable. The Contractor shall ensure that all Unit Battery modules from the plant after their 'end of life' (when they become defective/ non-operational/ non-repairable) are disposed in accordance with the "e-waste (Management and Handling) Rules, 2016" notified by the Government and as revised and amended from time to time and Battery Waste Management Rules, as and when notified by the Government of India.
- Contractor has to take Comprehensive Annual Maintenance Contract (AMC) from Original Equipment Manufacturer (OEM) **or OEM authorized service provider** for the following components:
  - PCS System
  - EMS/SCADA
  - Battery and BMS System

**Overvoltage Requirement**

- The Contractor shall carry out dynamic stability study till 220KV level upfront in order to assess the dynamic overvoltage requirements. These studies shall include conditions with maximum and minimum short circuit system MVA conditions, single phase and three phase faults as well as stuck breaker, outage of nearby generator and also with outage of parts of the BESS. It is important that the BESS rides through temporary over voltages and not trip when in voltage control mode.
  - The BESS shall be designed to withstand sequential over voltages.
  - The contractor shall evolve the insulation co-ordination of the components of the BESS after studies have been conducted to determine the over- voltage profile with the BESS connected to the system.
- ENCLOSURE/CONTAINER OF BESS**
  - The battery enclosure details as below.

Fire Rating	2 Hrs
Corrosion Level	C5M
Enclosure IP rating	IP54
HVAC	as per rated battery capacity
HVAC Mounting Arrangement	Wall/Roof Mount
FFS/FSS Suppressant used	Aerosol (UL Listed )
E-Stop Functionality	Yes
Design Standard	As per NFPA 855



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- BESS shall be provided in prefabricated containers specially designed for battery storage solutions, fully assembled and tested as per requirement of relevant codes/standards. Containers shall be designed to be dropped shipped onto properly prepared pads or foundations. The containers shall also be fire-retardant. The container material shall possess chemical and electrochemical compatibility and shall be resistant to acids and alkaline substances (as required). When fully installed, BESS components, including all auxiliaries shall be enclosed in containers, even if certain components are shipped separately and installed on-site. Containers shall have an IP54 class of protection. Suitable ventilation/controlled air conditioning and personnel safety measures in the battery room/container must be maintained to minimize health hazards from exposure to hazardous battery elements. Containers shall meet all safety requirements, including aisle width, working space, lighting, emergency provisions, etc. Container(s) shall be provided with lifting hooks of suitable capacity according to their weight and size.
- The effects of wind, storms, floods, lightening, elevation, temperature extremes, icing, contamination, pollution and earthquakes must be considered in the design and operation of the connected facilities.”
- The BESS, therefore, shall be designed keeping in view the ambient temperature and weather conditions prevailing at site i.e. The BESS shall be able to deliver rated performance at the extreme temperature and weather conditions at site where it is deployed. In this regard, the procedure notified by CEA on 8<sup>th</sup> April 2024 for assessment of the “Design Temperature for RE Plants in compliance to CEA (Technical Standards for Connectivity to the Grid) Regulations” shall be followed. Same is available at: <https://cea.nic.in/whatsnew/?lang=en>
- Cells/Racks/Packs Assembly shall meet seismic requirement for the plant location of the BESS. Labelling of cells/batteries shall include manufacturer’s name, cell type, name-plate rating, date of manufacture and date of expiry of parts and labour warranty.
- Other subsystems/components used in the BESS must also conform to the relevant international /national Standards for Electrical Safety for ensuring Expected Service Life and Weather Resistance.
- As Battery Energy Storage System is prone to fire hazards, the contractor shall provide suitable means such as fire barrier between switchyard and BESS to avoid fire spread from BESS to Yard equipment. The safety of the equipment / personnel related to BESS operations will be in the scope of the Contractor.
- Batteries/ Power Conditioning Units deployed in the project must have valid test certificates for their qualification as per above specified IEC/ BIS Standards by one of the ILAC member signatory accredited laboratories. In case of module types/ BESS/equipment for which such Test facilities may not exist in India at present, test certificates from reputed ILAC Member body accredited Labs abroad will be acceptable.
- Contractor shall procure performance guarantees from the OEM to ensure minimum performance levels for predefined application(s) as per the terms of the contract document. The Warranty shall clearly indicate life expectancy given discharge profiles provided for the application.
- 

#### TERMINAL POSTS



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Both the +ve and –ve terminals of the cells / modules 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 have acid/alkaline resistant and corrosion retarding properties. 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 +ve and –ve posts shall be clearly and unambiguously identifiable.

**CONNECTORS, NUTS & BOLTS, HEAT SHRINKABLE SLEEVES (As applicable)**

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding connectors of suitable material & size shall be provided to enable connection of the cells/modules. Connections shall be suitably protected to withstand corrosion even at a very high rate of charge or discharge. Nuts and bolts for connecting the cells/modules shall be made of copper, brass, galvanized steel or stainless steel, which shall be effectively coated (if required) to prevent corrosion

**ACCESSORIES**

The cells and battery system shall be supplied with all required / recommended accessories to make the system fully functional. Automatic fire fighting system should be provided as per NFPA.

**LABELING**

Stack/Cell terminals and interconnects shall have adequate current-carrying capacity. The labeling of the Stack/Cell shall include the manufacturer's name, Stack/Cell type, nameplate rating, and date of manufacture, all in fully legible characters. All Stack/Cells shall be traceable to their point of origin for the purpose of addressing safety issues. The polarities of Stack/Cell terminal posts shall be embossed on the cover at the terminal.

**EARTHING OF ENCLOSURES/RACKS**

The battery racks/container shall be grounded, and configurations may be solid or high resistance grounded. However, the battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for each 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. Earthing of Battery/Enclosures/Racks/PCS shall be as per OEM recommendations.

**DC CABLES**

Cables used shall be of min. 1.5 kV (DC) grade. Cables used between battery system and PCSs shall be of suitable grade as per maximum DC voltage of battery array. These Power cables shall have compacted Aluminium/copper conductor, XLPE insulated, PVC inner sheathed (as applicable), Armoured, FRLS PVC outer sheathed conforming to IS: 7098 (Part-II). These cables shall confirm to the requirements of the standards & codes of (LT Cables) or any other relevant standard specified elsewhere in the specification. For other details, refer to the sub section for LT power cables in the technical specifications.

**BATTERY MANAGEMENT SYSTEM**

The BMS shall be designed to provide automatic, unattended operation of the battery storage system. BMS shall manage a rechargeable battery (cell or battery pack), including protecting the battery from





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operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.

- a) 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.
- b) 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.
- c) 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.
- d) It shall also monitor utility side parameters such as voltage, charge/discharge current and protection system readings/status.
- e) 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 (CCCV) 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.
- f) 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 health and provide critical safeguards to protect the batteries from damage.
- g) Monitoring and storing the battery's parameters and communicating the same to SCADA/EMS.
- h) Alarm and fault generation and communicating the same to SCADA/EMS
- i) Isolating the battery in cases of any emergency.
- j) BMS, EMS and PCS shall be operated in a coordinated manner in order to achieve the above requirement.

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.

#### TYPE TESTING

During detailed engineering, the Bidder shall submit all the type test reports carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either should have been witnessed by a client or conducted at an independent laboratory by one of the ILAC member signatory accredited laboratories. In case of module types/ BESS/equipment for which such Test facilities may not exist in India at present, test certificates from reputed ILAC Member body accredited Labs abroad will be acceptable.



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

#### Factory Acceptance Test (FAT)

Factory Acceptance Test shall be performed at Manufacturer's premises and tests to be covered under FAT shall be as per guidance of Quality Acceptance Section.

The FAT shall be carried out as per the testing methods and procedures mentioned in IEC 62933-2-1: 2017 or IS 17067 (Part 2/Sec 1):2019. The tests which are applicable on complete system like AC-AC Round Trip Efficiency test, such tests shall be conducted during SAT, as per the above-mentioned testing methods.

The contractor shall carry out FAT at sub system and module level and it shall include for all component to the extent possible. The contractor shall submit FAT document to Employer for approval purpose prior to raising inspection call. It shall include following test:

- a. Visual Inspection of equipment including dimension and overall design
- b. Verification of sensors, metering and alarms
- c. Verification of all control function including remote control, monitoring and communication interface
- d. Verification of system performance at full/ partial Energy/ Power ratings
- e. Verification of maintenance and replacement features for unit batteries and other components
- f. During the FAT, system shall be operated as specified and designed in all the operating states, use cases and duty cycles. It shall meet power/ energy requirements and shall be demonstrated to meet the safety requirements.

Operation of all control, protective relaying and instrumentation circuits shall be demonstrated by direct tests, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local and remote operation of the controls shall be demonstrated.

BESS shall be verified for operation at temperature extremes defined in specification. For this, if it is not possible for the full system, then independent laboratory certification of operation of critical components and subsystems shall be submitted at the time of FAT.

During FAT, if something mal-operates then FAT shall be suspended and resumed after rectification of the problem. The system shall not be accepted for shipment until all FATs have been successfully completed.



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### 13. POWER CONDITIONING UNIT

#### PROVENNESS CRITERIA POWER CONVERSION SYSTEM (PCS)

The bidder/sub vendor should have manufactured grid-interactive bidirectional PCS of cumulative installed capacity of 10 MW or higher, out of which PCS installation at one location should be of 2.5 MW capacity or higher. The reference PCS installation of 2.5 MW or higher capacity should have been successfully commissioned at least one (1) month prior to the date of prebid tender opening.

And

The Bidder/sub-vendor should have in-house PCS routine testing facility as per relevant standard of PCS application to BESS.

**Note: Design validation of PCS sizing, IDT sizing, associated cable sizing, etc shall be done by the PCS Manufacturer. Certification for the same from PCS manufacturer shall be submitted by the Contractor during detailed engineering.**

#### GENERAL

The Power Conversion System (PCS) shall be bi-directional Inverter and shall act as an interface between the DC battery system & the AC grid. PCS shall be designed to charge & discharge the BESS battery in coordination with energy management system and battery management system. The PCS shall consist of fast acting solid state electronic switches along with all associated control & protection, filtering, measuring instruments and data logging devices. The PCS shall be bi-directional inverter with four quadrant operations. The PCS output shall always follow the grid voltage & frequency by sensing the grid voltage and phase and the PCS shall always remain synchronized with the grid. The PCS shall use only self- commutated device which shall be adequately rated.

The continuous combined rating of all PCSs shall not be less than respective BESS Plant capacity with 0.95 p.f. at 50-degree temperature.

However, PCS capacity used in the plant may be chosen such that it can comply the 0.95 power factor capability as per CEA regulation of the total plant at POI (220 KVas applicable) of thermal plant switchyard.

Inverter/PCS capacity at delivery point should be suitably designed to meet the reactive as well as active power as per site temperature as per CEA Connectivity to Grid Regulation for the entire design life of BESS.

Same size and same make of PCS is recommended for the whole plant.

The PCS shall also be capable of supporting Black Start operation, Ancillary Services (PRAS, SRAS, TRAS, etc.), and delivering Synthetic Inertia response as per grid requirements.

#### CODES AND STANDARDS

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



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IEC-61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency requirements
IEC 61000-6-2 Ed.2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-2 Ed.2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEEE 519-2022	Recommended practices and requirements for harmonic control in electrical power systems.
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h+ 12 h cycle)
IEC 62116 Ed.2	Testing procedure—Islanding prevention measures for power conditioners used in grid- connected photovoltaic (PV) power generation Systems
IEC 62477-1	Safety Requirements for power electronic converter systems and equipment-Part-1: General
IEC 62477-2	Safety Requirements for power electronic converter systems and equipment-Part-2: Power electronic converters from 1000Vac or 1500V DC up to 36kV AC or 54kV DC
IEEE 1547/IEC 61727/ BDEW (as applicable)	Standard for interfacing solar PV plant with utility grid.
IEC 60529	Ingress protection test
CEA Grid Connectivity Standard	Relevant CEA regulations and Indian grid code as amended and revised from time to time.

**General Requirements**

The PCS may consist of one or more parallel units. Paralleling may be at the DC or AC terminals. The PCS circuit topology shall be voltage source (that is, the PCS at its AC terminals shall appear to the grid



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as a voltage source rather than as a current source and, at its DC terminals, shall be capable of reversing current flow in the battery without reversing the polarity of the DC bus).

The PCS shall include all necessary self-protective and self-diagnostic features to protect itself from damage in the event of component failure or the excursion of operating parameters beyond a safe or expected range. This includes excursions due to internal or external causes. The self-protective features shall prevent the PCS from being operated in a manner that may be unsafe or damaging. Faults due to malfunctions within the PCS, including commutation failures, shall be cleared by the PCS over-current protection device(s).

PCS shall meet the following technical parameters:

1.	Nominal output voltage frequency	50Hz
2.	Continuous operating frequency range	47.5 Hz to 52 Hz
3.	AC Voltage Range	± 10% of rated AC voltage
4.	Euro efficiency	Minimum 97% (as per IEC 61683)
5.	Surge Protection Device (SPD)	Type-I & II DC side Type-II AC side
6.	Euro efficiency	Minimum 97% (as per IEC 61683)
7.	Operating power factor range	0.8 Lead to 0.8 Lag (minimum)
8.	SVG /Four Quadrant Operation	Required.
9.	Current harmonics	As per CEA regulation requirement/IEEE 519
10.	Current THD value	< 3% at nominal power
11.	DC Injection	<0.5 % at rated current
12.	Operating ambient temperature	0 to 60 ° C
13.	Humidity	95 % non-condensing
14.	Maximum Noise level	75 dBA (for indoor application)
15.	Flicker	As per CEA regulation requirement
16.	Remote start and stop facility from SCADA/EMS	Required.
17.	Active power limit control, reactive power, and power factor control features.	Required. Possible both from PPC and/or EMS SCADA.
18.	PCS designed DC fault current level	Maximum short circuit current of Battery system connected to PCS and duration continuous.

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19.	PCS designed AC fault current level	Maximum short circuit current of LV side of Inverter Duty transformer and duration one sec.
20.	(i) AC & DC overcurrent protection. (ii) Synchronization loss protection. (iii) Over temperature protection. (iv) DC & AC under and over voltage protection. (v) Under & over frequency protection. (vi) Cooling system failure protection (vii) Battery array ground fault monitoring & detection (if applicable) (viii) Battery system insulation monitoring (if applicable) (ix) LVRT protection (x) Anti-islanding protection (xi) Grid monitoring (xii) Black start feature (xiii) Provision to provide synthetic inertia (xiv) Ancillary Services (PRAS, SRAS, TRAS, etc.)	Required.

- The PCS shall comply with the Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments.
- The PCS shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.
- 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 in the islanded operation of BESS plant and loss of generation. In case there is excitation of any resonant condition in the system during BESS plant operation that may result in the islanding/tripping of the BESS plant and affect the power transfer, it shall be the responsibility of Bidder to rectify the design and carry out required modification in the equipment of his supply.
- The PCS must be self-managing and stable in operation.
- In case of grid failure, the PCU shall be re-synchronized with the grid after revival of power supply. Bidder to furnish the time taken by PCU to be resynchronized after restoration of grid supply during detailed engineering.
- The PCS shall include appropriate self-protective and self-diagnostic features to protect itself and the Battery system 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. The self-protective features shall not allow signals from the PCS front panel to cause the PCS to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCS protective devices.



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- PCS shall have necessary limiters in-built features in the controller so as to ensure safe operation of the PCU within the designed operational parameters.
- PCS shall have thermal overloading protection to prevent failure of switching devices and other components of Inverter. PCS controllers shall automatically regulate/limit the power output to reduce the PCS cabinet and switching devices temperature. Bidder to submit the PCS power vs ambient temperature curve during details engineering stage. PCS shall be able to provide inverter inside cabinet and switching devices temperature (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.
- PCS shall have AC and DC side monitoring capability and reporting to SCADA/EMS system (measured analog and digital value measured within PCS). Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.
- All-important alarm and trip signals shall be configured in the PCS and their corresponding modbus address shall be provided for SCADA/EMS configuration. Signals such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, Inverter cabinet temperature high alarm and all other important signals shall be necessarily included. Details signal list shall be finalized during detailed engineering stage.
- The PCS shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details of earthing arrangement of PCS and system earth pit requirement. The detailed specification for panel earthing for safety has been mentioned elsewhere in this specification.
- The PCS shall be capable of starting and operating as black start i.e., without the presence of the utility voltage. Exercise of the black start capability shall be manual and interlocked and 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.
- In case auxiliary supply of PCS is met internally, then it should have sufficient power backup to meet the LVRT requirement.
- Bidder to submit third-party verified OND files of the battery inverter during detail engineering.
- Bidder shall provide the only central PCU
- **CENTRAL PCS**
- PCS must have provision to be isolated from grid through Air Circuit Breaker/MCCB. The ACB/MCCB as required can be provided as a part of PCS/its Modules or separately based on standard design and configuration of PCS manufacturer. The ACB and MCCB shall be able to withstand the maximum fault current for minimum one sec duration. ACB/MCCB shall be able to isolate PCS from AC grid under all fault current condition. Any alternate provision other than ACB/MCCB which is recommended by OEM and meeting the requirement, shall be considered on a case-to-case basis during detailed engineering stage.





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- PCS shall have suitable rated DC isolator/contacter for isolation of DC Battery system from inverter. Suitable rated fuse shall be provided (at inverter end) in incoming DC cable from battery system. One set spare terminal with fuse/link (as applicable) and holder shall be provided for future use.
- The PCS should be designed for parallel operation through galvanic isolation. Solid state electronic devices shall be protected to ensure smooth functioning as well as ensure long life of the inverter. Parallel operated PCS system are also accepted subjected to recommendation of PCS manufacturer. In such case, PCS design shall also ensure that no abnormal interaction shall take place among the PCS unit during any grid operating condition which may result in outages.
- Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided.
- PCS shall have suitable communication cards (Modbus TCP/IP) for networking and SCADA/EMS integration and same shall support dual master communication. PCS shall include all important measured & internal calculated analog values and alarm & trip signals for remote monitoring, storing and report generation purpose in SCADA system. Details list of above such parameters shall be provided along with their Modbus address during detail engineering stage.
- In case of modular design of PCS is offered, the 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 good dynamic performance. The Bidder shall indicate the control scheme adopted for modular PCS and its merits and the test which will check its performance.
- Bidder may offer liquid cooling system subject to BHEL/End customer's approval. In case Liquid cooled inverters are offered, the Bidder to ensure that coolant is used in closed cycle. Complete inverter along with cooling system shall be of proven design.
- PCS shall have emergency stop push button for tripping of inverter with complete DC & AC electric isolation.
- Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized.
- String Monitoring facility:- PCS shall be provided with current monitoring transducer at incoming DC cables from each battery array. The current transducers used for this purpose shall have accuracy of 1.0 class or better.
- The PCS shall be capable of supplying reactive power as per grid requirement. PCS shall have Static Var Generation (SVG) function.
- 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.

**OUTDOOR PCS**



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- a. Outdoor PCS enclosure must be suitable to withstand the harsh environmental conditions for complete life of plant. Suitable shed along with canopy shall be provided for outdoor installation.
- b. The PCS enclosure protection class shall IP 54 or better protection. For outdoor solution (Other than containerized), the electronic card compartment shall have IP 65 or better protection.
- c. Bidder to submit temperature endurance test report of complete assembly during detail engineering stage.
- d. Containerized solution shall have projection of at least 60cm wherever an opening in the inverter door exposes the inverter component to outside environment. Structural steel and paints for shed shall be as per ISO 12944-5.
- e. Outdoor inverter (including containerized solution) platform shall be raised Min 1250 mm from NGL. Cable bending radius and other relevant factors to be considered during platform design. This shall be reviewed and finalized during detailed engineering.

#### TYPE TESTING

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

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



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## 14. ENERGY MANAGEMENT SYSTEM and SCADA

### PROVENNESS CRITERIA ENERGY MANAGEMENT SYSTEM (EMS)

Bidder/Sub Vendor should have designed/engineered and supplied EMS for grid interactive battery energy storage system of cumulative installed capacity 5 MWh or higher which should have been successfully commissioned at least one (1) month prior to the date of BHEL prebid tender opening. The Application Software of the Energy Management System (EMS) of the BESS shall be developed indigenously within India. (As per F.No. 48-15/7/2025-NRE Section; dtd. 04<sup>th</sup> August 2025, Amendment in Operational Guidelines for viability Gap Funding Scheme for development of Battery Energy Storage System supported through Power System Development Fund (PSDF)-reg.)

### GENERAL

Energy Management System (EMS) system of individual plants shall be a computerized system for real time monitoring, operation, control, reliable & efficient operation and optimization of performance of the BESS Plant. SCADA system shall be part of EMS system. EMS shall be able to acquire real time data of various equipment of BESS system, have in built logic/programming to monitor, control, and optimize the performance of BESS as per specification.

Parameter visualization at 100% capacity level is also required for performance measurement of total BESS Plant.

Suitable provision of Remote control and monitoring facility in EMS shall be provided in addition to local control and monitoring so that all trouble-shooting and subsequent action can be taken from BHEL/End customer corporate center. Necessary software at remote and local end shall be under scope of Bidder.

Bidder shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire BESS Plant and its auxiliary systems. The Bidder shall include all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Gateway, Networking equipment and associated Cable, Laser Printer etc. needed for the completeness even if the same are not specifically appearing in these specifications.

EMS system includes the supply and integration of redundant Power Quality Meters (02 nos) at suitable points. Interconnection with optical fiber communication cables through IEC 61850 to EMS shall also be in Bidder's scope. Also Supply of necessary Ethernet switches at HT switchgear and communication cable from EMS to individual numerical relays and its integration with required accessories is under Bidder's scope.

EMS Panels and EWS/OWS systems shall be located in Central Control room building.

All Rooms , Building construction in customer scope. If any Wiring , Lightning Arrester , other Electrical requirements shall be provided to BHEL/customer during initial stage prior to constructions.

EMS System shall have the provision to perform the following functions:



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- i. Provision to operate the BESS as per following minimum application requirement including Ancillary services but not limited to:
- Integrated control with thermal power plant
  - Standalone operation (independent of thermal plant) based on the grid schedule/requirements.
  - VAR support to Grid / voltage Regulation
  - Black Start application
  - Frequency Regulation /Grid support
  - Ancillary Services (PRAS, SRAS, TRAS)
  - Energy Arbitrage/energy shifting operation
  - Ramp rate support
  - Power Quality Application to Grid
  - Interaction on real-time with IEX for schedule of charging and discharging.
  - Inertia Support to Grid as virtual Synchronous ii. Remote control of all the HT Breakers either in hard or soft signal
- iii. Remote control of PCS active and reactive power as per requirement mentioned in respective chapter.
- iv. 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.
- Battery containers with Aux system and BMS
  - All the HT Switchgear/RMU equipment
  - PCS duty Transformers
  - Incomer and bus coupler breaker of LT Panel.
  - Power conditioning System (PCS)
  - UPS and Battery charger as per requirement/ Auxiliary supply systems
  - TEM/ABT/MFM meter, numerical relay, fire alarm panel, GPS time synchronization unit and Aux. transformers.
  - SCADA Hardware, Accessories and Communication link
  - Any other equipment required to complete monitoring of BESS pant upto 33kV level.
- v. Display of status of major equipment in Single Line/Mimic Diagram. Mimic Diagram colour shall comply to IS 11954: Guide for colour coding of electrical mimic diagrams vi. Display and storage of derived/calculated/integrated values
- vii. Generate, store and retrieve user configurable periodic reports. EMS/SCADA shall have facility to generate report in MS Excel file type.



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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 EMS/SCADA Administrator. Internet connection for transferring data to web shall be taken by Bidder in the name of BHEL/End customer Site for CAMC/O & M period.

Please refer Sub Section II of Part A for Nos. of Web Client Licenses for remote monitoring, Nos. of OWS/EWS/Historian with location.

ix. Performing self-monitoring and diagnostic functions

- The Bidder shall provide at least one PTP compliant GPS clock at each Thermal Plant, which shall be synchronized with the SCADA/EMS system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with BESS EMS/SCADA shall be synchronized with GPS Clock through SCADA or directly with GPS Clock.
- 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.
- 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.
- 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 systems 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. The systems shall be designed to ensure seamless operation without any disturbance upon restoration of power. These operations shall be demonstrated by vendor during Factory Accepted Test (FAT) in the presence of BHEL/End customer Representative.
- 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.
- Power plant controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby.
  - In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. The BESS plant SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently be able to control the individual PCS. Detailed control logic in the PPC shall be finalized during detailed engineering stage as per



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grid requirement to support voltage and frequency with suitable droop characteristic as per CEA standard.

1. BESS shall have capability to operate in AGC. The details regarding AGC signals required by not limited to, are given (the conventional power plant signal link) at the link, <https://posoco.in/download/detailed-signal-list-for-connecting-generators-under-agc/?wpdml=29546>. BESS shall be able to operate in AGC and be able to comply with the requirements desired by system operators. Some of the BESS signal list for implementation of AGC can be like below (list is indicative only):

- (i) Maximum MW permissible (dynamic or user entry)
- (ii) Minimum MW permissible (dynamic or user entry)
- (iii) Ramp rate up permissible (dynamic or user entry)
- (iv) Ramp rate down permissible (dynamic or user entry)
- (v) Actual MW
- (vi) Actual MVAR
- (vii) Auxiliary Consumption MW
- (viii) Scheduled MW (dynamic or user entry)
- (ix) BESS Temperature (for monitoring and correlation)
- (x) Ambient Temperature (for monitoring and correlation)
- (xi) Cycle limits (0-100%) per day (user entry)
- (xii) Circuit breaker status
- (xiii) Local/Remote status
- (xiv) AGC Set Point MW from NLDC to BESS
- (xv) Voltage (kV) at grid level

- The project shall comply with an Energy Management System (EMS), a technology platform that optimises the use and operation of energy-related assets and processes. In line with the “Amendment in Operational Guidelines for viability Gap Funding Scheme for development of Battery Energy Storage System supported through Power System Development Fund (PSDF)” notified by the Ministry of Power on 4<sup>th</sup> August 2025, the application software of the Energy Management System (EMS) of the BESS shall be developed indigenously within India.
- The Application Software of the Energy Management System (EMS) of the BESS shall be developed indigenously within India. (as per F.No. 48-15/7/2025-NRE Section; dtd. 04<sup>th</sup> August 2025, Amendment in Operational Guidelines for viability Gap Funding Scheme for development of Battery Energy Storage System supported through Power System Development Fund (PSDF)-reg.)

#### Performance Monitoring

As part of the performance monitoring, the following shall be carried out:

- a) The Bidder must install necessary equipment to continuously measure BESS operating parameters (including but not limited to voltage, current, ambient conditions etc.) as well as



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energy input into and energy output from the BESS along with Metering arrangement in accordance with extant regulations. They will be required to submit this data to **BHEL/End customer**, CTUIL and Grid -India online and/or through a report on regular basis every month for the entire duration of contract.

- b) The plant SCADA should be OPC UA compliant and implement appropriate OPC-UA server as per the specification of OPC Foundation. All data shall be accessible through the OPC server to provide real-time BESS parameters for remote monitoring/RLDC. The Project SCADA system shall make time-series data available for performance monitoring, covering key parameters required to facilitate preparation of daily, monthly, and annual reports.
- c) Web-based monitoring should be available, which should not be machine dependent. The web-based monitoring should provide the same screens as available in the plant. Also, it should be possible to download reports from a remote web-client in PDF or Excel format.

#### SCADA CONTROLLER SYSTEM:

The redundant controller of SCADA/EMS at control room shall be of PLC based as per specification given hereunder. For other locations such as Inverter/Battery containers Room, PLC/ IO modules/RTUs are acceptable

#### Main control room SCADA shall have the following feature:

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

#### DATA COMMUNICATION SYSTEM (DCS)

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



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The DCS shall have the following minimum features:

- i. Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator workstation.
- ii. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.
- iii. If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility
- iv. Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bump less and the same shall be suitably alarmed/logged.
- v. The design and installation of the system bus shall take care of the environmental conditions as applicable.
- vi. Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion
- vii. Cat 6 UTP or fiber optic cables shall be employed.
- viii. The Bidder shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.
- ix. Bidder shall setup Gigabit Ethernet based Plant Local Area Network (LAN) to connect to different communication nodes at Inverter /Switchgear location etc. with redundant backbone using ring or better topology. Each Modbus cable shall be provided with Surge protection device at SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.
- x. Provision of monitoring and event data via the communication interface shall adhere to DNP3 AN2011-001 / IEC 61850 to the extent possible and capture at least the following data points:
  - Frequency at the AC bus
  - AC real power
  - Power factor
  - Real energy delivered





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- Real energy received
- Auxiliary power
- Auxiliary energy
- DC power
- DC voltage
- DC current
- Phase A voltage
- Phase A angle
- Phase B voltage
- Phase B angle
- Phase C voltage
- Phase C angle
- Battery state of charge
- Battery string currents
- Battery temperature

The DAS shall provide unsolicited message capability for reporting critical alarms. The list of alarms shall be finalized during detailed engineering. However, a minimum of following parameters shall be displayed on BESS local control panel, console, or SCADA computer:

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



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- Weak Unit Battery Alarm
- AC system fault
- Control logic problem (problem with the BESS control logic)
- DC fuse blown
- Container door open (BESS container door opening)

**HUMAN MACHINE INTERFACE SYSTEM (HMIS)**

- HMIS shall be configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.
- The SCADA shall be OPC UA compliant and implement a OPC- UA server as per the specification of OPC Foundation. All data should be accessible through this OPC server.
- For communicating with the generation data of plant in End customer, the SCADA system shall be interfaced/ connected with PI server of End customer on OPC Protocol. The details of End customer PI server shall be furnished during the detailed furnished.
- Graphical Interface Unit (GIU) / Operator work station (OWS) shall perform control, monitoring and operation (as applicable) for plant equipment's connected with SCADA system.

Engineering workstation (EWS) shall work as a programming station both for controller and SCADA. It shall be possible to use same EWS as programming station and the Human Machine Interface System.

- SCADA System shall be provided with redundant OWS. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure at Control room in the HMIS.
- In addition to a desktop based EWS, vendor shall also provide dedicated portable (laptop) based EWS.
- 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.
- The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.
- 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.;



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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.

- xi. 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.
- xii. The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
- xiii. The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be on the basis of user profile. The system security shall contain various user levels with specific rights as finalized by the End customer 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).
- xiv. 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.
- xv. 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.
- xvi. SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.
- xvii. 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.
- xviii. 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.
- xix. All programming functionalities shall be password protected to avoid unauthorized modification.

**PROGRAMMING FUNCTIONALITIES**



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

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

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

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

#### SOFTWARE REQUIREMENT

- All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The Bidder shall provide sufficient documentation and program listing so that it is possible for the End customer to carry out modification at a later date.  
The Bidder shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
- Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other systems in industry.
- SCADA system shall include the following standard protocols as a minimum:
  - Modbus (TCP/IP, RTU, ASCII).
  - Sub Station Protocol (IEC-61850 and IEC 60870 -5-101/104).

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



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System at site. All licenses shall be valid for the continuous service life of the plant (15-year CAMC period).

- x. All SCADA software along with license keys shall be handed over to BHEL/End customer in secure USB drive media. All the hardware and software shall be licensed to BHEL/End customer .

#### PARAMETRIC REQUIREMENTS

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

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

#### INPUT/OUTPUT MODULES

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



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- c. Optical isolation between input and output signals with 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.
- vii. Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA. Analog output modules shall be able to drive a load impedance of 500 Ohms minimum. viii. 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.
- viii. Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) and Modbus link at Inverter and main control room shall be calculated based on the Input/output signal list to be submitted by the Bidder for approval during detail engineering

#### SYSTEM SPARE CAPACITY

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

- 10 % spare channels in input/output modules fully wired up to cabinets TB.
- 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.
- 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.
- Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space
- Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller. vi. The Data communication system shall have the capacity to handle the additions mentioned above vii. Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets. viii. The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

#### OPERATOR INTERFACE DISPLAYS/LOGS/REPORTS



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

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

**HISTORICAL STORAGE AND RETRIEVAL SYSTEM (HSRS)**

- i. The HSRS shall collect, store and process system data from MMIPIS data base. The data shall be saved online and automatically transferred to nonerasable long term storage media once in every 30 Days periodically for long term storage.
- ii. The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports.
- iii. The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same.
- iv. In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration on portable external long term storage media. Bidder shall provide two numbers of portable external hard drive of 2TB each.
- v. For long term plant performance analysis, the following plant data as a minimum with time stamping and interval as indicated in below table but not limited to shall be stored daily on historian.

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

Sl.	Parameter	Time Interval
1	Power Conditioning System (PCS):- DC Voltage, DC Power, DC Current,, AC Active & Reactive Power, Power factor, AC Current & Voltage, Energy, PCS room temp, PCS Cabinet temp and Modules Temp	1 (One) Minute
2	MFM, Energy meter and Numerical Relay data:- Active & Reactive Power, Energy (day), Current and Voltage	1 (One) Minute
3	Export feeder/s Energy Meter Data:- Active & Reactive Power, Energy import and export, Current and Voltage and Grid Frequency.	1 (One) Minute



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4	Daily energy export from each PCS	24 (Twenty Four) Hours
5	Total sum of daily energy export from all PCS	24 (Twenty Four) Hours
6	BESS Parameter for different application function assessment: (i) Active & Reactive Power (ii) Reference Target Active & Reactive power	1(one ) second
7	BESS Battery Voltage, SOC (upto Module and String level) and other Important Battery and BMS data.	1(one ) second
	Any other parameter as per End customer/Grid Controller requirement	

**SCADA PANEL/CABINET/CONTROL DESK/FURNITURE**

- i. The SCADA cabinets shall be IP-22 protection class.
- ii. 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 sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.
- iii. The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables for Main control room.
- iv. The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications, preferred height of the cabinet shall not higher than 2200mm. 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 End customer and shall be furnished by the Bidder during detailed engineering. Wall mounted cabinet is acceptable for Inverter room/sub- pooling switchgear.
- v. Cabinet doors shall be hinged and shall have turned back edges and additional bracing where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.
- vi. Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet





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thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm. The Preferable finish colors for exterior and interior surfaces shall conform to following shades:

- vii. Exterior:- As per RAL 9002 ( End panel sides RAL 5012),
- viii. Interior:- Same as above
- ix. Paint films which show sags, checks or other imperfections shall not be acceptable.
- x. As an alternative, single coat of anodic dipcoat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable.
- xi. Control desk shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. ASCII Keyboard shall be capable of being pulled out through a tray.
- xii. 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 remain in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.
- xiii. The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.
- xiv. 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. Armrests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon.
- xv. One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.
- xvi. All the furniture shall be of reputed make (Godrej or Equivalent)

#### HMIPIS HARDWARE

- i. The HMIPIS as specified shall be based on latest state-of-the-art Workstations and Servers and technology suitable for industrial application & Substation environment.
- ii. The Workstation/Servers employed for HMIPIS implementation shall be redundant based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of End customer developed and third-party software.



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iii. Redundant sets of communication controllers shall be provided to handle all the communication between the HMIPIS and redundant system bus and to ensure specified system response time and parametric requirements. Each communication controller shall have message checking facility. Power Fail Auto Restart (PFAR) facility with automatic time update shall be provided.

iv. iv) All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by BHEL/End customer during detailed engineering. The LAN to be provided under HMIPIS shall support

TCP/IP protocol (Ethernet connectivity) with OPC RDI for interface with PLCs/ Owners PI System/other systems and shall have data communication speed of min. 100 MBPS. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

**Engineering Workstations/ Operator Workstations/ Historian/ Portable EWS**

SI No.	Features	Industrial Grade Engineering Cum Operator Workstations/ Operator workstations/ Other workstations/ Documentation station
1.	Processor	<b>Engineering Cum Operator Workstations:</b> 64 bit Server Grade (Xeon or Equivalent), Octacore minimum <b>For other Workstation:</b> 64 bit (i5 or Equivalent)
2.	Memory	<b>Engineering Cum Operator Workstations:</b> 16 GB RAM upgradable to 24 GB minimum <b>For other Workstation:</b> 8 GB RAM upgradable to 16 GB
3.	Hard Disk/SSD	<b>Engineering Cum Operator Workstations:</b> 1 TB RAID1 <b>For Historian:</b> 1 TB ultra wide RAID1 <b>For other Workstation:</b> 500 GB ultra wide RAID1 for OWS/ 500 GB for Portable EWS
4	Communication port	<b>Engineering Cum Operator Workstations:</b> 2 Serial bus. Expansion slot=2 <b>For other Workstation:</b> 4 Serial bus, Expansion slot=2 <b>Portable EWS:</b> 2 Serial bus.

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4.	Monitor (color)	Min 22" TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz, Graphic Memory = 16 MB
5.	Removable bulk storage drive	2 TB (minimum) <b>NAS</b>  Logs for all the events (for all the devices) shall be maintained for a minimum duration of 6 months.
6	Network Connectivity	<b>Engineering Cum Operator Workstations: 4</b> Nos. Built-in Ethernet Network Port For other Workstation: 2 Nos. Built-in Ethernet Network Port  Portable EWS: 1 No. Built-in Ethernet Network Port and 1 No. Wifi
10.	Additional general purpose software (for using over network by servers/work stations/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc. Antivirus subscription shall include definition updates
11	Power supply Unit	Redundant Power Supply Units for Server grade workstations

#### FACTORY ACCEPTANCE TEST (FAT)

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

#### TIME SYNCHRONISATION EQUIPMENT

Time Synchronization equipment shall be provided and shall be located in the Control Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SCADA.


It shall be complete in all respects including antenna, all cables, processing equipment, etc.

All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Bidder.

It shall work from DC supplies only and the Bidder to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.

It shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.

The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.

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All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric protection relays, PCS, BMS and all network components etc. covering all equipment of BESS shall be synchronized with an accuracy of 1ms

The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable) required for time synchronization with SCADA and all other devices shall be in scope of Bidder.

The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.

The system shall have provisions for combination of any of the following output signals:

- PTP (Precision time protocol) 100Mbps Ethernet port
- IRIG-B00x (TTL, pulse width modulated signal)
- 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
- Any other output port as may be required for the offered system.
- Alarm status contact indicating healthy status of system


These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BCUs/ BPUs/Numerical Relays/IEDs etc. as per scope of the specification. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.

The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24-hour mode) and have a separate time display, having display size of approx. 144mm height.

#### **POWER QUALITY METER**

Class-A Power Quality Meter, which is fully compliant to IEC61000-4-30, shall be provided and shall be located at the indicated metering points.

- i. It shall have a facility for time synchronization on the NTP protocol from the existing GPS clock in the BESS SCADA network.
- ii. PQM at the minimum shall measure three-phase voltage & current, power factor, active power, reactive power, harmonics (amplitude and phase), voltage sag and swell, flicker, disruptions. It should have capability of recording 10 second fault recording during LVRT and HVRT phenomenon as per CEA Regulation
- iii. It shall be able to communicate with PPC on Modbus TCP/IP protocol iv. Selected PQM shall be able to measure grid frequency with a minimum of two- digit after the decimal point.
- v. All associated software to be supplied for configuration, monitoring & maintenance of PQM to be installed on the EWS cum OWS.
- vi. Relay shall monitor power quality parameter including DC Injection, create automated daily /event wise reports as per CEA, Grid India, regulatory compliance

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vii. i.e. IEEE519-2014, EN50160, LVRT/HVRT etc. and provide real time alarms for all power quality measuring parameters.

viii. The PQM supplied shall be in compliance to RLDC requirement of daily/monthly automatic generation of Power Quality Report as per IEEE/IEC formats. These reports need to be submitted weekly to RLDC. Bidder to refer the RLDC website of required format of the various power Quality reports for renewable plants. **A. EMS functionality for the BESS Control:**

The following operation modes of BESS can be set from the EMS system:

- **Automatic mode:** BESS behaves according to the selected operation mode.
- HMI mode or manual mode: in this mode, the operator has the possibility to:
  - **Select the operation point o Direct control of active and reactive setpoints of the PCS.**
  - **Command of balance of Plant**
- **OFF-mode:** BESS is not producing any power. The system is disconnected form the grid.
- **STANDBY-mode:** BESS is connected to the grid, but the IGBT's in the PCS system are in an off-state (i.e. open switching).

Also, the performance of every application mode will be controlled and adaptable by this system. This energy management strategy will be operated by the SCADA in Main Control Room. Any failure in the process or the control system including instrumentation must be detected and logged. This means that the instrumentation, electronic and electrical equipment shall include those failure detections.


A communication with the SCADA system must be possible to receive set points and transmit set points for each application mode. The SCADA should be able to remotely control the BESS. The EMS should allow the SCADA at least the following:

- Change the operation mode of each BESS independently
- Start/Stop each application mode appointed to a BESS.
- Change the application mode of each BESS (multiple modes can be selected together)
- Select the amount of power dedicated to each selected application mode.
- Control of control modes based on application for BESS use separately for capacity at each Thermal plant.
- Adapt the parameters needed for the operation of every application mode

The Communication protocol may be IEC 61850 or MODBUS over Ethernet connection (MODBUS TCP). Other solutions can be proposed but are subjected to the BHEL/End customer 's approval.

#### **B. EMS functionality for the Plant Control:**

The EMS monitors grid and Plant facility variables and should be programmable for selecting the optimum-operating mode of the whole plant through PPC or directly w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behavior to the new settings. The EMS (Energy Management System) can be considered as the Plant Power Controller (PPC) provided it meets all the functional and performance requirements specified for the PPC in

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the technical specifications. A separate PPC is not required if the EMS fulfills these requirements. However, if a separate PPC is required as per statutory, grid connectivity, or other regulatory requirements, the same shall be provided by the bidder accordingly.

The EMS shall perform the following functionality to Control the Plant facilities:

- Communication with grid or SCADA
- Communications with BESS and other power units
- Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)
- Control capability of BESS Inverters, BESS and other power units

The EMS shall allow the following operation modes for the Plant facilities:

- Reactive Control (Q Control, setting point of reactive power Q at EMS)
- Power Factor Control (PF Control, setting point of  $\cos(L)$  at EMS)
- Voltage Control (V closed loop control, setting point of V at EMS)
- Voltage Droop (Reactive power vs Voltage programmable curve or droop)
- Apparent Power Control (S Lim, setting point of S Lim at EMS)
- Active Power Limitation (P Lim, setting point of P Lim at EMS)
- Power Ramp Rate Control (setting point of maximum %Pn/min)
- Frequency Regulation (Power vs Frequency programmable curve or droop)

In addition to these operating modes, the EMS shall be prepared to work under voltage dips, allowing the PCS to inject the corresponding reactive power to provide the corresponding voltage support at the EMS. The EMS can receive the target values specified by grid operators using a standard protocol (i.e. Modbus TCP/IP) and over different communication media.

#### C. Measurements

To perform the application modes described above, measurements are needed at the Point of Common Coupling (PCC). The measurements are (but not limited to):


- Voltage measurement: This is needed to perform voltage regulation and reactive power compensation.
- Output power (Active and Reactive): This will be measured with an accuracy precised by the supplier. The measurement equipment should be class 0.2s.

#### D. Control & Power Supply Scheme

Bidder shall provide the UPS/ DC Power supply of suitable rating to cater all the load requirements of EMS system and its auxiliaries.

#### E. Software Documentation & Listings

All technical manuals, reference manuals, user's guide etc. in English required for modification/editing/addition/deletion of features in the software of the EMS System shall be furnished. The Bidder shall furnish a comprehensive list of all system/application software documentation after system organization for BHEL/End customer's review and approval. All The software listings for

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application software, Project data files etc. shall be submitted by the Bidder. All the EMS Software with license Key shall be handed over to the Owner on USB media. All the hardware and software shall be licensed to BHEL/End customer . License shall be for design life of BESS (15 years).

### **Next Generation Firewall (NGFW) Specification**

#### **General Requirements**

Bidder shall provide NGFW having electrical ethernet interfaces/ports and placed between FOTE & SAS gateway/s at the substation. All ethernet based applications shall be terminated in the firewall ports directly (e.g. PMU, AMR, VOIP, SAS/SCADA etc.). Each port of firewall shall work as a separate zone. Firewall shall be hardware based with features of Block/Allow/drop and IPSec VPN (network encryption).

The number of ports/interfaces in each firewall (i.e. Main/Standby) shall be minimum 5 nos. TSP shall provide either single firewall or multiple firewalls to meet this interfaces requirement, each for main as well as standby firewall. Minimum throughput of firewall shall be 200 Mbps.


The Firewall shall be managed/ configured as standalone at present and shall also have compatibility to manage/configure through Centralized Management Console (CMC) remotely in future.

Firewall shall be tested and certified for ISO15408 Common Criteria for least EAL4+.Further, the OEM must certify that it conforms to Secure Product Development Life Cycle requirements as per IEC62443-4-1. The firewall shall generate reports for NERC-CIP Compliance.

#### **Detail Specifications of Next Generation Firewall (NGFW)**


1. NGFW shall have following features including but not limited to: Encryption through IPSec VPN (Virtual Private Network), Deep Packet Inspection (DPI), Denial of service (DoS) & Distributed Denial of Service (DDoS) prevention, Port Block/ Allow, rules/ policies for block/allow, IP (Internet Protocol) & Media Access Control (MAC) spoofing protection, threat detection, Intrusion Prevention System (IPS), Anti-Virus, Anti-Spyware, Man In The Middle (MITM) attack prevention.
2. The proposed firewall shall be able to handle (alert, block or allow) unknown/unidentified applications e.g. unknown TCP & UDP packets. It shall have the provision to define application control list based on application group and/or list.
3. Firewall shall have feature and also have capability to update the definition/ Signatures of Anti-Virus online as well as offline. Firewall shall also be compatible to update the definitions/signatures through CMC. There shall be a defined process for security patching and firmware up-gradation. There shall be a feature to field validate firmware checksum. The same shall also be validated before using the OEM provided file/binary in the process of firmware up-gradation and security patching.
4. Firewall shall have Management Console port to configure remotely.
5. Firewall shall be EMI/EMC compliant in Substation environment as per IEC 61850-3.



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6. Firewall shall be rack mounted in existing standard equipment cabinets.
7. Firewall shall have support of SCADA applications (IEC-60870-5-104), IEC, PMU (IEEE C37.118), Sub-Station Automation System (IEC 61850), Ethernet and other substation environment protocols.
8. Client based Encryption/ VPN must support different Operating System platforms e.g. Windows, Linux & Mac.
9. The solution must have content and comprehensive file detection policies, blocking the files as function of their types, protocols and directions.
10. Firewall shall have logging facility as per standard logs/events format. Firewall shall have features to export the generated/stored logs/events in csv (Comma Separated Value) and also any other standard formats for offline usage, analysis and compliance. Firewall shall have suitable memory architecture and solution to store and be enable to export all logs/events for a period of last 90 days at any given time.
11. Firewall shall have features and be compatible with local as well as central authentication system (RADIUS, LDAP, or TACACS+) for user account and access right management. It shall also have Role Based User management feature.
12. Firewall shall have the capability to configure sufficient number of VLANs. Firewall shall have the capability to support sufficient number of sessions.
13. Firewall shall have provision to configure multiple IP Sec VPNs, at least 100 nos., (one-to-many or many-to-one). Shall support redundant operation with a similar router after creation of all the IP Sec VPN. IPSec VPN shall support encryption protocols as AES128, AES256 and hashing algorithms as MD5 and SHA1. IPSec VPN throughput shall support at least 200 Mbps.
14. Firewall shall be capable of SNMP v3 for monitoring from Network Management system. It shall also have SNMPv3 encrypted authentication and access security.
15. Firewall shall support in Active/Passive or Active-Active mode with High Availability features like load balancing, failover for firewall and IPsec VPN without losing the session connectivity.
16. Firewall should have integrated traffic shaping (bandwidth, allocation, prioritisation, etc.) functionality.
17. Shall support simultaneous operation with both IPv4 and IPv6 traffic.
18. Firewall shall be compatible with SNTP/NTP or any other standards for clock synchronization.
19. Firewall shall have the features of port as well as MAC based security.
20. Firewall shall support exporting of logs to a centralized log management system (e.g. syslog) for security event and information management.
21. Firewall time shall be kept synchronised to official Indian Timekeeping agency,time.nplindia.org.
22. Firewall product shall be provided with all applicable updates at least until 36 months since the applicable date of product shipping to the concerned utility.



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## 15. CONTROL & INSTRUMENTATION

### COMMUNICATION CABLE (Optic Fibre Cable)

Optic Fiber cable shall be **8/12** core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor /indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multimode fibers on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.

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

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

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

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

Spliced/ Repaired cables are not acceptable.

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

### COMMUNICATION CABLE (Modbus)

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

### INSTRUMENTATION CABLES

#### common Requirement

S No.	Property	Requirement
1.	Voltage grade	225 V (peak value)
2.	Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS- 10810 (latest editions) and their amendments read along with this specification.



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3.	Continuous operation suitability	At 70 deg. C for all types of cables
4.	Progressive automatic on-line sequential marking of length in meters	To be provided at every one meter on outer sheath.
5.	Marking to read 'FRLS	To be provided at every 5 meters on outer sheath
6.	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet
7.	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8.	Ovality at any cross-section	Not more than 1.0 mm
9.	Others	<p>a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name, insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacturer to be provided.</p> <p>b) Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground-buried installation</p> <p>c) Repaired cables shall not be acceptable.</p>
10.	Color	The outer sheath shall be of blue Blue

**Specific Requirement**

S No.	Property	Requirement
	Type of Cable	F and G Type cables
<b>A. Conductors</b>		
1.	Cross section area	0.5 sq. mm
2.	Conductor material	High conductivity Annealed bare copper
4.	Conductor Grade	Electrolytic
5.	No & dia of strands	7x0.3 mm (nom)
6.	No. of Pairs	4,8, ,16,24,48
7.	Max. conductor resistance per Km (in ohm) at 20 deg. C	73.4 (loop)
8.	ReferenceStandard	VDE 0815
<b>B. Insulation</b>		
1.	Material	Extruded PVC type YI 3
2.	Thickness in mm (Min/Nom/Max)	0.25/0.3/0.35
3.	Volume Resistivity (Min) in ohm-cm	1 x 10 <sup>14</sup> at 20 deg. C & 1x10 <sup>11</sup> at 70 deg. C.
4.	Reference	VDE 0207 Part 4



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5.		Core diameter above insulation	Suitable for cage clamp connector
<b>C. Pairing &amp; Twisting</b>			
1.		Single layer of binder tape on each pair provided	Yes
2.		Bunch(Unit formation) for more than 4P	To be provided
3.		Conductor /pair identification as per VDE081	To be provided
<b>D. Shielding</b>			
1.		Type of shielding	Al-Mylar tape
2.		Individual pair shielding	To be provided for F-type cabl
3.		Minimum thickness of Individual pair shielding	28 micron
4.		Overall cable assembly shielding	To be provided
5.		Minimum thickness of Overall cable assembly shielding	55 micron
6.		Coverage Overlapping	100% coverage with 20% overlapping
7.		Drain wire provided for individual shield	Yes (for F-type) Size=0.5 mm <sup>2</sup> ,No.ofstrands=7, Dia of strands =0.3 mm ,Annealed Tin coated copper
8.		Drain wire provided for overall shield	Yes. Size=0.5 mm <sup>2</sup> , No.of strands=7,Dia of strands=0.3mm Annealed Tin coated copper
<b>E. FILLERS</b>			
1.		Non-hygroscopic, flame retardant	To be provided
<b>F. Outer Sheath</b>			
1.		Material	Extruded PVC compound
			YM1 with FRLS properties
2.		Minimum Thickness at any point	1.8 mm
3.		Nominal Thick-ness at any point	>1.8 mm
4.		Resistant to water, fungus, termite & rodent attack	Required
5.		Minimum Oxygen index as per ASTMD-2863	29%



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6.		Minimum Temperature index as per ASTMD- 2863	250 deg.C
7.		Maximum acid gas generation by weight as per IEC- 60754-1	20%
8.		Maximum Smoke Density Rating as per ASTMD- 2843	Maximum 60%  To be provided  (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as per ASTMD-2843)
9.		Reference standard	VDE207 Part 5,VDE-0816
<b>G. Electrical Parameters</b>			
1.		Mutual Capacitance Between Conductors At 0.8 Khz (Max.)	120 nF/km for F type  100 nF/km for G-type
2.		Insulation Resistance(Min.)	100 M Ohm/Km
3.		Cross Talk Figure (Min.) At 0.8 Khz	60 dB
4.		Characteristic Impedance (Max) At 1 Khz	320 OHM FOR F-TYPE  340 OHM FOR G-TYPE
5.		Attenuation Figure At 1 Khz (Max)	1.2 db/km
<b>H. Complete Cable</b>			
1.		Complete Cable assembly	Shall pass Swedish Chimney test as per SEN-SS 4241475 class F3.
2.		Flammability	Shall pass flammability as per IEEE-383 read in conjunction to this specification

**I. Tests**

Sl. No.	Description	Details
1.	Routine & Acceptance Tests	Refer Type Test requirement of Specification for C & I System
2.	Type Tests	—



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J. Cable Drum

Sl. No.	Description	Details
1.	Type	Wooden drum (constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum
2.	Outermost layer covered with waterproof paper	Yes
3.	Painting	Entire surface to be painted
4.	Length	1000 m + 5% for up to & including 12 pairs 500 m + 5% for above 12 pairs



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## 16. CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

### • CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

#### General Requirements

**Customer VMS specification and other requirements may be complied.**

- The intent of the specification is to define the functional & design requirements for the CCTV System meant for gathering video information from the various areas of the power plant. The Bidder shall be responsible for selection, design, engineering, manufacture, testing at manufacturer's works/site, installation of all the equipments supplied as covered in this specification and commissioning of the system meeting the intent & functional requirements of the specification. All the cables, cable trays, power packs, erection hardware (viz. junction boxes, brackets glands, nut-bolts, conduits etc.) are also included in Bidder's scope.
- The Bidder shall guarantee satisfactory performance of the equipment under stipulated variations of voltage and frequency.
- The design and manufacture shall be such that equipment / components of same type and rating are interchangeable.
- Any other equipment, module, software required for the safe and satisfactory operation, control, protection, monitoring, testing and maintenance of the system shall also be included by the Bidder within the lump sum quoted price.
- The equipment furnished under this section shall meet the requirements of all the applicable International codes and standards as specified - BIS standard (Indian standard IS:13252)
- CCTV system shall be certified by STQC for compliance with Essential requirements prescribed by MeitY in line with MeitY notification dated 06<sup>th</sup> March 2024 and its subsequent amendments/revisions.

#### POWER SUPPLY ARRANGEMENT

- The CCTV System along with all its components i.e. network switches, storage devices, servers, LAN switches, cameras etc. shall be powered from UPS system. Bidder shall also provide local power distribution boxes as required for sub-distribution of UPS supply.
- For cameras to be located in remote areas where the UPS power supply cannot be extended due to voltage drop etc., then such cameras can be grouped and fed from miniUPS. Individual mini-UPS shall be provided for the cameras which cannot be grouped. Bidder shall also provide local power distribution boxes as required for subdistribution of supply from these mini-UPS to cameras.
- If the offered equipment is operating at voltage level other than standard level, the Bidder shall provide all required hardware, within lump sum quoted price to make the offered system compatible with specified power supply arrangement.

### • DESIGN AND TECHNICAL REQUIREMENTS



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- The CCTV system shall be designed as a standalone IP based network architecture. Exact topology of network architecture (Star /Ring / any other topology) for CCTV system shall be decided during detail Engineering. System shall use video signals from different cameras at different locations, process the video signals for viewing on monitors at different locations and simultaneously record all the video streams using H.264 or better compression technique. Joystick and mouse-keyboard controllers shall be used for Pan, Tilt, Zoom and other functions of desired cameras.
- The monitoring of these cameras shall be done at main control room or as finalized during details engineering. The required no. of hardware/software licenses to meet the requirement shall be supplied by the Bidder.
- The camera and database servers shall offer both video stream management, video stream storage management. These servers shall also manage and store configuration information/database for the whole system. Recording frame rate & resolution in respect of individual camera shall be programmable. It shall be possible to view and record at different resolutions and frame rates and this shall be individually programmable on every camera.
- System shall ensure that once recorded, video cannot be altered.
- Camera server shall be provided with sufficient storage space to store recordings (video and audio both) of all cameras at 25/30 FPS at 1920X1080 for a period of Fifteen (15) days or more using necessary compression techniques. All recordings shall have camera ID, Location, Date and time of recording.
- Facility shall be provided to select a camera or a group of cameras in a zone for recording in CIF, 2CIF, 4 CIF, HD (720P) & Full HD (1080P) resolution.
- It shall be possible to export selected portion of recording to portable media devices. The exported clip shall be in commonly used movie file formats e.g. MPEG, AVI and no special software shall be required to view the same.
- Server software shall allow the clients seamless operation of all cameras regardless of the actual connection to different recording servers. Software shall allow the client applications to interact with all the camera/database servers simultaneously and allow simultaneous display of live video/recorded video regardless of the zone in which the client is connected.
- The system shall be able to accept potential free contacts from other system and use the same for predefined actions (like zoom/pan/tilt of cameras, bringing out pre-defined views on predefined monitors etc.) This feature shall be extensively used for linking fire related signals. For implementation of the same, 25 nos. potential free contacts shall be provided and interfaced with CCTV system panels. This functionality can be provided as a part of camera or through separate network compatible alarm panel with integration to CCTV software.
- There shall be an interface to Plant security system through L3 switch of the CCTV system, so that the camera feeds of the CCTV system can be viewed in the Security Operation Centre (SOC) of the plant located near main gate & also cameras of security system can be viewed by operators, if needed. Cables & associated accessories between L3 switch of CCTV system & network switch of SOC will be in vendor's scope.
- The camera & Video Management Software shall be ONVIF compliant.



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- End customer intends to listen the sound of the selected camera surroundings with minimum noise level along with the video. Any hardware/software required to meet this functionality shall be supplied.

**DETAILED DESCRIPTION OF THE SYSTEM COMPONENTS:**

**Application Software for Video Monitoring, Recording & Management.**

- It shall be possible to control all cameras i.e. PTZ, auto/manual focus, selection of presets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitors for live video.
- The system shall have different recording modes i.e. continuous, manual, programmed, event activated etc. on date, time camera wise. It shall be possible to configure each mode using user friendly tools. It shall be possible to search and replay the recorded video date, time, camera, event wise.
- The system shall have alarm interface capability. When an alarm occurs in the Camera/Database Server, the live video output of the camera associated with that alarm shall be switched directly to a predefined monitor/monitors. On screen controls shall be provided to achieve remote operation i.e. PTZ operation of cameras.
- The software for clients shall preferably work on a browser-based system. It shall be possible to play back recorded video at different speeds i.e. 1/4X to 16 X. The system shall support multiple live videos on single monitor in different configurations like 1, 2, 4 etc. It shall be possible to retrieve recorded video without much delay for any date/time interval.

The system shall support video analytics in respect of the following

1. Video motion detection
  2. Object tracking
  3. Object classification & Tracking
  4. Line crossing
  5. Loitering
- The feature can be an integral part of camera or a part of camera server.
  - The system shall be able to provide complete system diagnostics. System shall have the spare capacity to add minimum five nos. client workstations with functionalities of viewing live video/recorded video, PTZ controls of cameras, viewing site maps etc. Software licenses for the same shall be supplied
  - The software shall support video loss and network loss alarm feature.

**Cameras:**

- All the cameras shall be color, suitable for day and night surveillance and network compatible. There will be two types of cameras viz. PTZ & Fixed. PTZ cameras shall be high speed integrated dome type.
- Detailed technical specification cameras (High Definition (HD)) is given below.





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Image Device	1/2.8-1/3" Progressive scan CMOS
Lens	For PTZ cameras: 4.45-4.7 /89-94.0 mm focal length For Fixed Cameras: Varifocal Lens f=8-50 mm, CS-Mount
Optical Zoom/ Digital Zoom for PTZ cameras	20x or better/12x or better
Number of Pixels/Effective resolution	1920X1080 (Full HD)/2 MP at 25/30 IPS
Sensitivity (at 6dB)	For PTZ cameras: color mode 0.6 lux, B/W mode 0.04lux @30IRE, F1.6
	For Fixed Cameras: 0.21 Lux color & 0.05 Lux B/W (at 30IRE), F1.2
Horizontal Angle of view for PTZ cameras	55.4 deg(wide)- 3.5 deg (Tele) minimum
Iris Range	For PTZ cameras: F1.6-F2.9 For Fixed Cameras: 1.6 to 360
Back Light Compensation	Required
White Balance	Automatic with mode selection options
Electronic Shutter	1/50 to 1/10000 Auto
S/N Ratio	>50dB
Audio	Full Duplex or 2-way
Automatic Gain Compensation	Up to 18 dB
IR cut filter	Yes
SD/SDHC/SDXC in Fixed Camera (For Local alarm recording & scheduled local recording)	Yes, minimum 32 GB capability
Alarm Input/output	For PTZ cameras: Minimum 2 Alarm I/Ps & 1 alarm output For Fixed Cameras: Minimum One Alarm I/P & One Alarm O/P
Pan, Tilt for PTZ cameras	360 Deg Continuous ,90 deg

#### Camera Housing& Mount

All the cameras and accessories are to be housed in Weatherproof IP 65 environmental housing made of aluminum and Sun shroud. The housing, with heater and blower installed, shall provide protection for camera/lens assemblies in the ambient temperature range of - deg. C to 50 deg. 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



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#### Workstation and Camera/Database Server

For hardware specification of Server/workstation shall be as per the standard and proven practice of supplier. However, RAM and hard disk/storage memory shall be sized to meet functional requirement as stipulated in this section.

#### Network Switch:

All the network switches shall be of high quality and shall be sized to meet the functional requirements as specified. The common switch to which all networks are connected shall be Layer-III switch/router. All the interconnecting cables between network switches shall be fiber optic only. All fiber optic cables shall be terminated directly to network switches through optical fiber port without using media converters. Bidder to ensure that minimum % cores are kept as spares in all type of optical fiber cables.

#### CABLES:

Cables shall be of FRLS PVC sheathed cables for use in CCTV and shall conform to latest applicable. The remaining cables can be as per CCTV supplier's standard. edition of Indian/International standards. Fiber optic cables are to be provided wherever

## 17. GENERAL ELECTRICAL SPECIFICATION

#### GENERAL REQUIREMENTS

For the purpose of design of equipment/systems, an ambient temperature of 50 deg. Centigrade and relative humidity of 95% shall be considered. The equipment shall operate in a highly polluted environment. However, for equipment in air-conditioned areas, design ambient temperature shall be 35 deg.C, if 2x100% air conditioning system is provided.

All equipment's shall be suitable for rated frequency of 50Hz with a variation of +4% & -5%, and 10% combined variation of voltage and frequency unless specifically brought out in the specification. The step-up voltage level shall be as indicated in the Single Line Diagram of the respective projects. The turbo generator unit will be connected to its own step-up transformers for feeding power into the EHV grid. The overall system shall be designed considering voltage variation of +/- 5% and fault level of 40kA for 220kV system.

Bidder shall provide fully compatible electrical system, equipment's, accessories and services for the entire plant in his scope as well as those specifically required by the BHEL/End customer .

All the equipment, material and systems shall, in general, conform to the latest edition of relevant National and International Codes & Standards, especially the Indian Statutory Regulations.

The auxiliary AC voltage supply arrangement shall have, 33 kV and 415V systems. It shall be designed to limit voltage variations as given below under worst operating condition:

- a) 33KV +/- 5%
- b) 415 V/240 V +/- 10%



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c) 220V/110V/48V DC -15% to +10%

- The preferred AC control supply voltage shall be 110V for all 415 V non breakercontrolled feeders. Control supply voltages other than above may be offered by bidder based on the bidder's standard proven practice.
- The designed fault level for various voltage levels shall have the following minimum values:
- 33 KV systems - 25 kA rms for 1 second
- 415 V systems - 50 kA rms for 1 second
- Transformer voltage ratios, taps, impedances and tolerances thereon, shall be optimized so that the auxiliary system voltages under various grid and loading conditions are always within permissible limits and equipment are not subjected to unacceptable voltages during operation.
- In fire hazardous areas like gas/ liquid fuel storage/ handling areas, lighting fixtures, and switchgears shall be flame proof.
- The responsibility of coordination with electrical agencies /TAC/Pollution control board and obtaining all necessary clearances including Safety clearance shall be of the Bidder.
- Provenness of the Equipment, system, being offered by the bidder should satisfy the criteria Indicated in the "Provenness criteria" indicated elsewhere in the specification.
- ELECTRICAL SCHEME FOR ELECTRICAL POWER EVACUATION AND AUXILIARY POWER DISTRIBUTION
- The scheme for Electrical Power Evacuation shall be as per the tender SLD of respective projects.
- **Electrical supply for Auxiliary Power Distribution may be taken from the two nos of 33kV separate distribution feeder through suitably rated 33/0.433kV distribution transformers as per SLD attached with tender , separate metering point need to be provided in distribution feeder bay,**
- The scheme with minor variations to above may also be offered as long as they meet the redundancies indicated in the above drawings and sizing criterion specified.

**SIZING & DESIGN**

- Inverter Duty Transformers
- The Inverter Duty Transformer shall be multi-winding type and shall have off circuit tap changer with the minimum range of +/- 5% with each step of 2.5%. Number of windings shall be as per the design practice of the system integrator and the Vector Group shall be as per the



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recommendation of PCS manufacturer. The rating of the Inverter Duty Transformer shall be suitable for continuous and stable operation of

- **BESS system for meeting its peak dispatch requirement at the identified Point of Interconnection over the entire range of voltage and power factor [0.95 lag to 0.95 lead]. The HV side voltage of Inverter Duty Transformer shall be 33kV.**

#### Auxiliary Transformers

- Adequate number of auxiliary transformers shall be provided to meet the demand on 415V auxiliary supply system systems under most onerous conditions. Auxiliary transformers may be fed from 33kV pooling switchgear or LV side of the Inverter Duty Transformer as per standard practice of the system Integrator. Oil filled transformer with outdoor application OR Dry type transformers with indoor application shall be acceptable. Necessary redundancy shall be maintained such that there is no loss of auxiliary power supply in case of outage of Single Auxiliary Transformer.
- All Auxiliary transformers shall be sized so as to have 10% margin at design ambient conditions after considering final load requirements, including owner's load (if applicable), at peak load conditions and the No Load Voltage Correction Factor.
- No Load Voltage Correction Factor (= Transformer No Load voltage/ rated bus Voltage) shall be used for sizing of all transformers

#### MV Switchgears

a) The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with IEC 62271-200, comprising of a row of free-standing floor mounted panels. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IEC 62271-200). The Circuit Breakers / Contactors / Bus VTs shall be mounted on withdraw able trucks which shall roll out horizontally from service position to isolated position. The Switchgear shall have an Internal Arc Classification of IAC FLR 25kA 1 sec. The Circuit Breakers / Contactors shall be of Vacuum type.

b) All MV incomers from transformers and ties between switchgears shall be through bus ducts or adequately rated cables.

c) The sizing Criteria for a Typical MV Switchboard shall be determined by the size of the transformer feeding the board.

d) Standard MV Switchgear Modules and their Selection Criteria

MV feeders shall be categorized into standard Modules. The module defines the feeder type, Protections, Feeder schematics and metering and monitoring requirements. The Standard Modules are listed in table below

S No	Module Type	Application	Applicability
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1	DBF	Transformer Feeder with Differential Protections	Transformer feeder > 5 MVA
2	DC	Incomer Feeder	MV Incomer Module
3	DD	Bus Coupler Feeder	Bus Coupler Module for MV Boards
4	DE (Outgoing)	Tie Feeder	Outgoing feeders except to transformers

### Switchgears

- All switchboards shall be of double front, draw out, complete closed-door operation, metal enclosed, indoor, floor-mounted, free-standing type of bolted design. Entire bus bar system shall be insulated with PVC sleeves (UL 224). Cable terminations located in cable alley shall be designed to meet the Form IVb Type 7 (as per IEC 60439) for safety purpose.
- All ACDBs, DCDBs, Solenoid Valve DBs and MCCs located on Stacker Reclaimer, Paddle feeders and Travelling trippers shall be of Fixed Module type. All 415V Circuit breaker modules and other MCC modules shall be fully draw out type.
- The Circuit Breakers / Contactors shall be of air break type & should conform to the requirements of IS / IEC 60947.
- MPCB/MCCB shall be provided for supply feeders of current rating upto 16 Amps. MCCB shall be provided for all supply feeders of current rating above 16 Amp and including 400A. Air circuit breakers shall be provided for supply feeders above 400 Amps.
- Bottom most operable handle should be at least 300mm above FFL. Shrouding of at least 3mm thickness to be provided below the hanging portion of vertical busbars. Half width module
- For 415V system, busduct assemblies shall be provided for incoming connection from transformers to the switchboard and interconnecting sections between switchboards wherever transformer rating is 1000KVA or above.
- The sizing of LV boards shall be dependent on conditions such as total load connected to a board, diversity factors for various loads connected, Fault Level and Voltage Regulation Considerations, etc.



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- All indoor floor mounted switchgear (PCCs/MCCs), ACDBs of busbar rating more than or equal to 100 A and DCDBs shall require to qualify the technical requirements, End customer qualifying requirements if any.
- **Sizing of LT boards**
  - Input kVA for a Drive = (Rating in kW X Load Factor) / (Efficiency X Power Factor) where values of load factor, power factor and efficiency are defined below:
- Load (service) factor for 415 V loads is taken as 0.85 for continuous and 0.1 for intermittent loads.

Power factor 415 V Uni-Directional drives is taken as 0.8 and efficiency as 0.85

Power factor of 415 V bidirectional drive loads is taken as 0.65 and efficiency as 0.8 for motor rating less than 15 kW. For motor ratings of 15 kW and above the corresponding values are 0.75 and 0.8.

- b) The Finally selected Busbar ratings for Switchboards, MCCs, ACDBs and Busducts shall include a 10% margin over the transformer full load current/calculated values whichever is higher.
- c) Lighting load shall be considered with a service factor of 70% of the associated lighting transformer size, on each section of main switchgears with incomer from transformer.

**j) Layout Criteria**

The switchboards can be split into two sections based on layout constraints in case of long switchboards to optimize Switchgear room layouts. The two sections of the split shall be connected by Busduct as per layout requirements.

**m) Plant control cable Interconnections**

Control cable interconnections between switchgears and transformer marshalling boxes, switchgears and motor terminal boxes / push button stations, and between various switchgears shall be in the Bidder's scope.

- a) Standard control cable sizes shall preferably be 3CX1.5, 5CX1.5, 7CX1.5 & 10CX1.5 mm<sup>2</sup>, 14CX1.5 mm<sup>2</sup>
- b) Interconnections for Current Transformer terminals shall use two cores of 1.5mm<sup>2</sup> size per phase
- c) Core identification shall be using core color for up to 5-core cable and core number for cable with more than 5 cores.
- d) Separate control cables shall be used for current transformers
- e) At least one spare core shall be made available in each of the control cable

**Numerical Relay Networking**



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The Numerical Relay Network system shall be an integrated to the BESS SCADA system. The system shall have communicable numerical relays complying with IEC61850 on all feeders which shall be networked on Ethernet to form a distributed dual ring architecture to be connected to BESS SCADA system for monitoring, control & data acquisition of all MV & LV circuit breakers on IEC 61850 protocol.

- The circuit breaker will normally be controlled from BESS SCADA through closing and shunt trip coils. All the protective relays associated with the Circuit breaker modules shall be of Numerical communicable type for Protection, Control, Metering and Status monitoring. All the numerical relays shall have communications on three ports, local front port communication to laptop and dual ports on IEC 61850 to communicate with the SACADA system. The auxiliary contacts of the MCCB shall be fed to the digital inputs available in the numerical relays of Incomer / bus coupler / motor circuit breaker feeders or 61850 Compatible IO Modules, for integration into the numerical relay network/ DCS.

#### Cables and Bus Ducts

- The minimum rating of cable/ bus ducts shall meet the following criteria:
- All the cables and bus ducts feeding switchboards from transformers shall be sized based on transformer rating. All the cables and bus ducts feeding transformers shall be sized based on current ratings of transformer at the minimum voltage tap of the transformer. All other cables/bus-ducts shall be sized based on the load demand under most onerous conditions.
- Cables shall be selected so as to limit maximum voltage drop at equipment terminals during normal operation and starting conditions well within permissible values. Cables shall be derated for the site ambient and ground temperatures, grouping and soil resistivity and cable laying configuration.
- **All cables from PCS upto BESS Pooling switchgear shall be laid in built up cable trenches. (if needed over concrete culvert) Cabled beyond BESS Pooling switchgear shall be laid in buried arrangement.**
- All HT cables upto 33kV shall be Armored and Earth grade.
- All cables including EHV, HV, LT power and control cables and cabling accessories shall be suitably designed and provided with protective devices to avoid failure due to long distance, overvoltages issue on various cable components and harsh environment.
- **Earthing & Lightning Protection System**
- The earthing system for plant shall be designed for a life expectancy of at least forty (40) years, for system fault current for duration of 1second. The minimum rate of corrosion of steel (over calculated diameter) for selection of earthing conductor shall be 0.12mm per year.



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- Grounding and lightning protection for the entire power plant, switchyard and other areas or buildings covered in the specification shall be provided in accordance with IS 3043, IEC 62305, IEEE 80 and IEEE 665.
- **D.C. Systems for BESS/UPS backed safe AC system for BESS Control supply**
- For control/Aux supply to 33KV MV switchgear including breaker circuit, spring charging motor, numerical relays, Energy meters etc and all other BESS requirements, both 220V AC or 220 DC are acceptable.
- For 220V DC ,2x100% redundant DC sources to be provided with sealed maintenance free batteries for at least 30 minutes back-up and SMPS based charger with input current harmonic less than 5%. The power output shall be distributed by 220V DCDB of suitable fault rating with 2 incomer and 1 bus coupler arrangement. Charger should have the facilities of online monitoring in SCADA.
- For 220V AC supply, Online UPS with remote monitoring having a battery backup of at least 30 min to be provided. The batteries for UPS System shall be Sealed Maintenance Free type. The power output shall be distributed by 220V AC UPS with 2 incomer and 1 bus-coupler arrangement.
- Both UPS and DC system must have a margin of at least 20% of the connected load and designed accordingly. The system shall be designed for indoor mounting with ambient temperature of 50-degree C. The AC source for both Charger/UPS shall be wired to LT switchgear/ACDB which is under bidder's scope. All equipment's shall comply to relevant IEC/IS standards.
- Complete DC system, comprising of batteries, battery charges, relays, contactors, timers etc. shall be suitable for continuous operation at the maximum continuous float voltage including suitable temperature correction factors.
- O The battery shall be sized considering a minimum electrolyte temperature of 15 C along with temperature correction factors as per relevant standard. An ageing factor of 1.25 shall be considered for Ni-Cd only. The no. of cells, end cell voltage shall be considered based on the minimum and maximum voltage window and cable drop etc. as per system requirement.
- Each system shall comprise of two nos. of batteries and two nos. of float-cum-boost chargers each rated for 100% capacity. DC scheme shall ensure that each critical consumer is fed from two different bus sections. DCDBs shall provide adequate number of feeders on each section.
- The various DC Systems envisaged along with minimum battery bank ratings to be adopted are indicated in the following table. Bidder may supply additional DC systems as per system requirement:





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Area	DC Voltage	Load	Minimum Battery Bank Rating
220KV Switchyard	220 V	(a) Emergency lighting in Switchyard control room for a period of 1 hour plus (b) All continuous DC loads of relay & control panels/PLCC panels for a duration of 3 hours plus (c) Interlocking coils of isolators/earth switches shall be considered including requirement of three future line bays for a duration of 3 hours plus (d) loads in worst of the following conditions (i) Simultaneous operation of the maximum number of breakers & associated equipments in case of bus fault in the switchyard. (ii) Operation of Breaker failure relay (LBB relay)	As per system requirements
220KV Switchyard	48 V	supply total DC load of the PLCC system at an acceptable voltage for at least 3 hours	As per system requirements

**(Switchyard DC voltage is not in bidder's scope)**

DC Health Monitoring Systems for above DC batteries (220 V) shall be provided to monitor the condition of each battery cell of 220V battery banks on-line on 24x7 basis. With DC Health Monitoring System, it shall be possible to measure & analyze the individual cell and battery parameters so that any damage to battery shall be prevented by pro-active maintenance. The location of cell monitoring systems shall be away from the battery bank. All the cards used for BHMS system shall have conformal coating.

**EHV cables and accessories**

EHV cables feeding transformers shall be sized based on current requirement of BESS at the minimum operating voltage, power factor and laying condition as specified elsewhere in the specification. The cables shall be Earthe grade. The cable screen shall be designed for solidly grounded system for the system fault level of 40kA for 1 sec. The BIL of the 132kV cable shall be 650 kVp.

**ISLANDING SCHEME**

BESS system shall have grid forming and black start capability as per requirements indicated elsewhere in the specifications.



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## INSULATION LEVEL

The insulation level for the transformer windings and bushings shall be as follows:

	WINDING		BUSHING	
Highest System Voltage	WINDING – Rated Power Frequency Withstand Voltage (kVrms)	WINDING – Rated Lightning Impulse Withstand Voltage (kVp)	BUSHING – Rated Power Frequency Withstand Voltage (kVrms)	BUSHING – Rated Lightning Impulse Withstand Voltage (kVp)
0.433 kV	3	-	3	-
3.6 kV	10	40	11	40
7.2 kV	20	60	22	60
17.5 kV	38	95	42	95
24kV	50	125	55	125
36kV	70	170	77	170
72.5 kV	140	325	155	325
145kV	275/38*	650	305	650
245 kV	395/38*	950/1050**	505	1050/1050**
420 kV	630/38*	1425/1570**	750	1550/1570***

Switching Impulse withstand voltage, (kVp)

400 kV      1175kVp

\* In case of non-uniformly insulated.

\*\* Chopped wave BIL.

\*\*\* Suitable for chopped wave impulse test on transformers.

All bushings and support insulators of Tie Transformer and PCS/Inverter Transformers shall have creepage distance of minimum 31mm/KV.



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### NEUTRAL GROUNDING

Neutral earthing equipment shall be designed duly considering the maximum permissible operating voltage.

33KV system earthing shall solidly earthed type. HV and LV neutrals of BESS Tie transformer shall be solidly earthed.

LV side of LT Transformers (415V) shall be solidly earthed through bolted links. Earthing of Inverter Duty Transformers shall be as per PCS manufacturers recommendation.

### FAULT LEVEL

Equipment through fault withstand capabilities under worst operating conditions duly taking into account negative tolerances on transformer, generator & maximum fault levels of source etc. shall be as follows :

- All transformers - 2 seconds
- Switchgears - 1 second
- Cables to the feeders protected by breakers
  - Main protection fault
    - clearing time with 0.12 second minimum
- Cables of all other feeders As per MCCB operating time
- EHV systems - 1 second

(\*\* Note) Thermal withstand design time duration. The indicated values of time durations are used in transformer design for ensuring thermal stability of the transformers and are to be proven through calculations.

- All the plant and equipment's/systems supplied under the contract shall be designed following "Fail Safe" concept in case of failure of Power Supply. The system shall be designed in such a way that the equipment shall always move/remains (as applicable) to safest position as per system requirement to ensure safety of Man and Machinery.
- Latest Cybersecurity guidelines laid down by CEA/Government of India shall be followed.
- Dielectric epoxy based coating covering entire finished floor and chequered plates shall be provided in all MV switchgear (11/3.3 KV) rooms and also in switchgear rooms having both MV and LV switchgears. For 33 KV switchgear rooms, dielectric epoxy based coating or insulating mats as per IS: 15652 shall be provided. The minimum dielectric strength for insulating floor (for all



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switchgear rooms up to and including 11 KV switchgear) shall be 45 KV ac rms (Class B as per Table-4 of IS-15652: 2006). For

- 33 KV switchgear rooms (if applicable), dielectric strength for insulating floor shall be 65 KV ac rms. The minimum thickness of insulation coating shall be 2000 microns for switchgear rooms up to 11 KV and 3000 microns for 33 KV switchgear rooms (if applicable) or as per the NABL accredited lab certificate fulfilling the dielectric strength requirement, whichever is higher. Dielectric test reports as per IS-2584 from a NABL accredited laboratory shall be submitted. Further, test reports for adhesion, tensile strength, scratch hardness, shore hardness, abrasion resistance shall be submitted in line with requirement of relevant national/international standard. The coating shall be high gloss finish and top color of coating shall be decided during the detailed engineering. Arc flash boundary and golden yellow safe boundary shall be provided. The bidder shall submit the procedure of coating for BHEL/End customer approval. Also, the bidder shall conduct dielectric testing in a NABL accredited laboratory on a sample prepared during application at site.

## 18. PCS TRANSFORMERS

### PROVENNESS CRITERIA INVERTER DUTY TRANSFORMERS FOR PCS

- The Bidder/its Sub-vendor should have designed, manufactured and supplied transformers of 33kV or higher voltage class of cumulative capacity of 40 MVA or above, out of which at least one transformer shall have a rating of 10 MVA or above capacity. The reference 10MVA or above capacity transformer should have been in successful operation for at least six (6) months. (and)
- Bidder/its sub-vendor should have its own facilities for conducting all routine tests for transformers as per IS: 2026/IEC 60076. (and)
- 5 MVA, 33kV or higher rated inverter transformer manufactured by Bidder/ its sub vendor should have been successfully short circuit tested.

### PCS/INVERTER TRANSFORMER

#### TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sr. No.	TRANSFORMER	PCS/INVERTER TRANSFORMER
i)	VA Rating & Quantity	As per system requirement
ii)	Voltage Ratio (KV)	As per system requirement
iii)	Duty, Service & Application	Continuous Solar Inverter application and converter duty (Outdoor)
iv)	Winding	AS per system requirement
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement OCTC +/- 5% (min.)
x)	Impedance at 75°C	



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	a) Principal Tap	As per system requirement and SLD* & as per PCS manufacturer recommendation.
	b) Other Taps	
<b>xi)</b>	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	50 deg.C
	b) Each Individual Winding	55 deg.C
<b>xii)</b>	SC withstand time (thermal)	2 sec.
<b>xiii)</b>	Fault Level & Bushing CT	As per system requirement
<b>xiv)</b>	Termination	As per system requirement (Cable/busduct)
<b>xv)</b>	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV) Creepage distance : 31 mm/kV
<b>xvi)</b>	Noise level	AS PER NEMA TR-1
<b>xvii)</b>	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600/ IEC60076-7. As minimum requirement, Transformers shall be designed with 110% continuous thermal overloading capability. The same shall be tested during Temp Rise Type test.
<b>xviii)</b>	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
<b>xix)</b>	Air Clearance	As per CBIP
<b>xx)</b>	Foundation	All the foundation shall be designed as per highest rating Transformer in case different capacity transformer are offered.

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S. No.	Power System Characteristic	Value	unit
1.	Nominal ac system voltage, line-to-line	400/220/132/66/33/11	kV
2.	Maximum continuous ac system voltage, line-to-line	420/245/145/72.5/36/12	kV
3.	Minimum continuous ac system voltage, line-to-line	380/200/120/62/30/10	kV
4.	Maximum short-term ac system voltage, line-to-line	448/246/148/--/--	kV
5.	Maximum duration of item 4	10	s
6.	Minimum short-term ac system voltage, line-to-line	120/60/40/--/--	kV
7.	Maximum duration of item 6	5	s
8.	Continuous negative-sequence voltage component (used for performance calculation)	1	%
9.	Continuous negative-sequence voltage component (used for rating calculation)	1.5	%
10.	Continuous zero-sequence voltage component	1	%
11.	Nominal ac system frequency	50	Hz
12.	Maximum continuous ac system frequency	50.5	Hz
13.	Minimum continuous ac system frequency	48.5	Hz
14.	Maximum short-term ac system frequency	52	Hz
15.	Minimum short-term ac system frequency	48	Hz
16.	Basic Insulation Level (BIL)	1550/1050/650/325/170/75	kVp



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17.	Switching impulse level (SIL)	1050/-/-/-/-	kVp
18.	Power Frequency Withstand voltage	630/460/275/140/70/28	kV
S. No.	Power System Characteristic	Value	unit
19.	1) Maximum three-phase fault current 2) X/R 3) Clearing time - normal 4) Clearing time - backup 5) Auto-reclose	1 & 2 to be provided during detailed engineering 3) 0.10 4) 0.75 5) < 2.60	kA kA/s s s s
20.	Maximum three-phase fault current	To be provided during detailed engineering	kA
21.	Existing three-phase fault current	To be provided during detailed engineering	kA
22.	Minimum three-phase fault current -for performance requirements -for safe operation	To be provided during detailed engineering	kA kA
23.	Maximum single-phase fault current	To be provided during detailed engineering	kA
24.	Existing single-phase fault current	To be provided during detailed engineering	kA
25.	Minimum single-phase fault current	To be provided during detailed engineering	kA
26.	Harmonic impedance sectors for each harmonic number up to the 49th harmonic or system impedance data as R-X values with frequency steps not larger than 1 Hz.	CIGRE 14.30 shall be used for the Network harmonic impedance together with information in PSSE network files.	
27.	Background harmonic voltage (or current) spectrum.	5th Harmonic 1.5% 7th Harmonic 1.0% Other Harmonics 0.5% (each)	
28.	Power System Phase Rotation	CCW	



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

- Inverter Transformer shall have copper/Aluminum Shield winding between LV & HV windings. Each LV winding must be capable of handling **no sinusoidal voltage with voltage gradient as per relevant applicable standards and PCS manufacturer recommendation**. Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.
- If Inverter transformer is provided indoor, it shall be necessarily dry type.
- Harmonic Factor as per PCS manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.
- The adverse effect on life of transformer due to cloud intermittency and loading cycle must be compensated through suitable design (as applicable).
- The thermal design of PCS/Inverter Transformer needs to consider the temperature dependent performance of the PCS. It is to in accordance with PCS/Inverter output and under worst condition it should not limit PCS/Inverter output.

The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one PCS/Inverter supplying power to only one LV winding

- For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings.
- In case of PCS/inverter transformer, it shall be proven and of successfully type tested design
- Contacts from PCS/Inverter transformer fittings/protection devices shall be wired for tripping of PCS/Inverter transformer Circuit Breaker. Detailed scheme regarding same shall be finalized during detailed engineering.
- Single Line Diagram (SLD) will be finalized during detailed engineering however kVA rating of PCS/inverter transformer shall not be less than kVA capacity of respective PCS/Inverters connected to it.

**CODES AND STANDARDS**





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

### General Construction

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

- The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- A double float type Buchholz relay conforming to IS: 3637 shall be provided.
- Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.
- All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site
- The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
- Transformer shall have Oil Temperature Indicator and Winding temperature Indicator with accuracy class of +/-2 deg.
- 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.
- M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level. Wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

### Windings

- The Bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.



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- b) The conductors shall be of electrolytic grade copper/electrolytic grade Aluminum free from scales & burrs.
- c) All windings of the transformers shall have uniform insulation.
- d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

**Core**

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

**Insulating Mineral oil**

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

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm <sup>2</sup> /s	<input type="checkbox"/> 12 at 40 <input type="checkbox"/> C <input type="checkbox"/> 1800.0 at (-)30 <input type="checkbox"/> C
2.	Flash Point, <input type="checkbox"/> C	<input type="checkbox"/> 140 <input type="checkbox"/> C
3.	Pour point, <input type="checkbox"/> C	<input type="checkbox"/> (-)40 <input type="checkbox"/> C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm <sup>3</sup> at 20 <input type="checkbox"/> C	<input type="checkbox"/> 0.895
6.	Interfacial Tension N/m at 25 <input type="checkbox"/> C	<input type="checkbox"/> 0.04
7.	Neutralisation value, mgKOH/g	<input type="checkbox"/> 0.01

S.No.	Property	Permissible values
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	<input type="checkbox"/> 30 in bulk supply <input type="checkbox"/> 40 in drum supply
10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	<input type="checkbox"/> 1.2 <input type="checkbox"/> 0.8
12.	Breakdown voltage As delivered, kV After treatment, Kv	<input type="checkbox"/> 30 <input type="checkbox"/> 70



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13.	Dissipation factor, at 90°C And 40 Hz to 60 Hz	□ 0.005
14.	PCA content	□ 1%
15.	Impulse withstand Level, kVp	□ 145
16.	Gassing tendency at 50 Hz after 120 min, mm <sup>3</sup> /min	□ 5

Subsequently oil samples shall be drawn at:


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

#### Bushings

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

#### Bushing CTs

- Shall be of adequate rating for protection (differential and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.
- All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

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### Valves

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies. Sampling & drain valves should have zero leakage rate.

### Gaskets

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

### PAINTING

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



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PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

#### Neutral Earthing Arrangement

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

#### Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above & for PCS/Inverter Transformer both side)

- (a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate END CUSTOMER's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)
- (b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.
- (c) A suitable removable gland plate of non-magnetic material drilled as per the BHEL/End customer's instruction shall also be provided in the cable box
- (d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron
- (e) The Bidder shall provide earthing terminals on the cable box, to suit BHEL/End customer's GI flat.
- (f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.
- (g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).
- (h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

#### FITTINGS

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



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

**DRY TYPE INVERTER TRANSFORMER (if applicable)**

Sr. No.	PARAMETERS	INVERTER TRANSFORMER
i)	Type	Epoxy cast resin/resin encapsulated
ii)	Duty, Service & Application	Continuous Solar Inverter application and converter duty (Indoor)
iii)	MVA & Voltage ratio	As per system requirement and SLD.
iv)	Vector group	
v)	Termination & Bushing CT	



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vi)	Fault Level & Earthing	
viii)	Impedance	As per system requirement and SLD & as per Inverter manufacturer recommendation.
ix)	Number of phases	Three (3)
x)	Type of cooling	<b>AN</b> Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance guarantee shall correspond to air natural (AN) cooling.
xi)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV)
xii)	Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method) with Air Natural (AN) cooling.	<b>90 deg.C. ( class F)</b> <b>115 deg.C. ( class H)</b>
xiii)	SC withstand time (thermal)	2 sec
xiv)	Noise Level	Not to exceed values specified in NEMA TR-1.
xv)	PD Level (max. Allowable)	10 pc
xvi)	Loading Capability	Continuous operation at rated KVA on any tap with voltage variation of +/-10% corresponding to the voltage of the tap as well as in accordance with IEC60076-12/IS: 6600.
xvii)	Flux Density	Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. d) For 150% over fluxing characteristics to be furnished
xviii)	Air clearance	As per CBIP
xix)	Foundation	All foundation shall be designed as per Highest rating transformer



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#### CODES AND STANDARDS

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

#### DESIGN AND CONSTRUCTIONAL FEATURES

The core shall be constructed from high grade non-ageing cold rolled grain oriented silicon steel laminations of M4 grade or better quality. The insulation of core to clampplates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.

The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. In case it is placed outdoor, IP for enclosure shall be minimum IP42 or higher. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

Winding conductor shall be electrolytic grade Copper/ Aluminum. Windings shall be of class F insulation or better. All windings are to be uniformly insulated.

Transformer HV bushings and LV bushings can be either solid porcelain or epoxy type. Bushing shall be suitable for satisfactory operation in the high ambient temperature inside Bus Duct enclosure (if applicable). LV flange area shall be of non-magnetic material.

Bushing CTs shall be provided in the LV neutral side of adequate rating for REF protection, WTI, etc (as applicable).


For Marshalling Box the sheet steel used shall be at least 1.6 mm thick cold rolled. The box shall be tank mounted type. The degree of protection shall be IP-54 in accordance with IS-13947. Wiring Scheme shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

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

#### PAINTING

The inside of enclosure and accessories (except M. Box) shall be painted with two coats of fully glossy white colour with total DFT of 25 to 60 microns. The external paint colour of transformer & accessories shall be blue corresponding to RAL 5012. The external surface of transformer & accessories shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of polyurethane finish paint with total DFT of 80 to 150 microns. The internal surface of M.Box shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of chemical & thermal resistant epoxy enamel white paint with total DFT of 80 to 150 microns.



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## FITTING

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

## TESTS AND INSPECTION

In case the bidder/Bidder has conducted type test within last ten years (Dynamic short circuit report shall be valid till the design is changed and transformer supplier shall give affidavit stating that there is no change in the design), he may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

In case the Bidder is not able to submit report of the type test conducted within above specified period from the date LOA by BHEL/End customer , or in case the type test report are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the BHEL/End customer and submit the reports for approval.

### Short Circuit Test:-

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

Option-1:- Performing actual short circuit test as Type Test. In order to meet project schedule, Bidder/Sub vendor shall take suitable steps quite in advance to ensure successful conduction of short circuit test.

Option-2: In case of Short Circuit test already carried out on similar design, report shall be provided for approval (Dynamic short circuit report shall be valid till the design is changed and transformer supplier shall give affidavit stating that there is no change in the design). The details shall be as per guidelines given in Annexure-A with applicable tables of the IEC 60076-5 is to be followed. The reference



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transformer chosen shall be of same application, winding configuration, conductor current density and as per Annexure-B of latest IEC-60076-5. Necessary Design document and reference transformer test reports related to theoretical comparative evaluation must be submitted by Manufacturer/Bidder as required by BHEL/End customer in this case.

S.N.	ROUTINE TESTS	
1.	All routine test shall be carried out in accordance with IEC 60076.	✓
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1)	✓
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	✓
4.	Vector group and Polarity Check (as per IEC 60076-1)	✓
5.	Magnetic Balance and Magnetising Current Test	✓
6.	Measurement of no load current with 415 V, 50 Hz AC supply	✓
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1)	✓
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	✓
9.	IR measurement (As per IEC 60076-1)	✓
10.	Measurement of capacitance & tan delta to determine capacitance between winding & earth (before and after dielectric test).	✓
11.	Separate Source Voltage Withstand Test /Applied voltage test (as per IEC 60076-3)	✓
12.	Induced overvoltage test/Induced voltage withstand(IVW) test as per IEC60076 part 3	✓
13.	Repeat no load current/loss & IR after completion of all electrical test	✓
14.	Oil leakage test on completely assembled transformer along with radiators	✓
15.	Jacking test followed by D.P. test	✓
16.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	✓
17.	IR measurement on wiring of Marshalling Box.	✓
S. N.	TYPE TESTS # (To be carried out on one transformer of each rating)	
1.	Lightning impulse(Full and chopped wave) test on windings(as per IEC 60076-3) (Not applicable for LV)	✓
2.	Short circuit test (special test) as per IEC 60076-5 (if applicable).	✓

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3.	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample taken before & immediately after temp. rise test. Gas analysis shall be as per IS: 9434 (based on IEC: 60567), results will be interpreted as per IS: 10593 (based on IEC: 60599).	✓
4.	Measurement of harmonics of no load current (special test)	✓
S. N.	<b>TYPE TESTS # (To be carried out on one transformer of each rating)</b>	
5.	Measurement of acoustic noise level as per NEMA TR-1 (special test)	✓
6.	Tank Vacuum & Pressure Test (as per CBIP norms)	✓

**(#) NOTE:-**

- All the type and special tests shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.
- Inverter Transformer LV winding Di-electric tests (except for lightning impulse test for LV winding) shall be carried out corresponding to levels (as per IEC 60076) for 3.6 kV class.
- All Type tests should be done as per BHEL/End customer 's approved procedure.

**Leakage test on assembled Oil filled Transformer (ROUTINE TEST)**

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

Suitable Fire Fighting arrangements for Oil filled Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/statutory requirements. In case Nitrogen based fire protection system is used, CBIP manual shall be followed for compliance. Firewall & soak pit as applicable (as per statutory requirement/TAC/IS 10028 / IS 1646) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to BHEL/End customer approval. However for all oil filled outdoor a pit shall be provided all around at a distance of 1.0 meter (min.) from transformer outer edge, a sump pit shall be provided for each pit. Transformer efficiency shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010.

**Routine / Type Tests (Dry Type Transformers)**

Transformer shall be short circuit tested after conducting the routine tests.

Rest of the type tests shall be conducted after successful short circuit testing.

All routine tests in accordance with IS: 11171 / IEC 60076-11 shall be carried out on each transformer.

And All Type tests should be done as per BHEL/End customer 's approved procedure.



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**Routine / Type Tests (Dry Type Transformers)**

a.)	Measurement of winding Resistance for each tap position.	Routine
b.)	Measurement of voltage ratio at each taps position.	Routine
c.)	Vector group and polarity check	Routine
d.)	Measurement of impedance voltage/short circuit impedance & load loss at principal tap and extreme taps	Routine
e.)	Measurement of no load losses and magnetising current at rated frequency and 90%, 100% and 110% rated voltage.	Routine
f.)	Measurement of insulation resistance	Routine
g.)	Measurement of capacitance and tan delta	Routine
h.)	Dielectric Tests	
1)	PF/Separate source AC withstand voltage test.	Routine
2)	Chopped wave lightning impulse voltage test on windings(as per IEC 60076-3) (Not applicable for LV)	Type
3)	Induced over voltage withstand test	Routine
i.)	Partial discharge measurement	Routine
j.)	Measurement of iron loss & IR (repeat after induced voltage test)	Routine
k.)	Short Circuit test as per IEC (if applicable)	Type
l.)	Noise Level Measurement	Type
o.)	Temperature rise test as per IEC (HV & LV winding)	Type

**Control/monitoring (Dry Type and oil filled Transformers)**

The supervision, control and communication of various parameters (including fan/pump controls as applicable, alarm, trips, all monitoring/control signals, as applicable etc.) for monitoring and control of PCS/Inverter Transformers shall be done at BESS SCADA. All required hardwares, softwares, protocols, cables etc. for above supervision, control and communication of various operating conditions, control and monitoring shall be carried out by Bidder and the same will be in Bidder's scope.

The same is in addition to the local monitoring and control.



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## 18.AUXILIARY TRANSFORMERS

### B-2(B) AUXILIARY TRANSFORMER

#### TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sr. No.	DESCRIPTION	AUXILIARY TRANSFORMER (AT)
i)	VA Rating & Quantity	As per system requirement and /or SLD*
ii)	Voltage Ratio (KV)	As per system requirement and / or SLD*
iii)	Duty, Service & Application	Continuous application (Outdoor)
iv)	Winding	TWO
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement and /or SLD*
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement and /or SLD*
x)	Impedance at75 <sup>0</sup> C	
	a) Principal Tap	As per system requirement and /or SLD*.
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	35 deg.C
	b) Winding	40 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault Level & Bushing CT	As per system requirement and SLD*
xiv)	Termination	As per system requirement /cable box
xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC Creepage distance : 31 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600.



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xviii)	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
xix)	Air Clearance	As per CBIP

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

- Auxiliary transformers shall be suitable for 3 phase, 4 wire system with additional LVN bushing for equipment earthing.
- Auxiliary Transformer can be either Oil Natural/Synthetic Ester oil) filled or Dry Type** (refer relevant specification).
- In case Ester Oil filled Transformers are offered, then 50% quantity shall be Natural ester filled and balance 50% quantity shall be of Synthetic Ester oil filled.**
- The adverse effect on life of transformer due to loading cycle, harmonics, grid disturbance etc. must be compensated through suitable design (as applicable) as per system requirement and BESS/PCS manufacturer recommendation.
- Applicable incase Auxiliary Transformers HV side fed directly from PCS (AC output side) or from Inverter/PCS Transformer LV side:
  - Auxiliary Transformer shall have copper/Aluminum Shield winding between LV and HV windings. Each HV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and PCS manufacturer recommendation. Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank and copper flat up to the bottom of the tank for independent grounding.
  - Harmonic Factor as per PCS manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design. Bidders system should comply with harmonic injection limits as per CEA standards for connectivity to grid and other statutory regulations applicable for Inverter based generation resources. Any additional equipment for complying the Statutory requirements shall be in Bidder's scope.



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- 3) Auxiliary Transformer HV side winding and bushing insulation class shall be of at least 3.6 kV.

**CODES AND STANDARDS**

Transformers	IS:2026, IS:6600
Bushings	IS:2099,IS 3347
Insulating oil	IS 16659 / IS 16081
Bushing CTs	IS:2705
Indian Electricity Act 2003, BEE Guideline & CEA notifications	

**General Construction**

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

The other important construction particulars shall be as below.

- The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality.
- The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- A double float type Buchholz relay conforming to IS: 3637 shall be provided.
- Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.
- All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site
- The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.
- Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
- Transformer shall have Oil Temperature Indicator and Winding temperature Indicator (WTI applicable for transformer above 50 KVA) with accuracy class of +/-2 deg.
- For Transformers above 100KVA, radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.
- M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level (for transformer above 100 KVA). For transformer above 100 KVA, wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.



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

#### Windings

- a) The bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.
- b) The conductors shall be of electrolytic grade copper free from scales & burrs.
- c) All windings of the transformers shall have uniform insulation.

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

#### Core


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

#### Insulating Mineral oil

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

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm <sup>2</sup> /s	<input type="checkbox"/> 12 at 40 ° C <input type="checkbox"/> 1800.0 at (-)30 ° C
2.	Flash Point, ° C	<input type="checkbox"/> 140° C
3.	Pour point, ° C	<input type="checkbox"/> (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm <sup>3</sup> at 20 ° C	<input type="checkbox"/> 0.895
6.	Interfacial Tension N/m at 25° C	<input type="checkbox"/> 0.04
7.	Neutralisation value, mgKOH/g	<input type="checkbox"/> 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	<input type="checkbox"/> 30 in bulk supply <input type="checkbox"/> 40 in drum supply



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10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	<input type="checkbox"/> 1.2 <input type="checkbox"/> 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	<input type="checkbox"/> 30 <input type="checkbox"/> 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	<input type="checkbox"/> 0.005
14.	PCA content	<input type="checkbox"/> 1%
15.	Impulse withstand Level, kVp	<input type="checkbox"/> 145
16.	Gassing tendency at 50 Hz after 120 min, mm <sup>3</sup> /min	<input type="checkbox"/> 5

Subsequently oil samples shall be drawn at:

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

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

#### **Bushings**

- a) Bushing below 52 kV shall be oil communicating type with porcelain insulator.
- b) No arcing horns to be provided on the bushings.


#### **Bushing CTs**

Shall be of adequate rating for protection as required, WTI (WTI CT applicable for transformer above 50 KVA) etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

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

#### **Valves**

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies. Sampling & drain valves should have zero leakage rate.

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#### Gaskets

- Gasket shall be fitted with weather proof, hot oil resistant, rubberized cork gasket.
- If gasket is compressible, metallic stops shall be provided to prevent over compression.
- 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.

#### PAINTING

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

#### Neutral Earthing Arrangement

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

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



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- (a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate BHEL/End customer 's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side) (b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.
- (c) A suitable removable gland plate of non-magnetic material drilled as per the BHEL/End customer 's instruction shall also be provided in the cable box
- (d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron
- (e) The Bidder shall provide earthing terminals on the cable box, to suit BHEL/End customer 's GI flat.
- (f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.
- (g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).
- (h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

#### FITTINGS

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

a)	-Conservator for main tank (transformer above 100 KVA shall be provided with MOG with low oil level alarm contact), drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement (Gas collecting arrangement applicable for transformer above 100 KVA).
c)	- For Auxiliary transformers below 2 MVA, diaphragm type explosion vent shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm (WTI only for transformer above 50 kVA) and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level).
e)	For transformer above 100 KVA: Top & bottom filter valves with threaded male adapters, bottom sampling valve, and drain valve/sludge removal valve at the bottom most point of the tank. For Transformer upto 100 KVA: common drain cum sampling cum bottom filter cum sludge removal valve and top filter valve can be provided.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.



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h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads(jacking pad applicable for transformer above 100 KVA), towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.	

#### Tests and Inspection

S.N.	ROUTINE TESTS	
1.	All routine test shall be carried out in accordance with IEC 60076.	✓
2.	Measurement of Voltage Ratio & phase displacement	✓
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	✓
4.	Vector group and Polarity Check	✓
5.	Magnetic Balance and Magnetising Current Test	✓
6.	Measurement of no load current with 415 V, 50 Hz AC supply	✓

S.N.	ROUTINE TESTS	
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	✓
9.	IR measurement (As per IEC 60076-1)	✓
10.	Separate Source Voltage Withstand Test /Applied voltage test.	✓
11.	Induced overvoltage test/Induced voltage withstand (IVW) test .	✓
12.	Repeat no load current/loss & IR after completion of all electrical test	✓
13.	Oil leakage test on completely assembled transformer along with radiators	✓
14.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	✓
15.	IR measurement on wiring of Marshalling Box.	✓
S.N.	TYPE TESTS	



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1.	Temperature Rise test at a tap corresponding to maximum losses as per IS 2026.	✓
2.	Tank Vacuum & Pressure Test (as per CBIP norms)	✓

**Leakage test on assembled Oil filled Transformer (ROUTINE TEST)**

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

**Fire Fighting**

Fire Fighting arrangements for Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/statutory requirements. Firewall & soak pit as applicable (as per statutory requirement/TAC/IS 10028 / IS 1646) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to BHEL/End customer approval. However for all outdoor transformer at a distance of 1.0 m (min.) from transformer outer edge. A sump pit shall be provided for each pit.

Transformer efficiency shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010.

**DRY TYPE AUXILIARY TRANSFORMERS:**

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

- The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. The enclosure shall be provided with suitable hardware (as required).
- The conductors shall be of electrolytic grade copper free from scales & burrs.
- Dry Type Transformer windings shall be of class F insulation or better. Cooling shall be AN.
- The core shall be constructed from non-ageing, cold rolled, grain oriented silicon steel laminations (M4 or better).
- The fittings/accessories including protection/monitoring device (temperature scanner) generally required for satisfactory operation of the transformer, are to be provided.
- The adverse effect on life of transformer due to loading cycle, harmonics, grid disturbance etc. must be compensated through suitable design (as applicable) as per system requirement and BESS/PCS manufacturer recommendation.



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g) Applicable in case of Auxiliary Transformers HV side fed directly from PCS (AC output side) or from Inverter/PCS Transformer LV side:

- 1) Auxiliary Transformer shall have copper/Aluminum Shield winding between LV and HV windings. Each HV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and PCS manufacturer recommendation. Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank and copper flat up to the bottom of the tank for independent grounding.
- 2) Harmonic Factor as per PCS manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.
- 3) Auxiliary Transformer HV side winding and bushing insulation class shall be of at least 3.6 kV.

#### Overload Requirements

BESS and all its components shall be designed to withstand overloading caused due to the following eventualities.

- i) Short circuits and ground faults in the HV system especially those occurring near to the BESS PCC and medium voltage bus of the BESS.
- ii) Short circuits in the transformer secondary circuit such as Bushing terminal fault.
- iii) LV AC / DC circuit faults iv) Protection system faults.

#### BESS Response

##### *i) Step response time*

The step response time of the BESS is the duration of the time interval between the instant T0 when the set point is received at the BESS, which is in stand-by mode, or when the grid parameter changes in a way to trigger the system response, and the instant T3 when the active power at the PCC reaches within 2 % of the set point. The reference set point for the definition of the step response time is the rated input/output power..

If the system has a rated value of reactive power, then the step response time shall be also tested at:

- rated input/output reactive power,
- rated input/output apparent power (with different ratio of active/reactive powers), – other set points with reduced power respect to the rated one.

The response time for BESS shall be as per the Section project of the specification.



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ii) Ramp rate

The ramp rate of the BESS is the average rate of active power variation per unit of time between T2 and T1 as shown in Figure 1. T1 is the time when the active power at the PCC becomes higher than 10 % of the set point value. T2 is the time when the active power at the PCC becomes higher than 90 % of the set point value. The reference set point for the definition of the ramp rate is the rated input and output power to decide the charge and discharge ramp rate. The ramp rate shall be as per the section project.

If the system has a rated value of reactive power, then the ramp rate shall be also tested at:

- rated input/output reactive power,
- rated input/output apparent power (with different ratios of active/reactive powers), – other set points with reduced power respect to the rated one.

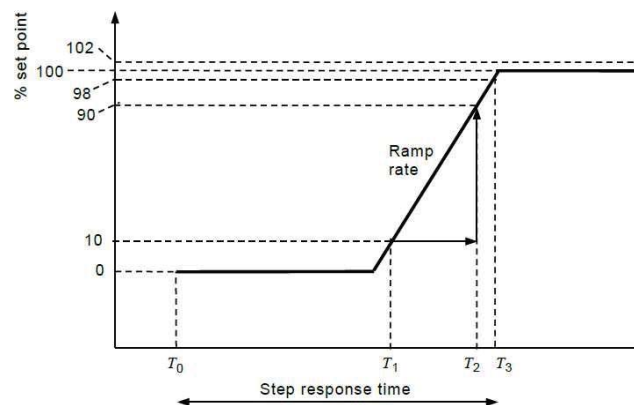


Figure 1: Step response time and ramp rate of BESS

### Harmonic Requirements

As per the requirement of grid interconnection the BESS shall connect to the HV system through a PCC transformer. PCS being a harmonics generation source there shall be some harmonics present on the MV side of the PCC transformer which might pass on to the HV side and into the grid.

The BESS contribution to the harmonic distortion levels at the PCC to the transmission system, shall not exceed the limits below.

Following are the maximum limits given using denominations according to IEEE STD 519-1992. The 2nd to the 60th harmonics should be considered.

Individual harmonics voltage distortion (Dn) < or = 0.5 %

Total Harmonic voltage distortion factor (THD) < or = 1 %



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### Broadband Interference

#### i) Radio Interference

The Contractor shall take necessary precautions in the form of shielding of building or Containers to meet its own requirement together with any requirements that may be specified in SectionProject. Further, the following requirements shall also be met:

- With the BESS operating at any load upto rated value and within the design range the radio interference level from electromagnetic or electrostatic inductions generated by the BESS shall not exceed 100 micro-volts/m, under fair weather conditions, at any point outside the station fence. The RIL criteria shall be achieved at all frequencies within the range of 150KHz to 300MHz and with the BESS operation at any level up to and including rated value, the design shall provide correcting measures, should the specified design not being realized in the final installation.
- Measurements of actual RI at BESS shall be made by the contractor, at points along the above defined contour and at other critical point.
- RIV (Radio Interference voltage) measured at a phase to ground voltage (266 kV rms) in accordance to NEMA-107 shall not be more than 500 micro-volts for 400 kV system. For other system voltages IEC/NEMA in the order of preference shall be applicable.

#### ii) Interference with Power Line carrier & open wire carrier system

The Contractor shall take the necessary precaution in the form of noise suppression techniques and filtering devices to prevent harmful interferences from BESS to power line carrier (PLCC) system operating on connected AC transmission network.

The frequency spectra to be protected are:

System	Frequency spectrum
Power Line carrier	30 kHz to 500 kHz
Open wire carrier	5 KHz to 30 kHz

The Contractor shall provide information on the noise spectrum at the termination of BESS installation in the frequency from 5 kHz to 500 kHz.

### Audible Noise

Primary equipment noise levels shall be as specified in the relevant equipment specifications. The Contractor shall limit the audible noise in various areas of the BESS buildings and Containers to the following values.

- Inside battery containers or building - 90 dBA.
- Mechanical equipment areas indoor 75 dBA (measured at 2 metre distance).
- Mechanical equipment outdoor 75 dBA (Measured at 15 m distance).
- At the limits of BESS installation perimeter fence 80 dBA.





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### Selection of Insulation Levels

Protective levels of arresters connected to the HV/EHV bus bars of the BESS shall be coordinated with the insulation and surge arrester characteristics of the HV/EHV systems to which the BESS is to be connected. The front of wave (FWWL), lightning impulse (LIWL) and switching impulse (SIWL) withstand levels shall be determined by the following margins:

- a) A SIWL at least 1.15 times the switching impulse protection level.
- b) A LIWL which is an IEC standard level corresponding to the SIWL and shall be at least 1.25 times the lightning impulse protection level.
- c) A FWWL which is at least 1.25 times the front of wave protection level.

## 19. 33KV- M V SWITCHGEAR

CODES AND STANDARDS		
a)	IS: 722	AC electricity meters.
b)	IS: 996	Single phase small AC and universal electrical motors.
c)	IS: 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories.
d)	IS/IEC: 60947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
e)	IS: 2544	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
f)	IS: 2705	Current transformers.
g)	IS: 3156	Voltage Transformers
h)	IS: 6005	Code of practice for phosphating of iron and steel.
i)	IS: 3427	Metal enclosed switchgear and control gear
j)	IS: 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
k)	IEC: 61850	Communication Standard for Numerical relays
l)	IEC: 61131-3	Automation Standard for Numerical relays
m)	IS: 9046	AC contactors for voltages above 1000 volts and upto and including 11000 Volts.
n)	IS: 13703	Low voltage fuses
o)	IS: 9385	HV fuses
p)	IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
q)	IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V
r)	IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.

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s)	IS: 13118	Specification for high voltage AC circuit breakers.
t)	IEC: 60099-4	Metal oxide surge arrestor without gap for AC system
u)	IEC: 62271-100	High voltage alternating current circuit breakers.
v)	IS/IEC: 62271200	High voltage metal enclosed switchgear and control gear.
w)	IEC: 60947-7-1	Terminal blocks for copper conductors
x)	IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips
y)	IS:15652/IS :2584	Dielectric epoxy-based coating for electrical purposes

#### TECHNICAL PARAMETERS

##### a) SYSTEM PARAMETERS

1	Nominal System voltage	33 kV
2	Highest System voltage	36 kV
3	Rated Frequency	50 Hz
4	Number of phases/ poles	Three
5	System neutral earthing	Solidly Grounding System
6	One minute power frequency withstand voltage	
	- for Type tests	70KV
	- for Routine tests	70KV
7	1.2/50 microsecond Impulse withstand voltage	170 kV (peak)
8	Maximum system fault level including initial motor contribution	25 kA (rms)
9	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	25 kA (rms) for one (1) sec.
10	Dynamic withstand rating	62.5 kA (peak)
11	IAC Rating	25 kA, 1 sec (As per IEC 62271-200)
12	Maximum ambient air temperature	50 deg. C

##### b) BUS BARS

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1.	Continuous current rating at 50°C ambient:	As Per System requirements
2.	Material	High Conductivity Al/Copper
2.	Temper Rise allowed above ambient	40°C for plain joints 55°C for Silver plated joints
3.	Sleeves	Non-Halogen Based Heat Shrinkable polyolefinic sleeves

**c) SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS**


1.	Cable entry				
	a)	Power Cables	Bottom		
	b)	Control Cables	Bottom		
2.	Busduct entry	Top			
3.	Degree of Protection - for outdoor	IP 6X (During Detailed engineering Bidder may submit details for approval)			
4.	Material	Enclosure: Rolled steel/Alu Zinc Door/covers:2mm CRCA Gland Plate:2.5mm (Hot/cold Rolled steel), 3mm(non magnetic )			
5.	Safety Shutter	As per IEC 62271-200			

**d) CIRCUIT BREAKERS**

1.	The circuit breakers current rating shall be selected from the load current given in SLD which is at an ambient of 50°C.				
2	Type	Vacuum type Anti pumping Electrical & Mechanical			
3.	Short circuit breaker	33 kV			
	Current				
	a) A.C. component	25 kA			
	b) D.C. component	As per IS: 13118 or IEC-62271			
4.	Short Circuit making current	62.5 kA (peak)			
5.	Operating Duty	O-3min-CO-3min-CO			
6.	Total break time	Not more than 4 cycles			
7.	Total make time	Not more than 5 cycles			
8.	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271			

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9.	Control supply voltage	Closing coil/spring charging motor /Tripping coil Suitable to UPS output (220V AC/DC)
<b>e) CURRENT TRANSFORMER</b>		
	Secondary Current	1A
	Class of Insulation	Class E or better
	Rated output	Adequate for the relays and devices connected, but not less than five (5) VA.
	Accuracy class	
	Protection	Class PS for differential, REF and Core Balance CTs (CBCT); 5P20 for other protection CTs
	Measurement	0.5 CL as per tender SLD
	Minimum primary earth fault current to be detected by CBCT	3 Amperes
	CBCT	50/1 A, Single, circular window type CBCT for each transformer feeder
	Instrument Security Factor for Measurement CTs	5
<b>f) VOLTAGE TRANSFORMERS</b>		
1.	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 30 seconds for star connected VTs.
2.	Class of insulation	Class E or better
3.	Other parameters	BUS PT-0.5 Class,VA req. adequate for application. Line PT-0.5 Class for sync./3P for door interlocks, VA req. adequate for application.
<b>g) SURGE ARRESTERS</b>		
		33 kV
1.	Nominal discharge Current (8x20 μs)	5kA
2.	Continuous Operating Voltage	36 kV
3.	Mounting	Inside panel
<b>h) Earthing and Earthing devices</b>		
1.	Material	Copper/Galvanized steel with adequate cross-section to carry the momentary short circuit fault current to Earth

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2	Earthing Truck or mechanism	Bus/ Line side earthing truck or mechanism of each type rating & size to be provided at individual switchgear room
i) Control terminal blocks		
1.	Rating	650V grade, 10 A ,6.6 polyamide UL 94
2.	Type	Screw less, push in technology (IEC 60947-7-1 and UL certified)
j) Switchgear Wiring		
1.	Rating & size	650 V grade, single core 2.5 sq. mm cu for CT connection 1.5 sq. mm cu for others
m)	Dielectric epoxy based coating	As per IS:15652/IS:2584

#### **GENERAL TECHNICAL REQUIREMENTS**

- a) The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying IEC 62271-200, comprising of a row of free-standing floor mounted panels.
- b) Suitable trolley shall be provided by the Bidder for withdrawal and insertion of the breaker truck from and into the (in case of truck roll out on telescopic rails)
- c) Circuit Breaker/Contactor rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition and compartment door shall not open while circuit breaker/contactors is in Service position.
- d) All insulating components being used in panel shall be Flame Retardant as per UL-94 V0 flammability standard.
- e) Suitable base frames made from steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and leveled when the flooring is being done, welding of base frame to the insert plates as per approved installation drawings shall be in Bidder's scope.
- f) The switchboard shall have the facility of extension on both sides. Adopter panels and dummy panels required to meet the various busbar arrangements, cable / busduct termination and layouts shall be included in Bidder's scope of work.
- g) **Rear Cover Safety Interlock Requirements:**
  - i. Busbar compartment cover of any panel can be opened only if the incomer/tie /buscoupler (i.e. incoming sources) are in isolated position and busbar is in deenergized condition. Inversely, incomer/tie /bus-coupler coupler (i.e. incoming sources) can be closed only if all the Busbar compartment covers are closed.
  - ii. Cable/Bus-duct compartment cover (Line Side) of Incomer/Tie can only be opened while upstream (source) breaker is in isolated position and line is dead. Inversely, upstream(source) breaker can be closed only if Cable/Bus-duct compartment cover (line side) of downstream side Incomer/Tie panel is closed.
  - iii. The cable compartment cover of any panel can be opened only when circuit breaker of that panel is in isolated position. Inversely, the circuit breaker can be closed only if subject cable compartment cover is closed.
  - iv. LED must be mounted on the rear side of panel indicating" RED" while breaker is on and in-service condition.
- h) Wireless temperature monitoring system to be provided and same shall be integrated to SCADA. Temperature sensors shall be installed in all relevant joints, contact joints etc. as per the standard



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OEM Practice, however Position of such sensors shall be decided at the time of detailed engineering.

### PROTOTYPE PANELS

In order to establish the compliance with the requirements of this technical specification, prototype panels of each module type shall be made and offered for the BHEL/End customer 's inspection and approval before the start of bulk manufacturing of panels for this project. **TESTS**

a)	The following type test reports on circuit breaker / circuit breaker panels, of each voltage class and current rating shall be submitted
	1) Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs, bushing and separators.
	2) Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators.
3)	Power frequency withstand test on breaker mounted in side panel.
	4.Lightning impulse withstand test on breaker mounted in side panel. 5.Temperature rise test on breaker and panel together. For this test, the test set up shall include three panels with breakers, the test breaker and panel being placed in the centre.
6)	The adjacent panels shall also be loaded to their rated current capacity. Alternatively the test panel may be suitably insulated at the sides, which will be adjoining to other panels in actual site configuration
6)	Internal Arc Test as per IEC 62271-200
7)	Measurement of resistance of main circuit.
8)	Mechanical operation test.
9)	Degree of protection
	Short circuit withstand test of earthing device (truck / switch).

### Routine Tests

All acceptance and routine tests as per the specification and relevant standards IEC 62271200 & IEC 62271-100 shall be carried out.

The manufacturer shall furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

Testing to observe compliance to degree of protection, shall be checked for each switch board enclosure and busbar chambers during routine inspection shall be as under.



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- a.) IP -4X It shall not be possible to insert a one (1) mm. dia steel wire into the enclosure from any direction, without using force.
- b.) IP-5X It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

#### COMMISSIONING CHECKS / TESTS

Bidder shall submit commissioning test procedure including details of all commissioning check before commissioning the system at site

## 20. 33KV MV-LV PROTECTION, CONTROL & MONITORING

#### PROVENNESS CRITERIA 33 KV SWITCHGEARS ELECTRICAL EQUIPMENT AND RELAYS

Bidder/ Sub Vendor should have manufactured and supplied at least forty (40) numbers of 33kV Air insulated Switchgear (AIS) panels with fault rating of at least 25kA for one (1) second and 62.5kA peak, which should have been in successful operation for at least two (2) years.

Bidder/ Sub Vendor should have manufactured and supplied at least forty (40) numbers of Vacuum Circuit breakers for 33KV with a rating of 25kA rms BREAKING, 62.5kA peak MAKING and 25kA withstand for one (1) second, which should have been in successful operation in 33kV voltage application for at least two (2) years prior to the date of prebid tender opening.

#### NUMERICAL RELAYS & NETWORKING

a) Bidder/ Sub Vendor should have manufactured and supplied and successfully configured at least one hundred (100) numbers of Numerical Relays with IEC 61850 used for application in Feeder Protections/Transformer Protections. These relays should have been in successful operation for at least two (2) years.

#### SYSTEM DESCRIPTION

The Switchgear SCADA system is envisaged to be an integrated system for protection, control (except motor feeders), measurement and monitoring of all MV & LV circuit breakers in the Auxiliary Power Supply network of entire project. The system shall have communicable numerical relays complying with IEC-61850 on all feeders which shall be networked on Ethernet to form the Switchgear SCADA. The system shall have a distributed architecture with multiple Data Concentrators and HMI Stations interconnected through the Station LAN. The Switchgear SCADA shall be so designed as to provide fast, safe and reliable control of the Auxiliary Power Supply system along with online monitoring and data acquisition. Typical architecture is shown in Drawing No. 0000-205-POE-A-001 & 002.

The Design Philosophy shall be as follows:

1. 33KV & LT Incomers, Bus Ties, Bus couplers and Transformer feeders shall be controlled from Switchgear SCADA .
2. The Architecture of Switchgear SCADA shall be double Ethernet ring networks with fast recovery features, redundant servers and dual port Numerical Relays to ensure a high reliability SCADA network.

#### SCOPE OF WORK



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The Bidder's scope of work shall include complete design, engineering, supply, installation, testing and commissioning and AMC (One Years) of the following.

- a) Communicable Numerical Relays (with IEC 61850) in all 33KV Switchgears and 415V LT Switchgear in the bidder's scope.
- b) IEC 61850 Ethernet switches in Switchgear panels – Sufficient quantity of Ethernet switches as per requirement for boards under bidder's scope. At least 2 ports per switch shall be kept as spare ports.
- c) Cat5e Ethernet cable / FO cable for connection of Numerical Relays to Ethernet switches in all Switchgears in the bidder's scope.
- d) Optical Fibre Cable with fire-retardant outer sheath as required for the complete SCADA network.
- e) Optical Fibre Cable termination equipment such as LIU, patch cord, etc. for the complete network including all MV & LV Switchgears.
- f) Data Concentrator systems along with associated Ethernet switches,
- g) HMI stations (Engineering & Operator Work Stations and printers) & suitable arrangement for integration of HMI to LVS in Control Room (LVS not in bidder's scope).
- h) GPS, Time synchronizing equipment & Digital Clocks.
- i) Laptops – 1 No's & Interface cable for connection of Numerical relay front port to the laptops – One No. cable per board / switchgear under bidder's scope.
- j) All other equipment required to meet the intended specification.
- k) The scope shall include the AMC Contract for the above specified system for a period of one years from the date of takeover by the BHEL/End customer .

#### SYSTEM ARCHITECTURE

- (a) The typical configuration of such a proposed system is as per the enclosed drawings 0000-205-POE-A-001 (Overall Architecture) & 0000-205-POE-A-002 (Ring Architecture). The numerical relay network shall include relays on all MV & LV switchgears being supplied under this package .
- (b) The network of each Data Concentrator shall consist of two separate rings of Ethernet switches connected through Fibre Optic cable. Each IED, located in individual switchgear panel, shall be connected to two Ethernet switches pertaining to each of the redundant rings mounted in the corresponding MV/LV Switchgear through Cat5e Ethernet cable. Data concentrators shall be distributed functionally and shall be interconnected through Fibre Optic cables forming a Station LAN.
- (c) The integration of the complete automation system (including all status, analogue indications, alarms and controls) to enable the operator to monitor the complete auxiliary power supply from the HMI station.
- (d) The point-to-point testing of all signals for the Switchgear network at the plant and protection equipment end and the terminal end (data concentrators/Controller and HMI Workstations) shall be the responsibility of the Bidder. The Bidder shall provide full details of the offered system Architecture with the Bid.





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- (e) The system shall be a computer-based system that shall integrate independently operating subsystems, such as Data Concentrators, Protection Units, Metering, and Alarm annunciation, into a unified data acquisition, monitoring, protection. During Bidding, the Bidder shall provide details of any similar systems (previous generation also acceptable) supplied by the Bidder that are in successful operation.
- (f) The System architecture shall be flexible to allow future extensions.
- (g) Each component / module of the system including all the communication links, shall be provided with built-in supervision and self-diagnostic features and any failures shall be alarmed to the operator.
- (h) The offered equipment shall be of state of art technology and hardware shall be of proven field track record. Vendor shall submit all type test reports for the offered model along with the offer.
- (i) Each of the circuit breakers shall be provided with communicable numerical relay i.e. Intelligent Electronic Device (IED) which shall be connected to two separate Ethernet switches located in the switchgear with Cat5e Ethernet cable /FO cable.
- (j) Each of the above Ethernet switches shall be connected with Optical Fibre cable to other Ethernet switches forming two redundant Ethernet ring networks.
- (k) All the Data concentrator system shall be interconnected through Optical Fibre cables forming a Station LAN.  
  
Data from the BHEL/End customer 's Battery Health Monitoring Systems shall also be integrated in the SCADA system.
- (m) Separate Energy management system and server shall be provided and to be integrated with SCADA.

The System architecture shall be flexible to allow future extensions. Required application features, spare capacity, spare ports etc shall be provided.

#### FUNCTIONAL REQUIREMENTS

The functionalities of the Switchgear SCADA System shall be distributed amongst the following components / sub-systems.

- (a) Feeder IED: IED located in the individual feeder shall have the complete protection, measurement & monitoring functionalities pertaining to the feeder. Control logics related to closing & tripping of the feeder, viz. upstream breaker interlock, protection (86) interlock of own & other associated feeders, synchronism check, tripping on bus no-volt, etc. shall be built in the feeder IED. The detail logic configurations shall be finalized during detail engineering.
- (b) Data concentrator & HMI: Overall and detailed Dynamic Single Line Diagrams for the entire Auxiliary Power Supply system shall be built in the Data concentrator / HMI .Trip selection for manual changeover and Station level logics shall also be included in the Data concentrator / HMI. Other functionalities of HMI shall include Sequence of Events, Alarms, Trends, Reports, Upload of Disturbance Records (DR), Online monitoring of Ethernet rings, etc.

#### SYSTEM PERFORMANCE REQUIREMENTS

- Latency: As the Switchgear SCADA system shall be controlling the entire Auxiliary Power Supply system and thereby the entire plant operation, requirement of speed is of utmost importance. The system shall be so designed and implemented as to provide data transfer speeds prescribed by IEC 61850-5. Latency



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calculations based on system design shall be submitted for review and approvals. Validation of the calculations shall be done during SCADA FAT and SAT.

- Reliability: All components shall be designed and configured to make the system highly reliable. Failure of any component shall be immediately announced and wherever possible, the system shall be made self-healing. Reliability analysis of the entire system considering the reliability of all individual components shall be carried out and the reliability analysis calculations shall be submitted for review and approval by the BHEL/End customer .
- Ease of operation: The system shall be user friendly with respect to engineering, configuration, operation & maintenance with built in tools for operator help.
- Diagnostic tools: The system shall have necessary diagnostic tools to continuously monitor the system performance and provide feedback to the operator / engineer.
- Necessary software tools to track changes in the system shall be provided.

#### NUMERICAL RELAYS

##### General requirements

- All Numerical relays shall be of types, proven for the application satisfying requirements specified elsewhere and shall be subject to BHEL/End customer 's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the BHEL/End customer .
- All numerical relays shall be rated for control supply voltage as mentioned elsewhere under system parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker / vacuum contactor close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker / vacuum contactor without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.
- One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
- All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts.
- The above quantities are only indicative and shall be finalized during detailed engineering. In case the offered IED does not have the required number of I/Os ,the same can be achieved through external I/O device of same make complying with the requirement stated elsewhere in this specification.
- Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker.
- Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.
- All the numerical relays shall have communications on three ports, local front port communication to laptop and dual ports on IEC 61850 to communicate with the data concentrator through LAN. The dual IEC 61850 ports shall be connected to redundant rings as shown in the architecture.
- All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.



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- Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
- Master trip (86) and non-86 trips shall be software configurable to output contacts and no separate master trip relay shall be used.
- All numerical relays shall have provision of both current (CT) and voltage (VT) inputs. Relays shall be suitable for both residually connected neutral CT input as well as CBCT input. Relays shall be suitable for CT secondary current of 1A. Following minimum no. of CT inputs to be provided in numerical relays used for different type of feeders as mentioned below including phase and neutral CT inputs.

1	DB(MV transformer feeders without differential)	4CT
2	DBF(MV transformer feeders with differential)	7CT
3	DC(MV incomer)	5CT
4	DD/DE-OG/DE-IC(MV Tie, buscoupler)	4CT
5	DAET(LT incomer)	4CT
6	DAE(Buscoupler,Tie)	4CT

- All CT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.
- All numerical relays shall have key pad / keys to allow relay setting from relay front. Pre-programmed or programmable key for Master trip (86) reset shall be provided on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
- Relays shall have suitable output contact for circuit breaker failure protection (CBFP).
- Relays shall have self diagnostic feature with continuous self check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of any failure.
- Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI / user-programmable characteristics.
- Design of the relay must be immune to any kind of electromagnetic interference. Vendor to submit all related type test reports for the offered model along with the offer.
- All cards/ hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.

#### Protections: Relay Types & Protections

##### Transformer Feeder Protections (Module Type DB/DBF)

The Transformer protection relay shall be suitable for providing the following protections.

- a) Three Phase Over current and Earth Fault protection (50 & 50N)

The relay shall have instantaneous as well as time delayed over current and earth fault protections. The over current element should have the minimum setting adjustable between 250-2000% of CT secondary rated current. The short circuit protection shall also have cold load pick up (doubling) / group-changeover feature to allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.



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With CBCT the relay shall be suitable for detection of earth fault currents in the range of 10mA secondary.

b) Restricted Earth Fault protection (64R)

Restricted earth fault protection (64R) shall be provided with high stability circulating current principle having pick up setting range of 10 to 40 % of CT secondary. Necessary stabilizing resistors shall be provided.

c) Stand by earth fault protection (51N)

For transformers of rating 5MVA and above, definite time delayed Stand by earth fault protection shall be provided having a pick up setting range of 10% to 40% with a timer delay of 0.3 sec to 3 sec.

d) Transformer Differential protection (87T)

Differential protection for transformers (87T) of rating 5MVA and above shall be provided with stabilized biased differential relay. The differential protection shall be provided with harmonic restraint during switching and over fluxing condition. No ICT shall be provided either for ratio correction or for transformer primary and secondary correction. The necessary correction shall be programmable at offered numerical relay. Sensitive phase current and phase angle displays should be available to facilitate the commissioning and checking of the measurement circuit connection and vector group matching.

e) Transformer trouble trips

Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips shall be wired to separate binary inputs of the relay and shall be configured to issue trip command to the breaker. f) Transformer trouble Alarm

Alarm contacts of the above transformer troubles shall be wired to separate binary inputs of the relay for communication to HMI.

Protections for Incomers, Bus-couplers and Tie feeders (Module Type DC/DE/DD)

The Incomer, Bus Coupler & Tie feeder protection relay shall be suitable for providing the following protections

a) Three Phase Over current and Earth Fault protection (50 & 50N)

The over current element should have the minimum setting adjustable between 2502000% of CT secondary rated current. The earth fault element should be suitable for residually connected CT input. The relay shall be suitable for detection of earth fault currents in the range of 5% to 10% of the CT rated current. b) Synchronizing Check (25)

Synchronizing check feature as a part of manual live change over and dead bus closing feature shall be provided.

c) Bus No-volt

Bus no volt signal shall be configured in the relay for use in control logics.

**Other Protections and Control features**

Control of breakers shall be carried out from the HMI station of Switchgear SCADA system through the LAN and the numerical relays. Provision of controlling the breaker from Local front port using a laptop shall be envisaged by the bidder.



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

**Upto 33kV switchyard end – Protection , relay settings and associated supplies, I&C in Bidder's scope. Bidder need to support for interfacing EMS with SAS , CRP ,Switchyard relays , Meters , PMU wherever required.**

- Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer functions shall be as required for the application. Timer functions shall be configurable for on & off delays as per requirement.
- The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker status monitoring, VT and CT supervision.
- 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.
- At least 200 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.
- 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
- The alarm / status of each individual protection function and trip operation shall be communicated to the Switchgear SCADA system.
- Sequence of events shall have 1ms resolution at device level.
- Measurement accuracy shall be 1 % for rated RMS Current and voltage
- It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.
- Additional GOOSE Controls shall be configured in the Numerical Relays for following functions. The response time of GOOSE interlocks shall be 10ms. (GOOSE Performance Class P1, Message Type 1A)
- Inter tripping
- Reverse Blocking
- Earthing Interlocks
- ETHERNET SWITCH
- Ethernet switches shall be 'substation hardened', and shall comply with IEC61850 for communications and environment requirements. The Ethernet switches shall be of managed type with two (2) No of Fibre Optic cable ports and Sixteen / Eight Copper ports to achieve the LAN configuration indicated in the drawings. The Ethernet switches shall have features to support the dual redundant rings as shown in the architecture drawings. These switches shall be mounted



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inside the switchgear Panels and shall be suitable for accepting dual redundant power supplies. The FO ports shall be Single-mode 1000Mbps ports. Copper ports shall be 10/100Mbps ports.

- Necessary software for configuration and real-time network monitoring shall be provided along with the Ethernet switches. Network monitoring feature shall be integrated with the SCADA software to provide complete network status on the HMI.

#### LAN CABLE & CONNECTOR

Cat5e Ethernet cable shall be used for connecting the numerical relays to Ethernet switches. In case FO ports are proposed on the numerical relays, Ethernet switches shall also have suitable FO ports as per the quantity mentioned above. Further, additional FO patch cords of maximum length (quantity – 10% of total quantity of IEDs) shall be supplied to facilitate maintenance.

#### FO CABLE & CONNECTOR

The Fibre Optic cable shall be armoured, Single-mode, graded index OMI (ISO/IEC 11801) of Diameter 125µm core / cladding with max attenuation of 1.52 dB/km at 1310nm wavelength & 1.0 dB/km at 1550nm wavelength. The cable should be suitable for operation at 1310/1550nm. The outer Sheath / Jacket of the FO Cable shall be Fire retardant.

#### DATA CONCENTRATOR PANEL

Each Data Concentrator panel shall consist of the following:

- (a) Redundant Servers (for both Control and Data)
- (b) Sleek foldable monitor with keyboard and mouse
- (c) Hardware for smooth changeover between redundant servers like KVM switch, etc.
- (d) Ethernet switches for both Numerical relay network and Station LAN
- (e) Power supply modules
- (f) Monitoring devices for power supply and healthiness of various important equipment
- (g) At least 4Nos (2 working + 2 standby) ventilation fans with monitoring
- (h) Binary I/O cards
- (i) Arrangement for receiving and distributing auxiliary power supply to various equipment / circuits
- (j) Any other equipment / device necessary for completeness of the system

The Data concentrators shall be provided to network the various switchgears at different locations through LAN system. The typical configuration shall be as per Drawing No. 0000-205-POE-A-001 & 002. Data concentrator shall provide gateway between Numerical relays, HMI.

Preferably, the Data Concentrator shall be capable of communicating simultaneously on dual redundant Ethernet rings with necessary redundancy management system.

- The data concentrator should be based on industrial hardware design operating on 64-bit Windows operating system and should allow monitoring and control the acquisition of the real-time data from numerical relays and should provide a framework for monitoring this data at HMI. The Data Concentrator shall have a local VDU facility for any kind of local maintenance activities from the Data Concentrator. The Data Concentrator shall have a redundant server with hot standby facility. Necessary hardware, application software and licenses shall be included in the scope of supply.



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- Data concentrator should have capability of storing data. Facility should be available to store the data day wise and it should be able to take back up of data at any time without affecting the normal operation of the system. The minimum storage capacity of the Data Concentrator shall be 320GB at least to enable long time storage of events/data. However, all the Servers/ PC being offered in the system shall be as per the latest available configurations.
- Each Data Concentrator System shall have Two (2) digital I/O cards (32 I/O) suitable for interface requirement. It shall also have required number of ports for LAN connections as shown in the architecture drawings. 20% or minimum 2 Nos. spare ports whichever is maximum shall be provided for future extensions.
- Data concentrator shall have required number of Ports for connection to HMI having operators work station and engineering station PC.
- Time clock synchronization equipment shall be provided for the Station and all the clocks of the numerical relays, LAN system with data concentrator, etc., shall be time synchronized. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system. The antenna for GPS receiver shall be installed on top of the main TG Building. Necessary cable (with protective conduit, if required) for connecting the antenna with GPS receiver / clock shall be in bidder's scope.
- Digital display of time shall be provided on top of each Data Concentrator panel.

#### HMI

HMI (Human Machine Interface) shall consist of Operator Work Station (OWS) & Engineering Work Station (EWS) as specified in the System Architecture. These shall include Server / PC, Laser printer, Ethernet switches for control, monitoring and connection to Station LAN, Power supply modules, etc.

Operating system of HMI shall be 64-bit Windows based with necessary application software such as relay status monitoring data logging, event recording, annunciations, display of single line diagram electrical system parameters relay settings and monitoring. Manual Control commands from HMI shall be direct to Data Concentrator system to ensure fast operation.

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#### The Main Features of HMI shall be:

- (a) The HMI shall have a graphical dynamic Plant Key Single Line Diagram to view the complete Auxiliary Power supply system status. This shall also include the status of the switchgears, measurement values, operation counters, graphical alarm representation, etc. Spontaneous changes of a state, typically opening of a circuit breaker from a protection, shall have a specific colour code.
- (b) All the Breakers with the status shall be clearly displayed along with values of currents, voltages, frequency, active and reactive powers, summated MW/MVAR.
- (c) High degree of security shall be provided to prevent unwanted operation of any equipment through Switchgear SCADA Systems.
- (d) Simultaneous switching of more than one device from the same or different Control Levels shall not be possible. The security features to achieve these requirements shall be clearly indicated.

Once a device is "Selected" for operation, the operator shall be able to recognize the "Selected" device on all the graphical and other displays. All other devices shall be blocked as long as a device is selected for operation.





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- (f) The “execution” of a command shall be possible only if the device is not blocked and no interlocking condition is being violated. The interlocking scheme, if any shall be checked before releasing the “execute” command.
- (g) The operator shall receive suitable feedback about the successful or unsuccessful execution of the command.
- (h) In case of unsuccessful execution, the reason for non-execution of command shall be indicated to the operator, which shall include details of the blocking condition in the interlocking logic.
- (i) The command for Breaker Close/Open from HMI shall be directly executed from the Data Concentrator System Controller to the individual feeder on IEC 61850 Network Ring.
- (j) In case of successful execution, the operator shall receive confirmation about the new switching position of the equipment depending on the command. The ability to override the interlocking shall also be available, subject to the security access.
- (k) Display of data from BHEL/End customer 's DC Health Monitoring Systems.
- (l) Display the alarm list and enable acknowledgement and clearance.
- (m) Display the sequence of event list.
- (n) Display curves, either real time or based on archived data. Invalid information shall be clearly marked. Curves shall manage the time shifts.
- (o) Display Disturbance Recording file.
- (p) Printing of sequence of event list and reports.
- (q) The reports shall be freely configurable and user friendly.
- (r) Historical data and Trending shall include Digital Fault Records and Sequence of Event logs received from various IEDs
- (s) Operations Log
- (t) Reports
- (u) Mass Storage Back up

**SYSTEM SOFTWARE REQUIREMENTS AND DOCUMENTATION**

- The Bidder shall provide all licensed software packages required by the system for meeting the intent, functional and parametric and performance requirements of the specification. All licenses (except anti-virus) shall be valid for the continuous service life of the plant.
- All technical manuals, reference manuals, user guide etc., in English required for modification/editing/addition/deletion of features in the software for the Numerical Relays, Ethernet Switches and Switchgear SCADA Systems shall be furnished.
- The Bidder shall furnish a comprehensive list of all such system/application software documentation. The developed application software dump /backup shall be submitted in Duplicate DVDs. Further Relay Configuration Files as commissioned shall be collated and submitted in a Hard disk drive for backup.
- System Security
- Security features shall be provided at each level for safeguarding against unauthorized access.
- An alarm message will be displayed at the HMI and recorded in the logs for any unauthorized access attempts. The Bidder shall provide software locks / passwords to the BHEL/End customer 's engineers at site for all operating and application software at all levels.





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The system shall maintain a SYSTEM CHANGE log, recording all system changes made along with the identification of the person making the change, date, time and area of the system modified. The format and details of this log shall be finalized during detailed engineering.

No single failure either of equipment or power source shall result in rendering any part / subsystem of system inoperative, except that the information related to failed part / component is not available.

To ensure system security, the complete functionality of Switchgear SCADA System shall be divided into various system security levels, to be decided by BHEL/End customer during detailed engineering.

The various system security levels and various user groups shall be defined by the BHEL/End customer during detailed engineering.

#### ENGINEERING

Complete engineering including the following:

- (a) Development of Module Type-wise Schemes with hardwired & soft logics
- (b) Configuration of Feeder IED including Protection and Control logics
- (c) Configuration of Board level IEDs
- (d) Configuration of Fast Bus Transfer Systems
- (e) SCADA Network Design based on reliability & speed
- (f) Configuration and application development of Switchgear SCADA Systems. Total SCADA application development as required for Integrated Control, protections and real time Monitoring.
- (g) Coordination for Integration of BHEL/End customer 's Numerical relays (ICD/CID) and Ethernet switches.
- (h) Integration of BHEL/End customer 's DC health Monitoring system

At least two licensed copies of necessary software for numerical relay configuration / setting / disturbance analysis and other utilities shall be supplied. Numerical relay configuration for all relays being supplied under the package shall be carried out in line with the approved schematics and shall be submitted for BHEL/End customer 's approval. Setting calculations and relay settings configured in relay software for all relays shall be submitted for BHEL/End customer 's approval. Approved relay configuration / settings files shall be loaded in all the relays prior to dispatch to site.

#### TRAINING

The vendor shall arrange for training on system design, engineering, operation and maintenance of Numerical relays and Switchgear SCADA system at the principal's facility and at site as follows:

Training at principals works (Relay Manufacturer) in the following areas:

- a) Basics of Feeder, Transformer and Motor Protection for IEC 61850 Numerical relay and detail discussion on functions available in the relays.
- b) Relay configurations and hands on practice of preparation of logics through relay software tools and relay GOOSE Logics.
- c) Interfacing / communication of relay with software: uploading / downloading of logic.
- d) Secondary injection testing of provided function blocks and guidelines for relay settings. DR downloading and analysis for Fault diagnostics



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- e) Switchgear SCADA - Structure and Architecture, Control, protection and monitoring concepts, Graphical User Interface, Single Line Diagram, Event List, Alarm List, Trends, Reports and System supervision. Basics and functions available in numerical relays with hands on practice on relay front end for Setting  
Changes, operators levels available in relay, enable / disable protections,
- f) Common problems faced and trouble shooting

The Scope shall include providing training in the areas stated above for five (5) No Executives from Engineering, Site Erection, and O & M for duration of 10 days. The cost of training including boarding & lodging and local transportation shall be in the vendor's scope.

#### **Training Workshop at Site**

Workshop Training at site shall aim for familiarization of Site Engineers for commissioning and day to day O & M of Numerical Relays and SCADA Systems and trouble shooting.

The scope shall include Two No's of Numerical Relay and SCADA workshops and Training for a batch of 20 Engineers at Project Site. One such Workshop shall be organized before the commissioning of First MV Switchboard and the Second workshop shall be conducted before Unit Commissioning. BHEL/End customer shall provide the required Infrastructure such as Training Conference room, Projection systems etc.

#### **AUXILIARY POWER SUPPLY**

The numerical relays & Ethernet switches being installed at switchboard shall be suitable for auxiliary power supply 240V/110V AC with tolerance of 80% to 120 % of rated voltage & shall be finalized during detailed engineering. Ethernet switches shall have provision to receive dual redundant power supplies. However other network components as data concentrator, LAN switches etc. shall be suitable for 240V AC & redundant 240V AC UPS supply for these components shall be provided by the Bidder.

#### **INPUT / OUTPUT INTERFACE, FILTERS AND OPTICAL ISOLATION**

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 I/Os shall have optical isolation. Analog inputs shall be protected against switching surges, harmonics etc.

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 plant earth mat.

#### **TIME SYNCHRONIZATION AND GPS**

Time clock synchronization equipment shall be provided for the Station and all the clocks of the numerical relays, LAN system with data concentrator, etc., shall be time synchronized. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system. The antenna for GPS receiver shall be installed on top of the main TG Building.

#### **TYPE TESTS AND FACTORY ACCEPTANCE TESTS**

Type test reports for the following tests on the model of the relays, Ethernet switches, LAN equipments shall be submitted for BHEL/End customer's review.



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S. No.	TEST ITEMS	Standard
1	Dimensions of structure and visual inspection	IEC 60297-3-101
2	Functional requirements:	Relevant
	– Steady-state simulation	IEC 60255-100
	– Dynamic simulation	series
3	Product safety requirements (including the dielectric tests and thermal short time rating)	IEC 60255-27
4	EMC requirements:	
	– Emission	IEC 60255-26
	– Immunity	
5	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
6	Contact performance	N/A
7	Communication requirements	Relevant IEC protocol standards
8	Climatic environmental requirements:	IEC 60068-2-14,
	– Cold	IEC 60068-2-1,
	– Dry heat	IEC 60068-2-2,
	– Change of temperature	IEC 60068-2-78,
	– Damp heat	IEC 60068-2-30,
		IEC 60255-27
9	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2,
	– Vibration	IEC 60255-21-3
	– Bump	
	– Seismic	
10	Enclosure protection	IEC 60529, IEC 60255-27

#### FACTORY ACCEPTANCE TESTS (FAT) & PRE-FAT

Pre-FAT shall be carried out at BHEL/End customer 's Engineering Office before the system is cleared for FAT. The pre-FAT shall include verification of the complete configuration of the system with respect to all process displays like single line diagrams, trends, alarms, reports, etc.

Full functionality of the relay including protection /metering to be demonstrated using secondary injection procedures.

All equipment furnished under this specification shall be subject to test by authorized quality assurance personnel of the bidder and BHEL/End customer 's representatives during manufacture, erection and on completion. The approval of the BHEL/End customer or passing such inspections or tests will not, however, prejudice the right of the BHEL/End customer to reject the equipment if it does not comply



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with the specifications when erected or fails to give complete satisfaction in service. Quality assurance system followed by manufacturer should preferably be in line with IEC 61850 Part 10. However, an indicative requirement of operational and pre-FAT tests as well as FAT test (Integrated Test) is given in this Section.

The FAT shall be mutually agreed upon and approved by BHEL/End customer during detailed engineering. The Factory Acceptance Tests (FAT) shall include all reasonable exercises which the combination of equipment and software can be expected to perform. These tests shall be divided into, as a minimum, but not limited to the following categories:

- Pre power on checks
- Power on checks
- Hardware tests
- Functional tests
- Parametric tests
- Specific tests on electronic hardware
- Power failure auto-restart tests
- Testing of interlocking

The Bidder shall submit a detailed FAT procedure for BHEL/End customer 's approval during detailed engineering stage based on the above guidelines. The test results obtained shall be properly documented by the Bidder and furnished in the BHEL/End customer approved format as decided during detailed engineering and submitted in the requisite number of copies with all annex irrespective of the fact that BHEL/End customer 's representative was present during the tests.

#### **ERECTION AND COMMISSIONING AND SAT FOR NUMERICAL RELAYS & SCADA SYSTEMS**

The Bidder shall prepare an erection guideline and commissioning Procedure, SAT procedure for the SCADA system and submit to BHEL/End customer for review and approvals.

Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and precommissioning trials start up tests, trial operation and performance and guarantee tests. The Bidder shall be responsible for all site / commissioning tests.

The Bidder shall maintain all tests, calibration records in BHEL/End customer approved formats, and these shall be countersigned by authorized quality assurance personnel of the Bidder supervising these works.

The Bidder shall maintain master checklists to ensure that all tests and configurations for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the Bidder.

The site / commissioning tests shall be categorized under following categories:

- (a.) Start up tests
- (b.) Calibration and configuration checks
- (c.) Pre-commissioning tests



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(d.) Trial Operation

(e.) Availability Tests

The system will be handed-over to the BHEL/End customer for commercial operation after the site / commissioning tests have been completed to the satisfaction of the BHEL/End customer . A hand-over certificate will be issued by the BHEL/End customer .

#### RELAY TEST EQUIPMENT

The required relay test equipment shall comprise the following:

- (a) One 3 phase (4 Voltage and 6 current sources) dynamic portable relay test system for allowing dynamic and steady state testing.
- (b) Any other auxiliary items required for comprehensive protection testing all types of the protection relays supplied under this contract.

It shall have the capability to replay the Disturbance / Fault records acquired by the numerical relays in IEEE / COMTRADE format or EMTP simulations, to facilitate dynamic testing of all the numerical relays supplied under this contract. The required software for steady state/dynamic testing of all the numerical protection relays along with a laptop PC shall also be supplied. The relay test set shall be suitable for IEC 61850 compliance testing with required no. of RJ45, FO and USB Ports. The test set shall have min 8 nos. (GI) binary inputs and 4 nos. (GI) binary outputs. The associated software for automated relay testing and IEC61850 GOOSE/GSSE Configuration shall also be supplied.

All commissioning tests on protection relays, energy meters and transducers shall be carried out with this relay test equipment being supplied under this contract and test reports shall be maintained as per the agreed protocols.

#### ANNUAL MAINTENANCE CONTRACT (AMC)

- The Bidder shall provide maintenance services of complete Switchgear SCADA System under a Comprehensive Annual Maintenance Contract (AMC) for period of one years from the date of hand over.
- The AMC shall cover total maintenance of all hardware & software coming under the scope of Switchgear SCADA System and shall include free repair/replacement of all cards/ modules/ peripherals/cables/ components etc., correction of software problems and supply of expendable items.
- The Bidder shall ensure 99.7% availability of the system with the AMC. For that purpose, Bidder may maintain adequate no. of staff at site as per his own assessment if considered necessary to ensure availability.
- Further, Bidder may note that during the AMC he will be allowed to use BHEL/End customer 's mandatory spares and has to replenish the same within three months time or before completion of AMC period whichever is earlier.
- However, if in the opinion of the Bidder, more spares than those included in the mandatory spare list are required to meet the availability requirement, then Bidder shall stock the same. The Bidder shall prepare detailed list of faults corrected and parts, expendables utilised during AMC period and shall furnish the same to BHEL/End customer , properly documented at the end of AMC



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period. Further, during AMC period the details as required by BHEL/End customer / Project Manager shall be made available by Bidder's personnel.

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## 21. LT SWITCHGEARS AND LT BUSDUCTS

CODES AND STANDARDS	
IS: 5	Colours for ready-mixed paints and enamels.
IS: 694	PVC insulated cables for working voltages upto and including 1100V.
IS: 722	A.C. Electricity Meters
IS: 1248	Electrical Indicating instruments
IS/IEC: 60947-1	Degree of protection provided by enclosures for low voltage Switchgear and Control gear
IS/IEC: 60947-2	A.C. circuit Breakers, MCCB, MCB, MPCB
IS: 2551	Danger Notice Plates
IS: 2629	Hot dip galvanising
IS: 2705	Current Transformers
IS/IEC: 60947-4-1	Contactors and motors starter for voltages not exceeding 1000 V AC or 1200 V DC
IS: 3043	Code of practice for earthing.
IS: 3072	Code of practice for installation and maintenance of Switchgear
IS: 3156	Voltage Transformers
IS: 3202	Code of practice for climate proofing of electrical equipment.
IS: 3231	Electrical relays for power system protection.
IS/IEC 60947	Air-Break Switches, air break disconnectors, air break disconnector and fuse combination units for voltages not exceeding 1000V AC or 1200 V DC.
IS/IEC 60947-1	General Requirements for Switchgear and Control gear for voltages not exceeding 1000 V.
IS: 5082	Wrought Aluminium and Aluminium alloys for electrical purposes.
IS: 6005	Code of practice of phosphating of iron and steel.
IS/IEC 60947-5-1	LV switchgear and Control gear Control current devices and switching element.



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IS: 13703 / IEC: 60269	HRC Cartridge fuses
IS: 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear.
IS: 11171	Specification for dry type transformers.
IEC: 60255	Electrical Relays
IEC: 61850	Communication networks and systems in substations
IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS: 12021	Specification of control transformers for switchgear and Control gear for voltage not exceeding 1000V AC.
IEC: 60947-7-1	Terminal blocks for Copper conductors
IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

#### TECHNICAL PARAMETERS

##### Power Supply

##### AC SYSTEM

1)	Voltage	415 V $\pm$ 10%, 3 Phase, 4 wire, solidly earthed
2)	Frequency	50 Hz $\pm$ 5%
3)	Combined variation (in volts & frequency)	10% absolute sum
4)	Fault Level	50kA(RMS)

##### DC SYSTEM

1)	System Voltage	220VDC 2-Wire, Unearthed
2)	Fault Level	20 kA

##### CONTROL SUPPLY VOLTAGE

1)	(i) Closing coil of circuit breaker	220V DC/110V DC
2)	Spring charging motor	220V DC/110V DC
3)	MCC control supply	110V AC Neutral solidly earthed



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4)	Space heater & lighting	240V AC Neutral solidly earthed
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#### CUBICLE DATA

##### Busbar Rating

1)	Continuous Current rating	As per requirement /Sizing Calculation
2)	Short time rating where	
	a) CB is used as incomer	50kA(RMS) for one sec (Ph-Ph & Ph-N)
	b)MCCB is used as incomer	Prospective current of 50kA(RMS) for the MCCB clearing time , (Ph-Ph & Ph-N)
3)	Dynamic Rating where	
	a) CB is used as incomer	105kA (PEAK) , (Ph-Ph & Ph-N)
	b) MCCB is used as incomer	Prospective current of 105 kA (PEAK) as limited by MCCB (Ph-Ph & Ph-N)
4)	Busbar insulation	
	a) For switchgear /MCC/ACDB/DCDB/MCCB Box	PVC Sleeve insulated (UL224) CE/UL certified
5)	Horizontal Busbar & Jumper Connection	High Conductivity Aluminium Alloy/Copper
6)	Vertical Busbar	Copper Only
7)	Hardware for busbars (Bolts/Nuts/Spring Washer)	High Tensile steels

##### Enclosure Details





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1)	Material	CRCA 2mm: Load bearing Structure and Frame 1.6mm: Doors, covers etc 3mm for Gland Plates (CRCA/HR) 4mm for Gland plates (Non-Magnetic)–Single Core Cable Entry
2)	Type	Metal enclosed, indoor, floor-mounted, Free Standing Type
3)	Degree of Protection	IP:52 (below 1600 Amp.) (IP:42 for Busbar chamber, 1600Amp& above, Gasketing arrangement shall be as per type tested design for IP 5X) As per IS/IEC:60947 IP65: Paddle Feeder and Travelling Tripper MCC IP55: Outdoor Panels enclosed in Stainless Steel Mounted on 500 mm Pedestal
4	Design	Complete Closed Door Design
5	Internal Arc Classification	50KA,0.5 sec
6	Cable Alley Compartment	Form-4B as per IEC-61439
7	Gasket	Steel Reinforced EPDM /PU Foam/Neoprene gaskets
8)	Height	2450mm max
9)	Clearances	i)25 mm: (Ph-Ph)/(Ph-earth) for Horizontal/vertical busbars and circuit breaker chamber. ii)Inside the modules: Min 25mm.However, if clearances are $\geq 10$ mm and $< 25$ mm shrouds/insulation barrier may be provided. Physical clearance less than 10mm shall not be allowed in any of the cases between Ph-Ph or Ph-E. iii)Incomer Rear Door and Busbar-400mm

**Circuit Breaker**

1)	Type	Air break spring charged stored energy type
2)	Operating duty	O-3 min-CO-3 min-CO
3)	Symmetrical interrupting	50kA(RMS)
4)	Short circuit rating	105kA(PEAK)



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5)	Short Circuit Breaking current	
	a) AC Component	50kA(RMS)
	b) DC Component	As per IS/IEC 60947
6)	Short time withstand	50kA(RMS) for 1 s
7)	No of aux. contacts	4 NO + 4 NC for DDCMIS interface 6NO+6NC Auxillary Contact(directly operated from breaker operated Mechanism)
	Antipumping Feature	Both Mechanical and Electrical

1)	Accuracy Class	2.0
2)	One min. power frequency withstand test voltage	2.0 kV(RMS)

**Current Transformers**

1)	Type	Cast Resin Bar Primary / Nylon Casing
2)	Voltage class and frequency	650 V, 50 HZ
3)	Class of insulation	E or better
4)	Rated Secondary Current	1 A
5)	Accuracy class & burden	
	a) For protection	5P20, 5VA PS Class for REF
	b) For metering	class 1.0, 5VA (min) class 0.2s, 5VA (min) indicated in SLD ,if any
6)	Instrument Security Factor (ISF) for metering CT	5
7)	Short time withstand	



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	a) For CT Associated with circuit breaker	50kA(RMS) for 1 sec
	b) For CT Associated with MCCB protected feeders	
8)	Dynamic withstand	
	a) For CTs Associated with circuit breaker	
	b) For CT Associated with MCCB protected feeders	

**BUSDUCT (NON-SEGREGATED, AIR INSULATED TYPE)**

1)	Rating	As per requirement /Sizing Calculation
1)	Type	Non-Segregated
2)	One minute power frequency withstand voltage	2.5 kV
3)	One second short ckt withstand current	50kA(RMS)
4)	Momentary dynamic current withstand	105kA(PEAK)
5)	Enclosure	3mm Al Alloy  Rectangular(IP:55)  Al sheet flange protection hood for outdoor
8)	Gasket	Steel Reinforced EPDM /PU Foam /Neoprene gaskets
9)	Conductor	Material: Alumunium  Clearance:25 mm(Min)
10)	Steel Structure	Hot Dipped Galvanised
11)	Earthing	GI of Adequate Size along full length

**VOLTAGE TRANSFORMERS**

1)	Type	Cast Resin
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2)	Voltage Ratio	415 / 110 V for line PT 415/√3 / 110/√3 V for Bus PT
3)	Method of Construction	V-V
4)	Accuracy Class	0.5 0.2 for feeders indicated in SLD ,if any
5)	Rated Voltage factor	1.1continuous, 1.5 for 30 sec.
6)	Class of insulation	E or better
7)	One minute power frequency withstand voltage	2.5 KV

#### HRC FUSES

1)	Voltage Class	650 Volts
2)	Rupturing capacity	80 kA (rms) for AC ckt., 20 kA for DC ckt.

#### CONTACTORS

1)	Type	Air break electro magnetic
2)	Utilising Category	AC3 of IS/IEC 60947 for non reversible AC4 of IS/IEC 60947 for reversible drives DC3 for DC contactor
3)	Operating Coil Voltage	(i)110V AC(-15%+10%) Drop out voltage-less than 70% Guaranteed Drop out at 20% of rated voltage (ii)220V DC((-15%+10%)

#### Relays

1)	Power frequency withstand voltage	2.5 kV for 1 sec. or 2.0 kV for 1 min.
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#### CONTROL TRANSFORMERS

1)	Type	Dry / Cast Resin
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2)	Voltage Ratio	415 / 110 V with taps $\pm$ 5% in steps of 2.5%
3)	Class of insulation	Class-B or better
4)	One minute power frequency withstand voltage	2.5 kV
5)	Rating	1.5 X Adequate for application.

**LIGHTING TRANSFORMER / WELDING TRANSFORMER**

1)	Type & Rating	Dry type / 100KVA(Welding TRF), 50KVA(Minimum)(Lighting TRF)
2)	Voltage Ratio	415/415V, +/- 5% taps in steps of 2.5%
3)	Class of insulation	B or better
4)	One minute power frequency withstand voltage	2.5 KV
5)	Enclosure protection	IP-42
6)	Type Test	As per IS 2026
7)	Fault level	3-5 KA secondary side

**TRANSDUCCERS**

1)	Current transducers	
a)	Input	0-1 A (CT secondary)
b)	Rated frequency	50Hz
c)	Output	4-20 mA (2 Nos. decoupled)
d)	Over current	Transducer for motor current ammeters shall be capable of withstanding min. 6 times CT sec. current of 1A for a min period of 30 seconds
e)	Accuracy	1.0

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2)	Voltage Transducers	
a)	Input	500 V,50 Hz (for AC)/250 V / 125 V DC (for DC)
b)	Output	4-20 mA (2 Nos. decoupled)
c)	Accuracy	1.0

#### MCCB& MPCB

1)	Type	Thermal Magnetic based(in built front adjustable releases
2)	Rated insulation level	690V
3)	Rated ultimate & Service S.C. breaking capacity	50 kA
4)	Rated making capacity	105 kA
5)	Utilization category	A


#### MCB

1)	Rated voltage	415V/240V/110V AC240V DC
2)	Current breaking Capacity	10 KA

3)	Characteristic Curve	C or above
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#### AC & DC MCCB Box

1)	Construction	(i)Metal Enclosed Fixed Type CRCA:2mm structure :1.6mm enclosure Or (ii)Poly Carbonate (a) Halogen Free,flame Retardant(UL-94,V0) (b) Thickness:4mm (iii) UL224 sleeved Busbars
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2)	Degree Protection	of	Indoor: IP52 Outdoor: IP54
3)	Characteristic Curve		C or above

#### Earth Bus and Earthing

Material	GS/Cu/Al of Sufficient cross section Separate Copper Earth bus for Electronic Earthing of IMCs
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#### Internal Wiring and Control Terminal Blocks

Control Terminal Blocks		
1)	Rating	650V grade , 10 A ,6.6 polyamide UL 94Separate Copper Earth bus for Electronic Earthing of IMCs
2)	Type	Screw less ,push in technology(IEC 60947-7-1 and UL certified)
3)	Spare	20%
Internal Wiring		
1)	Rating	650 V grade, FRLS, single core 2.5 sq. mm Cu for CT connection 1.5 sq. mm Cu for others

#### EMERGENCY PUSH BOTTON

1)	Construction	CRCA/Die Cast Al:1.6mm enclosure Or (ii)Poly Corbonate (a) Halogen Free,flame Retardant(UL-94,V0) (b) Thickness:4mm (iii) UL224 sleeved Busbars
2)	Degree of Protection	IP55 IP65(Dusty Area)
3)	Characteristic Curve	C or above
4)	Contacts	Latched Type EPB 2NO+2NC



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### CONSTRUCTIONAL DETAILS OF SWITCHBOARDS

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

#### (a.) BUSBAR COMPARTMENT

- A completely enclosed bus bar compartment shall be provided for the horizontal and vertical bus bars. Bolted covers shall be provided for access to horizontal and vertical busbars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. Auxiliary and power bus bars shall be in separate compartments All moving and fixed contacts of each draw-out modules must be of rating more than 125% of MCCB/MPCB mounted inside the module. Each phase of vertical busbars shall be separated by phase barrier and same shall be sleeved (UL-224).

#### SWITCHGEAR / FEEDER COMPARTMENT

- All equipment associated with an incomer or outgoing feeder shall be housed in a separate compartment of the vertical section. Two-tier breaker arrangement in a vertical section shall be offered for outgoing breaker feeders of rating up to 1600A. Fixed part of vertical busbar and moving part of draw-out modules for power connection shall be of Silver/Tinned plated Copper only. No live parts shall be accessible with equipment drawn out. The Module compartment door shall have external padlocking facility with MCC frame/fixed structure.
- A separate compartment shall be provided for relays and other control devices associated with a circuit breaker. For breaker-controlled motor feeders, an aux. relay shall be provided for taking Local push button station (EPB) “normally open (NO)” contact input from field and provide potential free output to DDCMIS to avoid probable mixing of switchgear control voltage with DDCMIS 24V DC voltage. This aux. relay shall have 2NO+2NC contacts. Canopy shall be provided over EPB.
- Wherever two breaker compartments are provided in the same vertical section, form 4B separation and separate vertical busbar chamber shall be provided. For Incomer panel.
- All 415V air circuit breaker switchgear panels shall be of single-front type. MCCs and DBs shall be of single-front / double-front construction as per the requirements. All ACDBs, DCDBs and Solenoid Valve DBs shall be of fixed module type. .
- For modules of size more than 300 mm, symmetric guides not less than 4 nos shall be provided for smooth removal or insertion of module. All identical module chassis of same size shall be fully interchangeable without having to carryout any modifications. Suitable interlock shall be provided in DCDB for prevention of opening of Isolator (Incomer) when the bus coupler is open and vice-versa.
- All draw-out modules shall be provided with “Closed door operation” feature wherein movement of the module from “Isolated” position to “Test” position and to “Service” position & vice-versa and power ON / OFF operation of the module shall be possible only with the module door closed condition. Degree of protection of the panel shall be maintained in both “Service”, “Test” and “Isolated” positions. Module door shall open only when module is in “Isolated” position and “Power off” condition. Interlock shall be provided to prevent the change of module state from “Isolated” to “Test” position and to “Service” position or vice-versa, if Main Switch/MCCB/MPCB of the module is kept in ON condition. All the modules shall be of standard width only and no half width, quarter width etc sized modules shall be acceptable.





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- It shall be possible to pad lock the module door irrespective of state of module i.e. “Service”, “Test” or “Isolated”. Module Operated Automatic safety shutter shall be provided to cover all the live power terminals in case the module is taken out from the panel.
- 2 nos of Dummy modules of each size to fill in module being taken out for maintenance purpose shall be provided in each switchgear room/area in case module door is part of module. These Dummy Modules shall be fitted in switchboard as vacant modules having no cut out on back side and cable alley side. In case door is hinged to the panel, 2 nos of blanking plates of each size need to be provided.
- Minimum 10mm of gap shall be ensured between busbar and moving power contact tips while module is in “Test” position to ensure user safety.
- Interlock mechanism shall be provided with the voltage monitoring such that, it should not be possible to open the rear door of incomer and bus coupler modules when the incoming power source is in live condition. In case of any bypass/overriding of this interlock appropriate hooter at local and alarm to DCS shall be provided by the bidder.
- Air Circuit Breakers Modules shall be provided with “Closed door operation” feature wherein movement of the module from “Isolated” position to “Test” Position and then to “Service” position & vice-versa and power ON / OFF operation of the module shall be possible only with the module door closed condition. Degree of protection of the panel shall be maintained in both “Test” and “Service” positions. Module door shall open only when module is in “Isolated” position and “Power off” condition.
- Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn.
- The compartment door of fixed type modules shall be interlocked to prevent opening while the MCCB/MPCB in “ON” condition.
- BHEL/End customer reserves the right to alter the cable entries, if required during detailed engineering, without any additional commercial implication.
- The Bidder shall provide adopter panel / dummy panel required to meet various configuration / arrangement of busbars/layout requirement adopted by the Bidder. The Switchboards fed from indoor transformer will be flange connected to the same and the same shall be located as close as desirable to the transformer.
- All insulating components being used in panel shall be Flame Retardant as per UL-94 V0 flammability standard.

#### PROTOTYPE PANELS

To establish the compliance with the requirements of this technical specification, prototype panels shall be made and offered for the Employer’s inspection and approval before the start of bulk manufacturing of panels for this project. The exact configuration of such prototype panels shall be finalized during detailed engineering. The switchgear shall be modified complying the observation marked during Prototype inspection (if any)

#### CONSTRUCTIONAL DETAILS OF AC & DC MCCB BOX

Each DC MCCBBoxshall comprise of the following :



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- (a.) 1 no. 63 A DP MCCB as incomer
- (b.) 100 A fully insulated (PVC sleeved,UL224) busbars.
- (c.) 8 nos. 16A outgoing DPMCCB feeders.
- (d.) 1 no. auxiliary contactor for supply monitoring.
- (e.) 1 no. Blue LED indicating lamp-

Each AC MCCB Boxshall comprise of the following :

- (a.) 1 no. 63A TPN MCCB as incomer.
- (b.) 100 A, 3-phase, 4-wire, fully insulated (PVC sleeved,UL224) busbars.
- (c.) 9 nos. 16 A DP MCCB and 3 nos. 16 A TPN MCCB units as outgoing feeders.
- (d.) 3 nos. LED indicating lamps (R, Y, B) for incoming supply monitoring.

#### POWER BUSBARS AND INSULATORS

Two separate sets of vertical busbars shall be provided in each panel of double front MCCs / DBs. Interleaving arrangement for busbars shall be adopted for switchboards with a rating of more than 1600A.

#### NUMERICAL RELAYS & NETWORKING

Please refer Protection, Control and Monitoring chapter of MV & LV Switchgear.

#### Power Cable Termination

Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded Aluminium conductor, PVC/ XLPE insulated, armored / unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc. for cables shall be provided by the Bidder to suit the final cable sizes.

#### TEMPERATURE –RISE

The temperature rise of the horizontal and vertical busbars and main bus links including all power draw-out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55<sup>o</sup> C with silver plated joints and 40<sup>o</sup>C with all other types of joints over an outside ambient temperature of 50<sup>o</sup>C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20<sup>o</sup>C. The temperature rise of manual operating means shall not exceed 10<sup>o</sup>C for metallic & 15<sup>o</sup>C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current. The above temperature rise limits are applicable for busducts also without any current derating.

#### DERATING OF EQUIPMENTS

The Bidder shall ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature



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as per Indian Standards / Specification. Continuous current rating at 50°C ambient in no case shall be less than 90% of the normal rating specified.

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

#### PROTECTION CO-ORDINATION

It shall be the responsibility of the Bidder to fully coordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers / MCCBs / motor starters, to provide satisfactory/complete discrimination. Further, the various equipment supplied shall meet the requirements of Type 2 class of Co-ordination as per IS: 13947.

All MCCBs shall be tested using primary injection kit in each switchgear during initial commissioning by the bidder. Such testing procedures shall be furnished during detailed engineering. Complete discrimination between incomer and outgoing breaker/MCCB feeders, Upstream and Downstream breakers/MCCB must be established by bidder at time of commissioning.

#### TESTS AND TEST REPORTS

##### GENERAL

The following type test certificates of LT Switchgear and MCC panels shall be submitted.

1)	Circuit breaker of each rating	
	a)	Test sequence 1
	b)	Combined test sequence (With Circuit breakers mounted inside the Switchgear panel)
2)	Complete design verification of Switchgear/MCC Panels as per IEC 61439 Part-1, Annexure-D	
3)	Internal arc test for Personnel and Assembly Protection as per IEC/TR 61641. Test shall be conducted for breaker compartment, busbar chamber, incoming side of smallest sized module, outgoing terminals of module in cable alley.	
4)	MCC modules of any three ratings, as selected by the Employer, for class - II	



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For the following equipment the Bidder shall submit the reports of all the type tests

- (a.) NUMERICAL RELAYS
- (b.) LOCAL PUSH BUTTON STATION
- (c.) LOCAL MOTOR STARTER
- (d.) MCCB
- (e.) Intelligent Motor Controller(IMC) for Electromagnetic Compatibility (EMC) & other requirements as per applicable standards

Type test reports for the following tests on the model of the Numerical relays, Ethernet switches shall be submitted for Employer's review.

S.	TEST ITEMS	Standard
No.		
1	Dimensions of structure and visual inspection	IEC 60297-3-101
2	Functional requirements: <ul style="list-style-type: none"><li>– Steady-state simulation</li><li>– Dynamic simulation</li></ul>	Relevant IEC 60255-100 series
3	Product safety requirements (including the dielectric tests and thermal short time rating)	IEC 60255-27
4	EMC requirements: <ul style="list-style-type: none"><li>– Emission</li><li>– Immunity</li></ul>	IEC 60255-26
5	Energizing quantities: <ul style="list-style-type: none"><li>– Burden</li><li>– Change of auxiliary energizing quantity</li></ul>	N/A IEC 60255-11
6	Contact performance	N/A
7	Communication requirements	Relevant IEC protocol standards
8	Climatic environmental requirements: <ul style="list-style-type: none"><li>– Cold</li><li>– Dry heat</li><li>– Change of temperature</li><li>– Damp heat</li></ul>	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
9	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
10	Enclosure protection	IEC 60529, IEC 60255-27

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



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- The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
- Routine checking to observe compliance to degree of protection, first numeral, on switchboard enclosures and busbar chambers shall be as under :

1) IP -4 X	It shall not be possible to insert a one mm dia. Steel wire into the enclosure from any direction, without using force.
2) IP-5X	It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

## ERECTION / INSTALLATION OF SWITCHBOARDS AND OTHER EQUIPMENTS

### COMMISSIONING OF LT SWITCHGEARS


Commissioning of LT switchgears at site shall only be carried out either by the switchgear manufacturer himself or under the supervision of the switchgear manufacturer.

The Associate/Collaborator (as applicable) for sourcing of LT Air Circuit Breaker shall be fully responsible and accountable for the item supplied and its compliance to the specification requirements.

The Associate/Collaborator (with respect to his manufactured and supplied LT Air Circuit Breaker) shall:

- Participate in the Inspection of the LT Switchgears at Switchgear Supplier's Works, if required by Employer.
- Participate in Technical Co-ordination Meetings (TCMs) from time to time during detailed engineering, if required.
- Participate in Site Testing and Commissioning of LT Switchgears, if required.

Participate/address/resolve the issues raised during Contract Execution Period.

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## 22. POWER & CONTROL CABLES

### PROVENNESS Criteria HT POWER CABLES (above 3.3kV(E) and upto 33kV)

The Bidder/ Sub Vendor should have manufactured and supplied following cables prior to the date of prebid tender opening:

At least 50kms of XLPE insulated power cables of 1.9/3.3 kV or higher voltage grade, executed in one or more limited to maximum of three orders. (and)

At least one (1) km of flame-retardant low smoke cables of any voltage level. **HT POWER CABLES (33kV)**  
The Bidder/ Sub Vendor should have manufactured and supplied following cables:

At least 20kms of XLPE insulated power cables of 19/33 kV or higher voltage grade, executed in one or more limited to maximum of three orders. (and)

At least one (1) km of flame-retardant low smoke cables of any voltage level.

### AC CABLES (UPTO AND INCLUDING 33KV)

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

IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS:7098 (Part -II)	Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV upto & including 33 KV
IS :1554 – I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.



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ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332 Part-3:	Tests on electric cables under fire conditions. Tests on bunched wires or cables (Category-B).
IEEE-383	Standard for type test of Class IE Electric Cables
IS : 4905	Methods for random sampling.
IS : 10418	Specification for drums for electric cables.

**General Requirements:**

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

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

All Cables shall be armored type.

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

If cables are to be laid underground, laying shall be as per latest relevant IS code. If cables are to be laid overground (eg on RCC/concrete pedestals etc), the cables shall be UV-resistant supported by test reports.

**CONDUCTOR**

Copper/aluminium conductor used in power cables (6 sq. mm and above) shall have tensile strength as per relevant standards. Cable below 6 sq mm shall be copper. Conductors shall be stranded.

**INSULATION**

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

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

**ARMOUR**



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

Calculated nominal dia.of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4mm thick GS formed wire / 4.0 mm dia GS wire

The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm<sup>2</sup> per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.

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

#### OUTERSHEATH

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

Oxygen index of min. 29 (as per IS 10810 Part-58).

Acid gas emission of max. 20% (as per IEC-754-I).

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

- In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.
- Cable size and voltage grade - To be embossed
- Word 'FRLS' at every 5 metre - To be embossed
- Screen Fault current \_\_\_KA for \_\_\_ Sec. ( Value of current & time shall be indicated) (If applicable)
- Sequential marking of length of the cable in metres at every one metre -To be embossed / printed
- The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.





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- All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.
- Allowable tolerances on the overall diameter of the cables shall be  $\pm 2$  mm maximum, over the declared value in the technical data sheets.
- Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

#### CABLE SELECTION & SIZING

Cables shall be sized based on the following considerations:

- Rated current of the equipment
- The Maximum Overall Voltage Drop: As per system requirement.
- Short circuit withstand capability
- Fault current- As per system fault current.
- Time- As per system requirement.

#### DERATING FACTORS

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

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

#### HT POWER CABLES

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

- In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.
- Distinct extruded PVC inner sheath of black colour as per IS:5831 shall be provided for the cables as follows:
  - a) For all multicore cables.
  - b) For single core armoured cables, where armouring is not being used as metallic screen
- Cores of the cables of upto 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.
- The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.
- The eccentricity shall be calculated as

Eccentricity

Ovality



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$t_{max} - t_{min}$ ----- x 100 t max	$d_{max} - d_{min}$ ----- x 100 d max
--	---

Where t-max/t-min is the maximum/minimum thickness of insulation and dmax/d-min is the maximum / minimum diameter of the core.

- The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%
- Cables shall conform to IS: 7098 Part - II. These cables shall have mutli-stranded, compacted circular, aluminium conductors, XLPE insulated, metallic screened suitable for carrying the system earth fault current, armoured, PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing for cables shall be “dry curing / gas curing”.
- The metallic screen of each core shall consist of copper tape with minimum overlap of 20%. However for single core armoured cables, the armouring shall constitute the metallic part of the screening.
- The standard length for HT power cables shall be 1000 meter for all single core cables and 750 meters for 3 core cables. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. One drum length of each cable size can be of non standard length (not less than 250 meter) so as to match the ordered quantity. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/-2% and the payment shall be made based on the actual cable length supplied within this limit.

#### LT POWER CABLES

- LT Power & control cables shall be of minimum 1100 volts grade XLPE /PVC insulated conforming to IS 1554 / IS 7098 (Part-I) for utilization voltages less than equal to 415 V.
- For cable connecting central inverter and inverter transformer, no. of runs and interconnecting trench, bus bar terminations, lugs shall be provided in such a manner so that no overheating of contacts & terminals encountered. Sufficient space for cabling & termination shall be kept.
- The sizing of the cable will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.
- Single core cables shall have no Inner sheath as per IS: 7098 Part-I
- All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated.  
KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured, PVC outer-sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armoured.



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

#### LT CONTROL CABLES

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

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

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

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

#### CABLE SELECTION & SIZING:

Control cables shall be sized based on the following considerations:

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

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

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



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2 TESTS

- 3 Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of power and control cables enclosed at relevant section.
- 4 All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. All cables to be supplied shall be of type tested design.
- 5 During detailed engineering, the Bidder shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- 6 However if the Bidder is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.
- 7 The type test reports once approved for any projects shall be treated as reference. For subsequent projects of BHEL/End customer REL, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.
- 8 The reports for following type tests shall be furnished:

Sl	Type Test	Remarks
	Conductor	
1.	Resistance test	
	For Armour Wires / Formed Wires	
2.	Measurement of Dimensions	
3.	Tensile Test	
4.	Resistance test	
5.	Wrapping test	
6.	Torsion test	For GS round wires only
7.	Elongation test	For GS wire only
8(a)	Mass& uniformity of Zinc Coating tests	For GS wires/formed wires only.
8(b)	Adhesion test	For GS wires/formed wires only
Sl	Type Test	Remarks
	<b>For XLPE insulation &amp; PVC Sheath</b>	
9.	Test for thickness	
10.	Tensile strength and elongation test before ageing and after ageing	
11.	Ageing in air oven	

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12.	Shrinkage test	
13.	Hot set test	For XLPE insulation only
14.	Water absorption test	For XLPE insulation only
15.	Loss of mass test	For PVC outer sheath only.
16.	Hot deformation test	For PVC outer sheath only.
17.	Heat shock test	For PVC outer sheath only
18.	Thermal stability test	For PVC outer sheath only
19.	Oxygen index test	For PVC outer sheath only
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only
22.	Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only
23.	Insulation resistance test (Volume Resistivity method)	
24.	High voltage test	
25. *	Partial discharge test	For HT cables only
26. *	Bending test	
27. *	Dielectric power factor test	
	a) As a function of voltage	
	b) As a function of temperature	
28. *	Heating cycle test	
29. *	Impulse withstand test	


\* Not applicable for 3.3/3.3kV grade cables.

### CABLE DRUMS

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

Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable.

**Co ordinates /Location of BESS block and Switchyard are indicated drawings. Bidders is requested to assess the requirement related to distance accordingly after taking into account all existing End customer thermal plant facilities. Bidder is expected to assess and provision cable lengths based on site conditions.**

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## 23. CABLING, EARTHING AND LIGHTNING PROTECTION

### CODES AND STANDARDS

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

Standard No.	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 up to and including 33 kV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners (Hot dip galvanized coatings on threaded fasteners)
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning
IS:2629	Recommended practice for hot dip galvanising of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles
IS:3043	Code of practice for Earthing
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles
IS:8308	Compression type tubular in-line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables
IS:9537	Conduits for electrical installation
IS:9595	Metal – arc welding of carbon and carbon manganese steels – recommendations
IS:13573	Joints and terminations for polymeric cables
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:422	Grounding of industrial & commercial power systems



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Standard No.	Description
DIN 46267 (Part-II)	Non-tension proof compression joints for aluminium conductors
DIN 46329	Lugs for compression connections, ring type, for aluminium conductors
BS:6121	Specification for mechanical cable glands for elastomer and plastic insulated cables
IE Act	Indian Electricity Act
IE Rules	Indian Electricity Rules

Indian Electricity Act.

Indian Electricity Rules.

All standards, specifications is applicable to cabling, earthing, and lightning protection systems for Battery Energy Storage Systems (BESS), which shall include fault-current-rated earthing, container-level lightning protection, and DC-specific grounding provisions . 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 alongwith 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.

#### DESIGN AND CONSTRUCTIONAL FEATURE (AS APPLICABLE)

##### Cabling

Cabling shall be carried out as per Part-A of technical specification and system requirement . In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. Cables crossing Railway line (if applicable) shall be laid underground through culvert/through hume pipes/ overhead trestle. Necessary statutory clearance if required shall be taken by Bidder. All EHV, HT, LT and control cable shall be armoured.

##### Cable Sizing Conditions

All cables shall be suitably derated as per the laying conditions for carrying the required load current and fault current. For derating, the ambient temperature for directly buried cables shall be taken as 40° C and 50° C for cables laid in air. All XLPE cables shall be rated at 90° C conductor temperature for AC Voltage drop calculation and 80° C for DC Voltage calculation. However, for Voltage drop calculation in DC Cable, actual conductor temperature as per loading can be used

##### Trenches (as applicable)

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

##### Cable Vault (As applicable)



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- The cable vault/ / cable spreader room space below the HT / LT switchgear room, Control Rooms, unit control equipment room, Programmer room, UPS, Charger & Battery Rooms, shall have **800 mm wide** and 2.1 m high movement passage all around the cable trays in the cable vault/ cable spreader room for easy laying/maintenance of cables.
- Cable vaults shall be provided with adequate drainage facilities for drainage of fire water.
- Each cable vault should have at least two fire proof doors preferably diagonally opposite.. Exit signs shall be provided near doors for personnel escape in case of emergency
- Two separate cable routes shall be provided for cable routing different set/group (say 50% capacity).
- The cable slits (as applicable) to be used for equipment power/control supply shall be sand filled & covered with PCC after cabling.
- Sizing criteria, derating factors for the cables shall be met as per respective chapters. However for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.

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

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

#### EQUIPMENT DESCRIPTION (AS APPLICABLE)

- Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.
- Cable trays, 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 shall be as per specification.
- Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.
- Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised shall be as per specification. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.
- The tolerance for cable tray and accessories shall be as per IS 2102 (Part-1). Tolerance Class: - Coarse

#### Support System for Cable Trays (AS APPLICABLE)





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Cable tray support system shall be pre-fabricated out of single sheet.

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:

- a) 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.
- b) 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.
- c) 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.
- d) All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation.
- e) The typical arrangement of flexible support system described briefly below:

The main support channel and cantilever arms shall be fabricated out of 2.5 thick rolled steel sheet conforming to IS 1079.

- f) Cantilever arms of 170mm, 320 mm, 620mm and 750 mm in length are required, and shall be as shown in the enclosed drawing. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.
- g) Support system shall be able to withstand
  - weight of the cable trays
  - weight of the cables (75 Kg/Metre run of each cable tray)
  - Concentrated load of 75 Kg between every support span
  - Factor of safety of minimum 1.5 shall be considered



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The size of structural steel members or thickness of sheet steel of main support channel and cantilever arms and other accessories shall be designed by the bidder to fully meet the requirements of type tests as specified. In case the system fails in the tests, the components design modification shall be done by the Bidder without any additional cost to the Employer. The bidder shall submit the detailed drawings of the system offered by him alongwith the bid.

#### **Pipes, Fittings & Accessories (AS APPLICABLE)**

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

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

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

Hume pipes shall be NP3 type as per IS 458.

HDPE pipes and conduits shall be PE-80, PN-10 type as per IS 4984/IS 8008 part-I.

#### **Terminations & Straight Through Joints**

Termination and jointing kits for 33kV, 11 kV, 6.6 KV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be Pre-moulded type or heat shrinkable type. Further Cold shrinkable type termination and jointing kits are also acceptable. The Cold shrinkable type kits shall be type tested as per relevant standards. Calculation to withstand the required fault level shall also be furnished in case of cold shrinkable type kits. 33 kV, 11 kV, 6.6 KV and 3.3kV grade joints and terminations shall be type tested and Type test reports as per IS:13573 Part-II and IEC60502 shall be furnished. Also, heat shrink material shall comply with requirements of ESI 09-13 (external tests). Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Cable joints and terminations should be with FRLS properties as per IEC 60754-1&2. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the tinned copper solderless crimping type cable lugs & ferrule or mechanical connectors (wherein bolts are tightened that shear off at an appropriate torque) as per DIN standard suitable for aluminium compacted conductor cables.

Straight through joint and termination shall be capable of withstanding the system fault level. Straight through joints shall have provisions for shield connection and earthing wherever required and complete with all accessories and consumables suitable for storage without deterioration at a temperature of 50 deg. C with shelf life of more than five years. 1.1 kV grade straight through joints shall also be of proven design.

1.1 KV grade Straight Through Joint shall be of proven design

#### **Cable glands**



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

#### **Cable lugs/ferrules**

Cable lugs/ferrules shall be solderless crimping type suitable for power and control cables as per the DIN 46239. Aluminium solderless crimping lugs/ ferrules shall be used for Aluminium cables and Copper lugs/ferrules shall be used for Copper cables. Bimetallic washers or bimetallic type lugs shall be used for bimetallic connections.

Crimping tool for crimping (from 1.5sqmm cable to 630sqmm cables) above mentioned lugs shall be of Hexagonal Type crimp profile, with suitable die of crimp match code.

Characteristics of crimping tool:

- 1) To should generate enough pressure to pass pull out test as per IEC 61238-1. Relevant type test to be produced for the sizes specified in the tender.
- 2) Tool die shall be replaceable for assorted sizes and crimp code to be mentioned on both part the die
- 3) Tool should be compliant of testing according to IEC, UL and GS standards

Tool shall have features such as

- Auto retraction system
- Manual retraction stop

Feedback signals for improper pressure

- Flexible and rotating head for easy crimping

#### **Trefoil clamps**

Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength, when installed at 1 mtr intervals, to withstand the forces generated by the peak value of maximum system short circuit current

#### **Cable Clamps & Ties**

The cable clamps/ties required to clamp multicore cables shall be of SS-316 material, 12mm wide, polyester coated ladder lock type. The clamps/ties shall have self locking arrangement & shall have sufficient strength. The cable clamps/ties shall be supplied in finished individual pieces of suitable length to meet the site requirements.

#### **Receptacles**

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped gavanised or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable surface mounting on wall/column/structure, gland



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plate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polyimide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with RCCB/RCD of 30mA sensitivity having facility for manual testing/checking of operation of RCCB/RCD.

**Not Used**

**Galvanising**

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

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

**Welding**

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

**INSTALLATION (AS APPLICABLE)**

**Cable tray and Support System Installation**

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

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

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

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 and the same shall be finalized at pre-award stage.



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

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**

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 water proof 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.

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

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

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

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

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

### **Junction Boxes Installation**

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



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### Cable Installation

Cable installation shall be carried out as per IS:1255 and other applicable standards.

For Cable unloading, pulling etc following guidelines shall be followed in general:

- Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.
- While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.
- Cables shall be laid on cable trays strictly in line with cable schedule
- Power and control cables shall be laid on separate tiers inline with the approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on top most 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 one metre. All multicore cables shall be laid in touching formation. Control and instrumentation cable can be laid in 3 layers subject to maximum cable tray filling upto 80% tray depth only. Power and control cables shall be secured fixed to trays/support with cable clamps/ties with self locking arrangement. For horizontal trays arrangements, multicore power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multicore power cables and control cables shall be secured at every one meter. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by cable clamps/ties with self locking arrangement at every five meter interval and at every bend. Fibre Optical cable shall be laid in trenches/trays or as decided by Employer
- Bending radii for cables shall be as per manufacturer's recommendations and IS:1255.
- Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe/overhead trestle.



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- No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.
- In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to be 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.
- Wherever few cables are branching out from main trunk route troughs shall be used.
- Wind loading shall be considered for designing support as well Cable trays wherever required
- Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures. The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day.

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

At least 300mm clearance shall be provided between:

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

#### Segregation

- 1) Segregation means physical isolation to prevent fire jumping

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, 5C	1
6C-10C	2
14C and above	3

#### Directly Buried Cables

- a) 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 and the enclosed drawings showing cabling details.
- b) 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





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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.

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Bidder may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags. The cable tag requirements mentioned above shall prevail over Tag requirements mentioned elsewhere in this document for HT power, LT power & control cables.

#### Cable Terminations & Connections

- The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Bidder shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site .
- Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.
- The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The 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.
- Control cable cores entering control panel/switchgear /miscellaneous panels shall be neatly bunched, clamped and tied with self locking type nylon cable ties with de interlocking facility to keep them in position.
- All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.
- All cable terminations shall be appropriately tightened to ensure secure and reliable connections.
- **33KV Cable supply , Laying , testing , terminating at Tie-up transformers is in Bidder's scope. All jointing kits & associated works , 33KV cable supports during laying , terminations, other accessories is in Bidder's scope.**
- **Methodology , Philosophy of laying ,Cable sizing will be in finalised during detailed engineering .**





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## 24. EARTHING SYSTEM

- Earthing system shall be in strict accordance with IS:3043 and Indian Electricity Rules/Acts. The earthing system shall be designed for a life expectancy of at least twenty five (25) years, for a system fault current of as specified in relevant chapter of the specification. The minimum rate of corrosion of steel for selection of earthing conductor shall be 0.12mm per year. Electrical Resistivity Test (ERT) of the soil is included in the scope of bidder.
- The object of protective earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrences take place. Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system.
- Earthing system network/earthmat shall be interconnected mesh of mild steel rods buried in ground in the plant. All areas under Bidder scope of supply shall be interconnected together by minimum two parallel conductors. The Bidder shall furnish the detailed design and calculations for Employer's approval. Bidder shall obtain all necessary statutory approvals for the system. All the columns shall be earthed by nearby risers and earthmat grid spacing shall be maximum 15 mts Separate dedicated riser shall be provided for C&I Control and Instrumentation earthing purpose and also for Lightning down conductor connection purpose.
- 
- Sufficient nos of risers near the equipment shall be provided as per the system requirement. Ring type earthing around the building shall be provided with interconnection of with main grid at minimum two points.
- The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.

Equipment	Earth Conductor Buried in Earth	Earth Conductor Above Ground Level & in Built-up Trenches
I. Main Earth Grid	Min. 40 mm dia. MS rod or as per actual calculation, whichever is more	65 x 6 mm GS flat



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Equipment	Earth Conductor Buried in Earth	Earth Conductor Above Ground Level & in Built-up Trenches
II. 33kV/11kV/6.8kV/3.3kV Switchgear Equipment and 415V Switchgear	—	65 x 6 mm GS flat
III. 415V Distribution Boards / Transformers	—	50 x 6 mm GS flat
IV. LT Motors		
• Above 125 kW	—	50 x 6 mm GS flat
• 25 kW to 125 kW	—	25 x 6 mm GS flat
• Below 25 kW	—	25 x 3 mm GS flat
• Fractional Horse Power Motor	—	8 SWG GS wire
V. Control Panel & Control Desk	—	25 x 3 mm GS flat
VI. Push Button Station / Junction Columns, Structures, Trays, and Bus Ducts Enclosures	—	8 SWG GI wire
VII. Crane, Rails, Rail Tracks & Other Non- Current Carrying Metal Parts	—	50 x 6 mm GS flat (Crane, Rails) 25 x 6 mm GS flat (Other Parts)

Note:



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- MS: Mild Steel
  - GS: Galvanized Steel
  - GI: Galvanized Iron
  - SWG: Standard Wire Gauge
- Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed at switchgear end only unless otherwise approved. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Railway tracks within the plant area shall be bonded across fish plates and connected to earthing grid at several locations. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable.
  - Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.
  - Transformer neutral shall be connected to earth mat through 2 Nos, treated earthing pit (as applicable) and shall meet the statutory requirements.
  - 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.
  - 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.
  - 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.
  - 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.
  - Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.
  - Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

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- A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same.
- Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively.
- Earth pit shall be of treated type & shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 600mm. Earth pits shall be treated with salt and charcoal as per IS:3043. Test links shall be provided with bolted arrangement along with each earth pit, in order to facilitate measurement of earth resistance as & when required.
- On completion of installation continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by Bidder.
- Earthing conductor shall be buried at least 2000mm outside the fence of electrical installations. Every alternate post of the fences and all gates shall be connected to earthing grid by one lead.
- The earthing system shall be capable of withstanding the maximum prospective fault current, including BESS inverter contributions, for at least 1 second. Earthing shall be designed using IEEE 80 or IS 3043.
- All metallic components of the BESS (containers, racks, HVAC, cable trays, etc.) shall be interconnected via an equipotential bonding network
- The DC grounding configuration (floating or grounded) shall be defined per inverter manufacturer recommendation. Isolation monitoring devices shall be provided if floating.
- Suitable earthing provision shall be provided by Bidder for all BESS Containers, Transformers as per system requirement, manufacturer's recommendation, statutory requirement, relevant standards and as specified elsewhere.

#### Other Requirements of Earthing System

Parameter / Requirement	Specification
Applicable Standards / Codes	IEEE 80, IS 3043



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Parameter / Requirement	Specification
Life Expectancy	25 Years
System Fault Level	As per System Fault Level
Soil Resistivity	Actual as per site conditions
Minimum Steel Corrosion Rate	0.12 mm/year (over the conductor)
Depth of Burial (Main Conductor)	600 mm below grade level. Where crossing trenches, pipes, ducts, etc., minimum 300 mm below them.
Conductor Joints	Electric arc welding, with joint resistance not more than that of the conductor. Welds must be treated with red lead for rust protection and coated with bitumen compound for corrosion protection.
Surface Resistivity	<ul style="list-style-type: none"><li>• Gravel: 3000 ohm-meter</li><li>• Concrete: 500 ohm-meter</li></ul>

#### LIGHTNING PROTECTION SYSTEM

Lightning protection system shall be in strict accordance with IEC: 62305 and latest IS standards.

Lightning conductor shall be of 25x6mm GS strip when used above ground level and shall be connected through test link with earth electrode/earthing system.

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Lightning system shall comprise of air terminations, down conductors, test links, earth electrode etc. as per approved drawings.

#### **Down Conductors**

1. Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.
2. Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.
3. All joints in the down conductors shall be welded type.
4. Down conductors shall be cleated on outer side of building wall, at 750 mm interval or welded to outside building columns at 1000 mm interval.
5. Lightning conductor on roof shall not be directly cleated on surface of roof. Supporting blocks of PCC/insulating compound shall be used for conductor fixing at an interval of 1500 mm.
6. All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.
7. Lightning conductors shall not pass through or run inside GI Conduits.
8. Testing link shall be made of galvanized steel of size 25x 6mm.
9. Pulser system for lightning shall not be accepted.

Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths.

#### **TESTS**


Cable termination kit and straight through joints should have been tested as per IS:13573 for 3.3kV grade & above.

#### **Routine/ Acceptance Tests**

##### **Routine Tests**

- a) Routine tests as per specification and applicable standards shall be carried out on all requirements/items covered in the specification
- b) Physical & dimensional check on all equipments as per approved drawings/standards c) HV/IR as applicable
- c) Check/measurement of thickness of paint/zinc coating/nickel-chrome plating as per specification & applicable standard

##### **Acceptance Test**

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a) Galvanising Tests as per applicable standards

b) Welding checks

c) Deflection tests on cable trays

One piece each of 2.5m length of cable tray of 300mm & above shall be taken as sample from each offered lot. It shall be supported at both end & loaded with uniform load of 76 kg/meter along the length of cable tray. The maximum deflection at the mid-span of each size shall not exceed 7mm

#### Proof load tests on cable tray support system

- i. Tests on Main Support Channel shall be done if only C1 Channel are in scope of supply and cantilever arms shall be fitted on one side. This test shall be same as test 4 of type test.
- ii. Test on Main Support Channel shall be done with C2 channel and cantilever arms fitted on both sides, if C2 channels are in scope of supply. This test shall be same as test 2A of type test. Then test (i) above shall not be done.
- iii. Nut slip characteristic test (it shall support minimum load of 350kg before nut slips with a bolt torque of 65 NM). This test shall be same as test 5B3 of type test The procedure for carrying out tests at “d” above shall be as per details given in Type Tests in specification thereafter Die-Penetration test shall be carried out to check weld integrity The above acceptance tests shall be done only on one sample from each offered lot.

#### COMMISSIONING


- i. The Bidder shall carry out the following commissioning tests and checks after installation at site. In addition the Bidder shall carry out all other checks and tests as recommended by the Manufacturers or else required for satisfactory performance.

#### Cables

- i. Check for physical damage
- ii. Check for insulation resistance before and after termination/jointing
- iii. HT cables shall be pressure tested (test voltage as per IS:7098) before commissioning
- iv. Check of continuity of all cores of the cables
- v. Check for correctness of all connections as per relevant wiring diagrams. Any minor modification to the panel wiring like removing/inserting, shorting, change in terminal connections, etc., shall be carried out by the Bidder.
- vi. Check for correct polarity and phasing of cable connections
- vii. Check for proper earth connections for cable glands, cable boxes, cable armour, screens, etc.
- viii. Check for provision of correct cable tags, core ferrules, tightness of connections

#### Cable trays / supports and accessories

1. Check for proper galvanizing/painting and identification number of the cable trays/supports and accessories.
2. Check for continuity of cable trays over the entire route.

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3. Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
4. Check for earth continuity and earth connection of cable trays.

#### **Earthing and Lightning protection system**

1. Earth continuity checks.
2. Earth resistance of the complete system as well as sub-system.

#### **ELECTRICAL LAYOUT PHILOSOPHY:**

While developing the layout the bidder must give due consideration to the following requirements:

- a) Adequate distance shall be maintained between the transformers as per statutory requirement and standards. As basic guidelines following norms will be adhered to:

1. Jacking pads shall be provided where the rail track changes the direction. Mooring post shall be provided on rail track for handling the transformers
2. Rail track shall be provided for all outdoor transformers up to road for movement of each transformer of size more than or equal to 7.5MVA Transformer. Jacking pads shall be provided where the rail track changes the direction. Jacking pad shall also be provided at the location of installation of transformer and mooring post shall be provided on rail track for handling the transformers.
3. The Transformer fencing shall be at 1.0 M (minimum) distance from the pit wall. The Height of fencing shall be 2.5 M (minimum) and fencing shall have personal entry gate and removable type fencing/gate for transformer withdrawal.
4. The transformer firewall, pit sizing, sump pit, oil retention pit and clearances from adjacent building/structures etc. shall be as per statutory requirement, relevant standard, IS 1646/CBIP manual on Transformer.
5. However, for all outdoor transformers of oil capacity less than 2000 litre, a trench of suitable size shall be provided all around at a distance of 1.0 m (minimum) from transformer outer edge. A sump pit shall be provided for each trench.

#### **b)1. The following clearances shall be maintained for HT Switchboard**

- i) For one Row of Swgr. - **2.0 M (Min)**
- ii) For two Rows of Swgr. - **2.5 M (Min)**

**Back Clearance - 1.5 M (Min.)**

#### **c.) Side Clearance**

Min. 800 mm, however provision to be made for any additional panel in future at both ends. Therefore end clearance shall be 800+width of panel (including spare panels/dummy panels etc.)

The following clearances shall be maintained for LT Switchboard.





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**a.) Front Clearance**

- i) For one Row of Swgr - 1.5M (Min)
- ii) For two Rows of Swgr - 1.5/1.75M depending upon the depth of panels etc

**b.) Back Clearance**

- i) For single front - 1.0M (Min) ii)
- For double front - 1.5M (Min)

c.) Side Clearance: Min. 800 mm, however provision to be made for any additional panel in future at both ends. Therefore end clearance shall be 800 mm + width of panel.

**Height of HT/LT Switchgear Room**

- i. With Bus Duct – 4.5 m (min) ii. Without Bus Duct – 4.0 m (min)

**Cable trench/Cable vault**

For LT switchgear room (as applicable) at EL 0.0M, 1400 wide x 1400 deep cable trench shall be provided to route the cables. Horizontal cable trays shall be routed in cable trenches

Minimum clear working space 1200mm around the equipment

The cable entry and exit from switchgear Panel area shall be from 1.5 mtr (minimum) above FGL

Wash basin with mirror shall be provided in battery room (as applicable).



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## 25. LIGHTING

### GENERAL


This specification covers the general description of design, manufacture and construction features, testing, supply, installation and commissioning of the Lighting system equipment.

### CODES AND STANDARDS

All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of 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.

#### Lighting Fixtures and Accessories

IS:1913	General and safety requirements for luminaries.
IS:2148	Flame proof enclosures of electrical apparatus.
IS:1534	Ballast for fluorescent lamps.
IS:1777	Industrial luminaire with metal reflectors.
IS:2418	Tubular fluorescent lamps for general lighting services.
IS:4013	Dust-tight electric lighting fittings.
IS:8224	Electric Lighting fittings for Division 2 areas.
IS:10276	Edison screw lamp holders.
IS:10322	Luminaires.
IS:13021	AC Supplied Electronic Ballasts for tubular fluorescent lamps.
IS 16103	LED Luminaire Standards Lighting Panels, Switch-boxes, Receptacles and Junction Boxes
IS:2147	Degree of protection provided by enclosures for low-voltage switchgear and control gear.
IS:1293	Plugs & socket outlets of rated voltage upto and Including 250volts & rated current upto and including 16 Amps.
IS:2551	Danger notice plates.

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IS:13947 Low voltage switchgear and control-gear

IS:3854 Switches for domestic and similar purposes.

IS:6875 Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V AC and 1200 V DC.

IS:13703 Low voltage fuses for voltages not exceeding 1000V AC or 1500 V DC.

#### **Conduits, Pipes and Accessories**

IS:2667 Fittings for rigid steel conduit for electrical wiring.

IS:3837 Accessories for rigid steel conduits for electrical wiring.

IS:9537 Conduits for electrical installations.

#### **Lighting Wires/Cables**

IS:694 PVC insulated cables for working voltages upto and including 1100 V

IS:3961 Recommended current ratings for cables.(PVC Insulated and PVC sheathed heavy duty cables and light duty cables).

IS:8130 Conductors for insulated electric cables and flexible cords.

IS:10810 Methods of tests for cables.

#### **LED Luminaries**

16101:2012 General Lighting. LEDs and LED modules  
Terms and definitions

16102(Part 1):2012 Self Ballasted LED Lamps for General Lighting Services.  
Part-1 Safety Requirements.

16102(Part 2):2012 Self Ballasted LED Lamps for General lighting Services.  
Part-2 Performance Requirements.

16103(Part I):2012 LED modules for General lighting Safety Requirements.

15885(Part 2/Sec. 13) :2012 Lamp control gear Part 2 particular  
Requirements Section 13 d.c. or a.c.  
Supplied Electronic control gear for LED modules

16104:2012 d.c. or a.c. Supplied Electronic control gear  
for LED modules - Performance



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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	Luminaires Performance
16108:2012	Photo-biological safety of Lamps and Lamp Systems
IS 12063	Classification of degree of protection provided by enclosures
IS 14700 (Part 3/Sec. 2)	Electro magnetic compatibility (EMC) – Limits for Harmonic 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	Lamp control gear: particular requirements for (Part 2/Sec. 13) DC or AC supplied electronic control gear IS 16004 – 1 and 2) for LED modules.
IS 4905	Method for random sampling

**Electrical Installation Practices & Miscellaneous**

IS:1944	Code of practice for lighting of public thorough fare
IS:3646	Code of practice for interior illumination.
IS:5572	Classification of Hazardous areas (other than Mines) having flammable gases and Vapours for electrical installation
IS:6665	Code of practice for industrial lighting.
IS:280	Mild steel wires for general engineering purposes.
IS:374	Electric ceiling type fans & regulators.
IS:732	Code of practice for electrical wiring installations.

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IS:1255	Code of practice for installation and maintenance of power cables Upto and including 33KV rating.
IS:2062	Steel for general structural purposes
IS:2629	Recommended practice for hot-dip galvanizing of iron and steel.
IS:2633	Methods for testing uniformity of coating of zinc coated articles.
IS:2713	Tubular steel poles for overhead power lines.
IS:3043	Code of practice for earthing
IS:5216	Guide for safety procedures and practices in electrical work.
IS:5571	Guide for selection of electrical equipments for hazardous areas.
BS:6121	Mechanical cable glands

#### **LIGHTING SYSTEM DESCRIPTION**

The illumination of various indoor and outdoor areas in the bidders/project area shall be provided as described here. The lighting system of various areas shall comprise of the following systems as identified in Annexure-B:

- (a) Normal AC Lighting System
- (b) Emergency AC Lighting System
- (c) Self Contained DC Lighting System

#### **Normal AC Lighting System**


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

#### **Emergency AC Lighting System**

Lighting fixtures connected to this system shall be normally "ON" along with the normal AC system. These will be fed from emergency lighting panels (ELPs) which in turn will be fed 3-phase, 4-wire supply from the emergency lighting distribution boards (ELDB'S). These lights will go off in case of Station AC supply failure but shall be automatically restored from UPS supply.

#### **DC Lighting System**

Emergency DC lighting is to be provided, through self-contained DC emergency fixtures with four hours back-up duration, at entry/exit of all buildings/equipment area. at strategic locations The fixtures shall be switched 'ON' automatically in case of failure of AC supply.

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## DESIGN PHILOSOPHY

1. A comprehensive illumination system shall be provided in the entire project areas under bidder's scope.
2. All outdoor lighting system shall be automatically controlled by synchronous timer. Provision to bypass the timer shall be provided in the panel.


The system shall include distribution boards, normal lighting panels, lighting fixtures, junction boxes, receptacles, switch boards, lighting pole/masts, conduits, cables and wires, etc. The system shall cover all interior and exterior lighting such as area lighting including Transformer yard & Switch yard area, Street lighting, security lighting, etc. The constructional features of lighting distribution boards shall be similar to AC distribution boards described in chapter of LT Switchgear. Outgoing circuits in LPs shall be provided with MCBs/RCBOs of adequate ratings.

4. The illumination system shall be designed on the basis of best engineering practice and shall ensure uniform, reliable, aesthetically pleasing and glare free illumination. The lighting fixtures shall be designed for minimum glare. The design shall prevent glare/luminous patch seen on VDU/ Large video screens, when viewed from an angle. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection. The diffusers/ louvers used in fixtures shall be made of impact resistant polystyrene sheet and shall have no yellowing property over a prolonged period. The Lux levels to be adopted for various area are indicated at Annexure - A. (placed at the end of this Chapter).
5. While finalizing the detailed layout of lighting fixtures, the position/location and layout of equipments should be taken into account to have adequate illumination at desired locations. Each building shall be provided with adequate light fittings, 6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room, etc
6. **LED Luminaires:**

LED Luminaires shall be used for the lighting of all the indoor & outdoor areas in bidder's scope. In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

The individual lamp wattage for LED shall be upto 3 watt. Fractional wattage LEDs are also acceptable. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall be not less than 100 Lm/W. Suitable heat sink shall be designed & provided in the luminaire. The LED used in the luminaires shall have colour rendering index (CRI) of Min 80. Colour designation of LED shall be "cool day light" (min 5700K) type for indoor areas. However for outdoor areas, the colour temperature of LED shall be min. 4000K, including rough & dust prone areas. The LED luminaries shall have a minimum life of 25000 burning hours with 80% of lumen maintenance at the end of the life. LED shall conform to the LM 80 requirements.

The max. junction temperature of LED shall be 85 deg C. Further the lumen maintenance at this temperature shall be min 90%. The THD of LED Luminaires shall be less than 10%. Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards.

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Suitable heat sink with proper thermal management shall be designed & provided in the luminaire.

The connecting wires used inside the system, shall be low smoke halogen free, fire retardant type and fuse protection shall be provided in input side specifically for LED luminaires.

Care shall be taken in the design that there is no water stagnation anywhere in the housing of luminaire. The entire housing shall be dust and waterproof protection as per IS 12063.

#### 7. **Driver Circuit**

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

LED Drivers shall have following control & protections: - •

Suitable precision current control of LED.

- Open Circuit Protection
- Short Circuit Protection
  
- Over Temperature Protection
- Surge Protection

8. Apart from maintenance factor as given below, Temperature correction factor shall be considered in the lighting design for fixtures located in non air conditioned area.

- |      |                                    |   |     |                       |
|------|------------------------------------|---|-----|-----------------------|
| (a.) | Office area (air conditioned)      | : | 0.8 |                       |
| (b.) | Office area (non air conditioned)  | : | 0.7 | and other indoor area |
| (c.) | Dust prone indoor and outdoor area | : | 0.6 |                       |


9. (i) All outdoor fixtures shall be weather proof and of min. IP65 degree of protection.

(ii) For Indoor type of fixtures:-

- (a) Surface/Pendent mounting: - IP 54 class of protection.
- (b) Recess Mounting (False ceiling):- IP 20 class of protection.

(a) Lighting panels shall be constructed out of 2 mm thick CRCA sheet steel. The door shall be hinged and the panel shall be gasketted to achieve specified degree of protection. Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have min. IP55 degree of protection.

(B) All MCBs/Isolators/Switches/Contactors etc. shall be mounted inside the panel and a fibre glass sheet shall be provided inside the main door such that the operating knobs of MCBs etc., shall project out of it for safe operation against accidental contact.

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- (c) Terminal blocks shall be 1100 V grade, clip-on stud type, made up of polyimide 6.6 or better suitable for terminating multicore 35 or 70 Sq. mm. stranded aluminium conductor incoming cable and 10 Sq. mm. stranded aluminium conductor for each outgoing circuits voltage. All terminals shall be shrouded, numbered and provided with identification strip for the feeders.
- (d) MCB's/RCBOs shall be current limiting type with magnetic and thermal release suitable for manual closing and automatic tripping under fault condition. MCB's/RCBOs shall have short circuit interrupting capacity of min 9 KA rms. MCB/RCBOs knob shall be marked with ON/OFF indication. A trip free release shall be provided to ensure tripping on fault even if the knob is held in ON position. MCB/RCBOs terminal shall be shrouded to avoid accidental contact. RCBOs shall be of 30mA sensitivity having facility for manual testing/checking of operation.
- (e) Contactors of AC lighting panels shall be 63 A, with neutral link, load makebreak type suitable for 415 V, 3 phase 4 wire system.
- (f) Programmable Digital Timer shall be Electronic Astronomical Time switch with LED display, 24 hours range, manual override facility, 10 Amp relay output with NO/NC Contacts suitable for operation on 240V single phase AC supply.
- (g) Lighting Panels shall have 20% spare outgoing feeders and shall be of following types:-

TYPE	INCOMER FEEDER	OUTGOING FEEDERS	DETAIL OF CONTENTS
LP-1	415V, 63 A, MCB (31/2Cx70sq.mm cable)	18Nos.,20A, 220/240V RCBO 30mA	415V, 63A(min.), AC2 duty contactor and Astronomical Programmable Digital Timer of 24 hour range 10A, 240V selector switch, fuse, etc. outdoor type and IP:55 degree of protection
LP-2	415V, 63 A, MCB (31/2Cx70sq.mm cable)	9 Nos.,20A, 220/240V RCBO 30mA	415V, 63A(min.), AC2 duty contactor and Astronomical Programmable Digital Timer of 24 hour range 10A, 240V selector switch, fuse, etc. outdoor type and IP:55 degree of protection

- 11. Wires of different phase shall normally run in separate conduit.
- 12. Power supply shall be fed from 415 / 240 V normal AC supply, through suitable number of conveniently located lighting distribution boards (LDB) and lighting panels (LP). AC lighting supply shall be isolated from main supply by 2x100% isolation transformers of max. rating of 50/100 KVA for 10/15 nos. outgoing feeder with changeover switch facility. The isolation





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transformer shall be fed from two different bus sections of MCC and fault level restricted to 3 KA at Lighting Panels. 20% spare feeder (Min 2 two no.) shall be provided in each lighting DBs.

13. Atleast one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc. Further 20A, 240V AC industrial receptacle with switch shall be provided strategically in all industrial areas.


Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for entire plant for welding purposes. Atleast one 63A, 3ph, 415V AC receptacle shall be provided in each floor of buildings/ structures.

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped gavanised or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with RCCB/RCD of 30mA sensitivity having facility for manual testing/checking of operation of RCCB/RCD.

Receptacles shall be of following types:

Type	Switch rating	Socket & plug rating	Type & make of plug & Socket	Terminal Block size
RA	20 A, SP240V AC(Industrial)	20A, 3 pin240 V AC	NTPC appd. make	1-4 way, suitable for loop-in loop-out of 10 sq.mm. Al. Conductor
RB	16A, S.P240V AC	6A+16A6 Pin decorative Piano-key Type Switch	NTPC appd.make	1-4 way, suitable for loop-in loop-out of upto 10 sq.mm. Al. Conductor

15. All fittings shall be have "Cool day light" colour designation. The mirror optics type fixtures shall have no iridescence effect. Fixtures with better efficiency and upgraded proven system may also be considered

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16. Aviation warning lights shall be provided as per the recommendations of ICAO and Director general of civil aviation, India. The arrangement of light should be marked such that the object is indicated from every angle in azimuth. The aviation warning lighting system shall also conform to the latest Indian standard IS 4998.
17. Bidder shall demonstrate the average lux level achieved for different areas as per specification requirements, after completion of the lighting work, at site to the satisfaction of engineer-in-charge.

#### **Fans & Regulator**


Ceiling Fans, to be provided in non air-conditioned office/control room area. Further tentatively one (1) no. ceiling fan shall be provided for 10 sq.m area, at suitable mounting height. The ceiling fans shall be suitable for operation on 240 V +/-10%, 50 Hz, AC supply comprising of class 'E' or better insulated copper wound single phase motor, 1200mm sweep, aerodynamically designed well balanced AL blades (3 Nos.), down rod, BEE 5 star rated, die cast aluminium housing, capacitor, suspension hook, canopies etc. finished in stove enameled white or with electro static powder coating. Power factor of fans shall not be less than 0.9. Fan regulators shall be stepped electronic type suitable for operation on 240V +/-10% AC supply.

#### **Junction Boxes, Conduits, Fitting & Accessories, Pull Out Boxes:**

Junction box shall be made of Fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type. The box shall be provided with the terminal blocks, mounting bracket and screws etc. The cable entry shall be through galvanized steel conduits of suitable diameter. The JB shall have suitable for installing glands of suitable size on the bottom of the box. The JB shall be suitable for surface mounting on ceiling/structures. The JB shall be of grey color RAL 7035. All the metal parts shall be corrosion protected. Junction box surface should be such that it is free from crazings, blisterings, wrinkling, colour blots/striations. There should not be any mending or repair of surface. JB's will be provided with captive screws so that screws don't fall off when cover is opened. JB's mounting brackets should be of powder coated MS. Type test reports for the following tests shall be furnished:

- a) Impact resistance for impact energy of 2 Joules (IK07) as per BS EN50102
- b) Thermal ageing at 70deg C for 96 hours as per IEC60068-2-2Bb
- c) Class of protection shall be IP 55
- d) HV test

Terminal blocks shall be 1100V grade, of suitable current rating, 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 the required cables/wire size. All internal wiring shall be of cu. Conductor PVC wire.

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- Junction boxes for street lighting poles and lighting mast if applicable , shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.
- All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.
- Conduits, Pipes and Accessories Galvanised heavy duty steel conduits for normal area and galvanised heavy duty steel conduits with an additional epoxy coating for corrosive area shall be offered. Alternatively glass reinforced epoxy conduits with comparable compressive and impact strength with that of heavy duty steel conduits may be offered Conduits in walls and ceilings in buildings with RCC and masonry structure such as Control Room, Office etc shall be concealed. Rigid steel conduits shall be heavy duty type, hot dip galvanised conforming to IS : 9537 Part-I & II shall be suitable for heavy mechanical stresses, threaded on both sides and threaded length shall be protected by zinc rich paint.
- Conduits shall be smooth from inside and outside.
- Flexible conduit shall be water proof, rust proof, made of heat resistant steel with temperature rating of 150 deg C.
- Pull out boxes shall be provided at suitable interval in a conduit run .Boxes shall be suitable for mounting on Walls, Columns, Structures, etc.. Pull-out boxes shall have cover with screw and shall be provided with good quality gasket lining. Pull out boxes used outdoor shall be weather proof type suitable for IP: 55 degree of protection and those used indoor shall be suitable for IP: 52 degree of protection. Pull out box & its cover shall be hot dip galvanized. **Lighting Wires**
- Lighting wires shall be 1100 V grade, light duty PVC insulated unsheathed, stranded copper/ 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 Minimum size of wire shall not be less than 1.5 sq.mm. copper.

#### Lighting Poles

- The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. The Poles shall be mounted above ground using base plate and minimum height of pole shall be 8 mtrs The poles shall be hot-dip galvanized as per IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall be min. 70 micron. The System shall be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.
- The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.
- Hot dipped Galvanized hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable

#### Lighting Masts

- Suitable number of lighting masts shall be provided for entire plant..Lighting Mast shall be of continuously tapered polygonal cross section hot dip galvanised. The Mast shall be of 30 M or suitable height with lantern carriage to enable raising/lowering for ease of maintenance, including the Head Frame, Double Drum Winch, continuous stainless steel wire rope, in built power tool, luminaires, suitable aviation warning light, lightning alongwith necessary power cables within the mast. The mast shall be delivered in not more than three sections & shall be

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joined together by slip stressed fit method at site. No site welding or bolted joints shall be done on the mast

- The Mast together with the fixtures shall be capable of withstanding the appropriate wind loads as per IS: 875. The Mast shall be fabricated from special steel plates conforming to BS-EN10-025 and folded to form a polygonal section.
- Suitable feeder pillar with TPN MCB, contactors, timer, MCB and other necessary accessories for operation & protection of the mast and fixtures shall be provided.
- Lighting fixtures shall generally be group controlled directly from lighting panel. However, in office areas, control shall be provided through switch boxes. Each switch shall control a maximum of three fixtures.
- A.C. normal, wiring shall run throughout in separate conduits. Wires of different phase shall run in different conduits.
- 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 alongwith each conduit run. Cable armours shall be connected to earthing system at both the ends.
- Alternately Vendor may offer technically superior and proven product subject to approval of employer.
- All lighting fixtures, lamps and other items shall be subjected to routine test, as per relevant specified standards and QAP (as applicable).
- Junction boxes, switch boxes, receptacle enclosure etc. shall be subjected to physical and dimensional checks also. Switch boxes shall be made of 1.6 mm thick MS sheet with 3 mm thick decorative, Perspex cover. Switch box shall be hot dip galvanized.

#### Galvanizing Tests


The quality of galvanizing shall be smooth, continuous, free from flux stains and shall be inspected visually.

In addition following tests shall be conducted as acceptance tests.

- Uniformity of coating - The coating of any article shall withstand for one (1) minute dips in standard copper sulphate solution without the formation of an adherent red spot of metallic copper upon the basic metal.
- The quality of cadmium/zinc plating on items with screw threads shall be free from visible defects such as unplated areas, blisters and modules and shall be inspected visually.
- In addition, the plating thickness shall be determined microscopically/ chemically or electronically.

#### COMMISSIONING CHECKS

- On completion of installation work, the Bidder shall request the Project manager for inspection and test with minimum of fourteen (14) days advance notice.

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2. The Project manager shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Bidder.
3. The installation shall be then tested and commissioned in presence of the Project manager.
4. The Bidder shall provide all, men material and equipment required to carry out the tests.

All rectifications repair or adjustment work found necessary during inspection, testing and commissioning shall be carried out by the Bidder without any extra cost. The handing over the lighting installation shall be effected only after the receipt of written instruction from the Employer/his authorized representative.

6. The testing shall be done in accordance with the applicable Indian Standards and codes of practices. The following tests shall be specifically carried out for all lighting installation.
  - (a) Insulation Resistance.
  - (b) Testing of earth continuity path.
  - (c) Polarity test of single phase switches.
  - (d) Functional checks.
7. The lighting circuits shall be tested in the following manner:
  - (a) All switches ON and consuming devices in circuit, both poles connected together to obtain resistance to earth.
  - (b) Insulation resistance between poles with lamps and other consuming devices removed and switches ON.



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ANNEXURE-A

Sl No.	Location**	Average Illumination Level (Lux)	Type of Fixture
(a)	Switchgear rooms, Charger, Rectifier room	200	Industrial type LED Luminaire
(b)	Control room, computer room, control equipment room	350	LED luminaire equivalent to Mirror optics with anti-glare features or down-lighter.
(c)	Offices, conference rooms, etc.	300	Decorative mirror optics Type LED luminaire or LED down-lighter
(d)	Battery rooms	100	Totally enclosed corrosion Proof LED Luminaire
(e)	Transformer yard	20 (general) 50 (on equipment)	LED Luminaire
(f)	Cable galleries/vault	50	Industrial type LED Luminaire
(g)	Street lighting- primary roads secondary roads	20 10	LED street lights
(h)	Outdoor storage handling and unloading area	20	LED Luminaire
(i)	Permanent stores	150	LED high/medium bay / Industrial trough LED Luminaire
(j)	Garage/Car Parking	50	Industrial type LED Luminaire
(k)	AIS Switchyard and Substation	20(general 50(on strategic equipment)	LED Luminaire
(l)	Facility building, canteen, Misc Building etc	150	Industrial type LED Luminaire
(m)	Corridors, Walkways	50	LED Luminaire
(n)	Building Periphery Lighting	20	LED Street Light fixture/ LED Luminaire

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## 26. METERING

### Phasor Measurement Unit (PMU)

The specification identifies some minimum requirements for each of the major component which are essentially required for measurement of complex quantities and transmitting the same to the PDC (Phasor Data Concentrator). 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 also be used for carrying out the post- facto analysis.

The offered panel mounted PMUs shall be complete in all respect so that they can be installed at the substation and can communicate with Phasor Data Concentrator (PDC). The necessary cable, connector, and installation hardware, as required, shall be in bidder's scope. PMUs shall be considered for EHV line bays **Tie Line Bays** and shall be installed in switchyard control room and adjacent to line BPU panels. CT/CVT connections to the PMU shall be extended from the control & relay panels. In case of multiple PMUs, the Router shall be provided which shall interface PMUs on one side and communication equipment on the other side.

### PMU sizing requirements.

- A minimum 2 (two) No. of PMUs shall be offered at Each Feeder bays/ Substations/power plants, except in the locations, where only two 3-phase voltage and two 3- phase current phasors are required to be measured.**
- The minimum configuration offered PMUs shall have at least 2 set of 3-phase voltages, two set of 3-phase current and 8 digital inputs, frequency, ROCOF and two analog values. Based on the no. of phasors, analog values, and digital values to be measured within a substation/Power plant, the Bidder may optimize the no. of PMUs.
- The no of GPS receivers shall be minimum two at every substation except in case of in-built GPS in each PMU.
- The no of ports required in industrial grade layer-3 LAN switch shall be based on the no of PMUs in the substation, including 50% expandability in the ports.

The PMU shall support data 'Reporting Rates' of 25, and 50 frames per second for 50 Hz System. The actual rate to be used shall be user selectable. All the hardware and software shall be sized considering 50 frames per second. The typical network architecture of PMUs at substation is given at Fig 1.1 below



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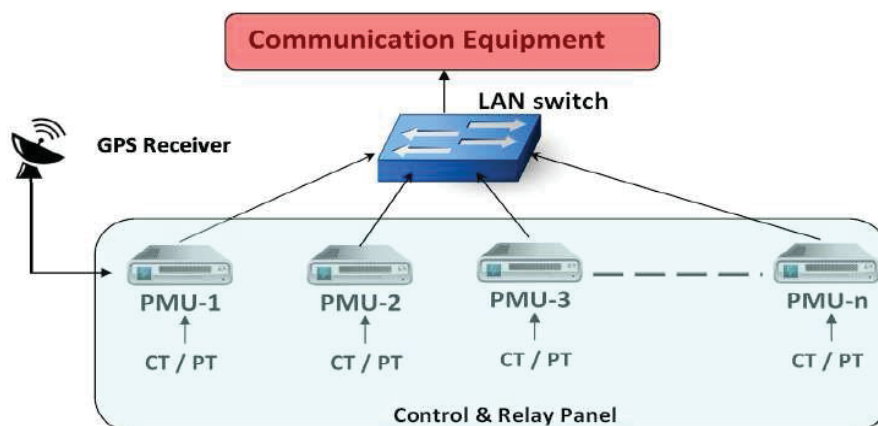



Fig 1.1: Typical Network Architecture at Substation Control room

#### PMU Functional Requirements

The PMUs offered shall conform to IEEE C37.118.1 & C37.118.2 standard for both P and M class performance and shall be designed to meet the following requirements:

- i. The PMU shall receive time from reliable and accurate Global Positioning System (GPS) directly or through separate GPS receiver. GPS shall provide time traceable to coordinated universal time with sufficient accuracy. The PMU with supplied GPS shall keep the total vector error (TVE), the frequency error (FE), and the Rate of Change of Frequency (ROCOF) within the limits specified as per IEEE C37.118.1 & IEEE C37.118.2 standard.
- ii. The PMU may have inbuilt GPS or a separate unit. The PMUs shall be timesynchronized from GPS using either IRIG-B port or IEEE 1588 v2.0 on Ethernet port.
- iii. Upon loss of signal from the GPS source, the PMU shall detect a loss-of-signal and generate an alarm which will be transferred to PDC. Upon loss of signal, the PMU time facility shall revert to an internal time base. The internal clock should have a minimum stability of 1 ppm. Within one minute of re-acquisition of signal, the time shall return to within 0.2 micro-second of UTC. Re-synchronization accuracy shall be less than 1.5 microsecond of UTC. Proper correction of the leap second shall be provided.
- iv. The PMU supplied shall be panel mounted.
- v. The PMU shall support Data Reporting Rates at 25 & 50 frames per second at System Frequency of 50 Hz. The actual rate to be used shall be user selectable.
- vi. PMU shall meet all requirements as specified for both P and M Class of Performance, which shall be user selectable as specified in IEEE C37.118.1 & C37.118.2 standard.
- vii. The auxiliary power supply to PMUs will be provided from the station DC which is used for control and protection of substation devices. Accordingly, the PMUs shall be suitable to operate on unearthed 220 V or 110V (+10%, -15%) DC power supply depending upon the station DC supply available.



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viii. The PMUs shall be used to measure the following:

**For every Feeder in a Substation / IPP:**

- a) One set of 3-phase voltage phasors (input can be from Bus PT/CVT), b) 3-phase current phasors,
- c) positive sequence voltage, positive sequence current, d) 4 Digital Inputs
- e) Analog values (MW & MVAR)

**For every Substation/Power Plant/IPP:** a) Frequency,

- b) Rate of Change of Frequency (ROCOF) -df/dt,

Provision shall be made for user selection of measured value.

ix. The PMU output shall communicate with the PDC as per latest IEEE C37.118.2.

- x. The PMUs shall have continuous self-monitoring, diagnostic feature and capable to identify & communicate problems and shall generate alarm in case of any abnormality which shall be displayed locally as well as shall be transferred to the PDC. The indication shall be available for each module on the front panel of the PMU.

The offered PMUs shall meet the measurement compliance for both P & M class of measurements as given in Section 5.5 of IEEE C37.118.1 standard.

- xii. The PMUs shall communicate with PDC over the communication link provided by the employer. For this, PMU shall be provided with One Ethernet port of 10/100 Base Tx and one optical fiber port of 100 Mbps for streaming the data in TCP/UDP method as per IEEE C37.118.2 format.

- xiii. There shall be provision for HMI (Human Machine Interface) in PMU to perform setting changes. The HMI shall also display the real time measured values. Alternatively, Portable configuration device for PMUs can be provided for configuring the PMUs. Testing & configuration accessories such as test switch, connector, software, hardware etc. which are required for testing and configuration changes locally shall be supplied.

- xiv. Remote configuration facility shall be provided in PMU and the supplier shall supply the necessary hardware/software required for remote configuration of PMU.


- xv. PMU shall be capable of sending data in Uni-cast and multi-cast both simultaneously.

However, the following strategy is to be adopted for the Project:

Data from PMUs to first level control center at State/Regional/NTAMC level shall be transmitted through UDP/IP multicast. 30% of the supplied PMUs shall report to two (multiple) destination PDCs (regional and state boundaries)

- xvi. PMU shall support multiple data streams i.e. a PMU shall be capable of transmitting its data in one or more separate data streams. Each stream shall be configurable independently based on the following.

- a) Contents
- b) Sampling rate
- c) Class of service (P or M)

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d) Communication mode (TCP/UDP)

e) Different destinations with separate IDCODE.

All these features shall be demonstrated during testing at the factory and at site. PMU shall support multiple data stream i.e. a PMU shall be capable to transmit its data in one or more separate data streams. Each stream shall be configurable independently based on the following.

a) Contents

b) Sampling rate

c) Class of service (P or M)

d) Communication mode (TCP/UDP)

e) Different destinations with separate IDCODE.

All these features shall be demonstrated during testing at factory and at site.

#### Industrial Grade Layer-3 LAN switch

In case of multiple PMUs at a substation all the PMUs shall be connected to the communication equipment through an industrial grade router Layer-3 LAN switch. The industrial grade router LAN switch shall interface PMUs on one side and communication equipment on the other side. The LAN switch shall operate on 220VDC Or 48V (+10%, -15%) DC supply voltage. The sizing requirement of LAN switches shall be as per section 9.03.01 mentioned above. Router shall be provided with following features: -

S. No.	Description of the Features	Minimum Quantity of the features
1.	Functions	High performance Routing for data
2.	Routing Capability	Static& Dynamic routing
3.	Processing capacity	Minimum 2Mpps
4.	IPSec VPN tunnels	Minimum 10
5.	Features to support	QoS, MPLS, Security, Broadband, Multiservice, Voice, IP to IP Gateway
6.	Routing protocols	EIGRP, IGRP, IS-IS, OSPF, BGP, ARP, IPCP, IP forwarding, VLAN & MPLS etc.
7.	Network protocols	TCP/IP, IPv4,IPv6, OSI, Telnet, UDP, DHCP
8.	Network management	Using SNMP Protocol



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9.	Minimum inbuilt software firewall features required	Data encryption supported DES (56 BITS) 3des (168 bits) and hashing algorithm like MD5and SHA-1 Filtering of packets based on Source address, Destination address, Protocol type, User, Port number, URL Filtering of Protocols such as FTP, SMTP, HTTP, SNMP, UDP, ICMP, RPC, DNS, DHCP, ARP d) Detailed system logging
10.	Speed Configurability at each port	All ports shall be configurable from 64kbps to 2Mbps
11	Interface ports	For connecting to communication equipment on 1Gbps Ethernet port or G.703 Port. b) 1Gbps Ethernet port for each PMU
12	Mounting	Rack mountable
13	Minimum no. of concurrent TCP sessions	10

#### Environmental Requirements

The PMU & GPS system will be installed inside switchyard control room. The PMU & GPS shall be capable of operating in ambient temperatures from -10 deg C to +55 deg C and relative humidity up to 10-90% non-condensing.


**Energy meters at POI shall be integrated into the existing ABT/Energy metering system. This includes all required hardware, software, accessories, and any necessary upgrades. Dummy panels for owner-supplied meters and integration with the existing ABT system shall be included.**

#### Energy Meters

One no. class 0.2s accuracy energy meters suitable for ABT requirement as specified below ,shall be provided at each location indicated in respective tender SLD. All ABT type meters shall be fed from accuracy class 0.2s CT and accuracy class 0.2 CVT/VT/PT.

This metering system shall have following features:

- Meters shall be microprocessor-based MWH meters having an accuracy class of 0.25 or better. MVARH meters shall have accuracy class of 0.5 or better.
- These meters shall have provision for downloading of data through an optical port and /or through RS 232/485/ Ethernet port.

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- iii. Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meters.
- iv. All these meters shall be networked using Modbus protocol and connected to the Metering Master Station (MMS), provided for the ABT meters.

Dummy panels shall be supplied for mounting of owner's supplied energy meters.

These energy meters shall be as shown in Tender SLD. Terminal blocks (disconnecting type) shall also be provided with these panels.

Quantity and dimension of these panels shall be decided during detailed engineering.

#### Technical Requirements of Energy Meters for ABT Requirement

Bidder shall supply energy meters along with metering station, 4 Nos. machine Clients, 20 nos web client license. MRI or laptop (as applicable) as per the technical specification given below:

- i. Shall be microprocessor-based conforming to IEC 62052-11, IEC 62053-22 IS 14697
- ii. Shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4 wire principle suitable for balanced/ unbalanced 3 phase load.
- iii. Shall have an accuracy of energy measurement of at least Class 0.2S for active energy and at least Class 0.5 for reactive energy.
- iv. The active and reactive energy shall be directly computed in CT & VT primary ratings.
- v. The reactive energy shall be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (Lag) when active import, MVARh (lead) when active export, MVARh (Lead) when active import.
- vi. Two separate registers shall be provided to record MVARH when system voltage is  $\geq 103\%$  and when system voltage is  $\leq 97\%$ .
- vii. Shall compute the net MWh and MVARh during each successive 15-minute block metering interval along with a plus/minus sign, instantaneous MWh, instantaneous MVARh, average frequency of each 15 minutes, net active energy at midnight, , net reactive energy for voltage low and high conditions at each midnight.
- viii. Each energy meter shall have a display unit. It shall display the net MWh and MVARh with a plus/minus sign and average frequency during the previous metering interval; peak MWh demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with a plus/minus sign, date and time; and instantaneous current and voltage on each-phases.
- ix. All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable. All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.

x At least the following data shall be stored before being over-written for the following parameters:-



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

- xi. Shall have a built-in clock and calendar with an accuracy of less than 15 seconds per month drift without assistance of external time synchronizing pulse.
- xii. Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment being supplied by the Bidder.
- xiii. The meter shall be suitable to operate with power drawn from the VT supplies.
- xiv. The power supply to the meter shall be healthy even with a single-phase VT supply. An automatic backup, in the event of non-availability of voltage in all the phases, shall be provided by a built-in long-life battery and shall not need replacement for at least 10 years with a continuous VT interruption of at least 2 years. Even under absence of VT input, energy meter display shall be available, and it shall be possible to download data from the energy meter. In case data downloading is not possible in absence of VT supply, meter with provision of 220V DC auxiliary supply shall be provided. Date and time of VT interruption and restoration shall be automatically stored in a non-volatile memory.
- xv. Shall have an optical port on the front of the meter for data collection from either a handheld meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software. The Bidder shall supply the MRI and/or notebook complete with all optical interface unit required.
- xvi. The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ and test terminal blocks shall be provided for the same.

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

#### Time Synchronization Equipment

- i. Time Synchronization equipments shall be provided and shall be located one in the switchyard Control Room, one in CER-1. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the generator relay panel.
- ii. Shall be complete in all respects including antenna, all cables, processing equipment, etc.
- iii. All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Bidder.
- iv. Shall work from DC supplies only and the Bidder to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.
- v. Shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.
- vi. The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255. One copy of all the test reports shall be enclosed with the bid.
- vii. All components of the Protection units (PU) and all numeric protection relays shall be synchronized with an accuracy of 1ms.
- viii. The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.
- ix. The system shall have provisions for combination of any of the following output signals:
  - a) NTP (network time protocol) 100Mbps Ethernet port
  - b) IRIG-B00x (TTL, pulse width modulated signal)
  - c) 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
  - d) Any other output port as may be required for the offered system.
  - e) Alarm status contact indicating healthy status of system
- x. These output ports shall be compatible with the requirement of the equipment to be synchronized. The master clock in control room shall also be synchronized with the time synchronization system. **The actual port requirements (no. /type) in line with the system offered shall be finalized during detailed engineering.** vi. The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24 hour mode) and have a separate time display unit to be mounted on top of the MIMIC panel, having display size of approx. 144mm height.

#### Relay Test Equipment

- i. The required relay test equipment shall comprise the following:
  - a) Dynamic portable relay test system for allowing dynamic and steady state testing of IEC 61850 compatible IEDS also.
  - b) Any other auxiliary items like phantom loads, etc. required for testing all the protection relays supplied under this contract.

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- ii. It shall have the capability to replay the Disturbance / Fault records acquired by the numerical relays / stand-alone DR in IEEE / COMTRADE format or EMTP simulations, to facilitate dynamic testing of all the numerical relays supplied under this contract. The required software for steady state/dynamic testing of all the numerical protection relays, energy meters and transducers, along with a laptop PC, shall also be supplied.
- iv. All commissioning tests on protection relays, energy meters and transducers shall be carried out with this relay test equipment being supplied under this contract and test reports shall be maintained as per the agreed protocols.

#### **Panels**

- i. All panels shall be free standing, floor mounting type and completely metal enclosed. Cable entries shall be from the bottom. Panels shall be of IP 31 class or better.
- ii. Panels shall have removable gland plates with glands made of brass and shall be suitable for armoured cables.
- iii. Thickness of panel sides shall be 2mm for Cold Rolled Sheet Steel, 2.5mm for Hot Rolled Sheet Steel.
- iv. Panels shall be painted. The colour of paint for exterior of the panel shall be as follows:
  - I. Ends : Colour-Blue, Shade-RAL5012
  - II. Front and Rear : Colour-Grey, Shade-RAL9002
- v. Panels shall have a lockable front toughened glass door and a swing frame/ fixed rack. Panels shall facilitate direct access to any component mounted inside and shall have at least 20% free space for future expansion.
- vi. Shall be supplied complete with interconnecting wiring between all devices mounted therein.
- vii. All equipment mounted on front and rear side of the panels shall have individual name plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.
- viii. Each panel shall be provided with a 240V AC fluorescent lighting fixture controlled by door switch as well as a 5A, 240V AC switch-socket unit.
- ix. Shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of AC & DC supplies for various circuits for control, signalling, lighting, interlocking, etc. Selection of main and sub-circuit fuse rating shall ensure selective clearance of the sub-circuit faults.
- x. Voltage circuits for protection and metering shall be protected by fuses. Suitable fuse failure relays shall be provided to give an alarm for voltage circuits of protection/metering. Voltage selection scheme based on relays shall be provided for meters wherever applicable.
- xi. The DC supplies at the individual relay and protection panels shall be monitored and failure of DC supplies shall be enunciated.

#### **Earthing**

- i. The panels shall be equipped with an earth bus of at least 50x6mm<sup>2</sup> galvanized steel flat bar or equivalent copper.

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- ii. Earth buses of adjoining panels shall be connected for continuity. The continuous earth bus so formed shall be connected to the main earth grid at one end only.

All metallic cases of the mounted equipment shall be separately connected to the earth bus by 2.5mm<sup>2</sup> copper wires. No loops in the earth wiring shall be permitted.

- iv. CT/VT neutral secondary shall only be earthed at the terminal block of the panel through links, such that the earthing of one group may be removed without disturbing others.
- v. An independent Electronic Earth System shall be provided as per Bidder's standard. The electronic earth shall be connected to the substation earth mat through a dedicated riser.


#### **Wiring**

- i. Internal wiring to be connected to external equipment shall terminate on terminal blocks.
- ii. The terminal blocks for CTs and VTs shall be provided with test links and isolating facilities. The CT terminal blocks shall be provided with short circuiting and earthing facilities.
- iii. Shall have 20% terminals as spare terminals in each panel.
- v. All equipment mounted on front and rear side of the panels shall have individual nameplates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.
- vi. All wiring shall be with 660V grade, single core, PVC insulated stranded copper conductor. 1.1kV grade Terminal Blocks shall be provided.
- vii. Wires shall be vermin proof. Minimum size of conductor shall be 1.5 mm<sup>2</sup> in general, but for CT & VT circuits it shall be 2.5 mm<sup>2</sup>. Minimum number of strands shall be three.
- viii. Bidder shall be solely responsible for completeness and correctness of all the wiring, and for proper functioning of the connected equipment.

#### **Control Cabling Philosophy**

- i. Each secondary core of all the phase CT/CVT shall be brought to the equipment marshalling box through independent cables.
- ii. Each three phase secondary core of each CT/CVT shall be brought to the associated control/relay panel from the equipment marshalling box through independent cables.
- iii. Minimum 2.5 sq mm cable shall be used for realising Control and protection scheme. Further, Duplicated cores with at least 2 x 2.5 sq.mm CU/equivalent core cross-sectional area per connection shall be used for connection of all CT/CVT circuits.
- iii. VT leads used for tariff metering shall have an equivalent core cross-sectional area of at least 10 mm<sup>2</sup> CU/equivalent per phase/neutral connection.
- iv. Duplicate channels of protection shall have independent cables for tripping, DC supply, etc. Duplicated cores shall be used for ALL closing/tripping commands and interlocking signals involving long (MORE THAN 500 m) cable lengths.
- v. For the following applications multiple cores with at least 2 x 2.5 mm<sup>2</sup> CU / equivalent core cross - sectional area per connection shall be used:
  - a) DC supply to circuit-breaker cubicle
- vi. DC looping for closing and tripping circuits of circuit-breaker All the interconnections (both AC/DC) required for the successful implementation of the control, interlocks and protection



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schemes under present package, as shown in the tender drawings for protection and control philosophy, shall be in the scope of the bidder. Such interconnections shall include but not limited to the following:

- a) CT connections 11kV switchgear / transformer MB to Control Room for transformer protections as per relevant protection SLD.
  - b) Any special cables.
  - c) Necessary interconnections for the Inter tripping / closing interlocking between upstream and downstream systems for miscellaneous transformer.
  - d) Necessary interconnections from transformer MB to RTCC for OLTC control & monitoring.
  - e) Any screened cable required for connecting 4-20 mA analog signals.
- vii. Spare cores shall be provided as per following norms:
- a) Up to 3-core cable - Nil
  - b) 4 to 6 Core Cable - Min. 1 core
  - c) 7 to 14 core cables - Min. 2 cores
  - d) More than 14 core - Min. 3 cores

#### Site / Commissioning Tests

Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and precommissioning trials start up tests, trial operation and performance and guarantee tests. The Bidder shall be responsible for all site / commissioning tests.

The Bidder shall maintain all tests, calibration records in Owner approved formats, and these shall be countersigned by authorized quality assurance personnel of the Bidder supervising these works.

The Bidder shall maintain master checklists to ensure that all tests and calibration for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the Bidder.

The site / commissioning tests shall be categorized under following categories:

- i. Start-up tests
- ii. Calibration and configuration checks
- iv. Pre-commissioning tests
- v. Trial Operation
- v. Availability Tests

Point-to-point testing of all the I/O signals in the MV/LV network shall be done by the Bidder.  
Point-to-point testing shall include:

Verification of all status indications by operating the plant

- Verification of event / alarm indications by simulating alarm conditions
- Verification of all analogue indications by injection testing
- Verification of all controls by operating the plant



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### System Hand-over and Final Acceptance

- i. The system will be handed over to the Owner for commercial operation after the site / commissioning tests have been completed to the satisfaction of the Owner. A hand-over certificate will be issued by the Owner. The Bidder will still be responsible for the Availability Tests.
- ii. Final acceptance of the system by the Owner will take place after the Availability Tests have been done to the satisfaction of the Owner.

### Type Test Requirements

Test reports for following type tests shall be submitted for all PUs / DR / Energy Meter. Reports / Certificates of tests conducted in accredited Laboratories (accredited by the national accrediting body of the country where the lab is located) are also acceptable.

### Protection Unit

#### i. Insulation Tests

S.No.	Description	Standard
1.0	Dielectric Withstand Tests	<p>IEC 60255-27 ed2.0</p> <p>2kV rms for 1 minute between all case terminals connected together and the case earth.</p> <p>2kV rms for 1 minute between all terminals of independent circuits with terminals on each independent circuit connected together.</p> <p>ANSI/ IEEE C37.90</p> <p>1kV rms for 1 minute across the open contacts of the watchdog relays.</p> <p>1kV rms for 1 minute across open contacts of changeover output relays.</p> <p>1.5kV rms for 1 minute across open contacts of normally open output relays.</p>



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2.0	High Voltage Impulse Test, class III	IEC 60255-27 ed2.0 5 kV peak; 1.2/50 $\mu$ sec; 0.5 J; 3 positive and 3 negative shots at intervals of 5 sec
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**Electrical Environment Tests:**

S.No.	Description	Standard
1.0	DC Supply Interruption	IEC 60255-26 ed3.0
2.0	AC Ripple on DC supply	IEC 60255-26 ed3.0
3.0	AC voltage dips and short Interruptions	IEC 61000-4-11 ed2.0
4.0	High Frequency Disturbance	IEC 60255-26 ed3.0, class III At 1MHz, for 2s with 200 $\Omega$ source impedance: 2.5 kV peak; 1 MHz; T = 15 $\mu$ sec; 400 shots/sec; duration 2 sec between independent circuits and independent circuits and case earth. 1.0kV peak across terminals of the same circuit.
5.0	Fast Transient Disturbance	IEC 60255-26 ed3.0, class IV 4kV, 2.5kHz applied directly to auxiliary supply 4kV, 2.5kHz applied to all inputs.
6.0	Surge Withstand Capability	IEEE/ANSI C37.90.1 4kV fast transient and 2.5kV oscillatory applied directly across each output contact, optically isolated input and power supply circuit.
7.0	Electrostatic Discharge	IEC 60255-26 ed3.0 Class 4 15kV discharge in air to user interface, display and exposed metal work.
8.0	Surge Immunity	IEC 61000-4-5 Level 4 4kV peak, 1.2/50ms between all groups and case earth. 2kV peak, 1.2/50ms between terminals of each group.



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iii. EMC Tests:

S.No.	Description	Standard
1.0	Radiated Immunity	C37.90.2 25MHz to 1000MHz,
2.0	Radiated Electromagnetic Field Disturbance Test	IEC 60255-22-3 80-1000 MHz, Amplitude Modulated
3.0	Disturbances Induced by Radio Frequency fields, Amplitude Modulated (Conducted Immunity)	IEC 60255-22-6 150kHz – 80 MHz;
4.0	Power Frequency Magnetic Field	IEC 61000-4-8 ed2.0, class IV
5.0	Interference Voltage, Aux. Voltage (Conducted Emission)	EN 50081-2, 1994 or equivalent 150 kHz to 30 MHz
6.0	Interference Field Strength (Radiated Emission)	EN 50081-2, 1994 or equivalent 30 MHz to 1000 MHz

iv. Atmospheric Environment Tests:

S.No.	Description	Standard
1.0	Humidity	IEC 60068-2-78 ed1.0
2.0	Temperature	IEC 60255-1 IEC 60068-2-1 ed6.0 for Cold IEC 60068-2-2 ed5.0 for Dry heat



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**Mechanical Stress Tests:**

S.No.	Description	Standard
1.0	Vibration (during Operation and Transportation)	IEC 255-21-1; IEC 68-2-6
2.0	Shock (during Operation and Transportation)	IEC 255-21-2, IEC 68-2-27
3.0	Seismic Vibration (during Operation)	IEC 60255-21-3

**ENERGY METER**

All type test reports as per IEC 62052-11/IEC 62053-22

**DISTURBANCE RECORDER**

Type test reports for the following tests shall be submitted

i. High Voltage Impulse Test, class III as per IEC 60255-27 ed2.0 ii. High Frequency

Disturbance as per IEC 60255-26 ed3.0, class III iii. Fast Transient Disturbance as per

IEC 60255-26 ed3.0, class IV


**Functional Tests**

All the numerical relays shall be tested for the functions specified in BHEL/End customer technical specifications. In case of Numerical Distance Relays, test reports for dynamic tests clearly indicating the operating time under different system / fault conditions shall be submitted.

**Settings**

Fault levels will be provided to the Bidder by the Owner. The Bidder shall, based on this information, compile a complete and detailed report for the setting of the protection elements on all the protection equipment, to the approval of the Owner. Any additional information required to complete this exercise shall be timely requested by the Bidder.

The Bidder shall provide the Owner with a philosophy document clearly setting out the philosophy the Bidder will use in determining setting levels. Each setting will have a brief description of the specific function or element. The setting calculation and formula will also be shown on the document. All relevant system parameters, line data, transformer data additionally used for calculating the setting will appear in the setting document. The Bidder will conduct system studies in determining fault levels on different locations. These study results will also form part of the setting document. Any additional information required to complete this exercise shall be timely requested by the Bidder.

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The setting document will be presented and discussed with the Owner prior to final issue of the document. The final accepted setting document should be made available to the Owner in PDF format.

It is the Bidder's responsibility to configure each protection relay to provide the protection and control facilities required. A full set of relay configuration and setting files shall be included in the design and documentation submissions. The Bidder will issue three sets of setting documents once accepted by the client and consultant.

#### **Furniture**

The furniture required for the officials/ operators & for locating the various items in the control/ relay room shall be supplied. The exact requirement/ details shall be finalized during detail engineering. However, a minimum requirement is specified below:

i)	Desk for control room – Modular) & Desk (Size for 01 workstation and printer) for workstations and printers covered under this package
ii)	Chairs
iii)	Filing Cupboard


**TIE Transformer , Switchyard , CRP , SAS Supply , I&C and associated civil is in customer scope.**

**Note – The ABT /PQM/TEM meters at POI and all the PMUs - supply , I&C , with all accessories , wiring , integrating with EMS / SAS/Scada , warranty for 5 years for CAMC completion in the bidders scope.**

**Switchyard SAS , Meters at POI , PMU interfacing with EMS/Scada at BESS level is in Bidder's scope. Any extra hardware requirement , FO / Cable laying , interfacing for the same is in Bidder scope.**

**Including Switchyard , All the Plant data communication to End customer AGC , END CUSTOMER OPC PI server, Main control room , external monitoring , LDC , State networks is in customer scope. Bidder need to facilitate.**

**Internet provided for the communication, day to day work till 5 years of CAMC completion is in Bidder's scope.**


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## 27. NETWORK CONFIGURATION AND EQUIPMENT CHARACTERISTICS

### INTRODUCTION

This section describes the Fiber Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

- (1) Fiber Optic Transmission System (FOTS)
- (2) DDF and Cabling
- (3) Craft Terminal based Network Management System (NMS)
  - The requirements described herein are applicable to and in support of network requirements. The equipment supplied shall support the existing regional network for Power system operational requirements.
  - The security related requirements of the equipment shall be as per DoT (Department of Telecommunication) guidelines and all similar security requirements as amended by DoT on time-to-time basis shall be followed/complied with by the vendor.
  - The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility, and supply chain and subject all software to a security /threat check any time during the supplies of equipment. The Bidder shall ensure that the supplied equipment's have been got tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. The certification shall be got done from authorized and certified agency/lab in India.
  - The Bidder shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipment, software etc. supplied and implemented in the project shall be given for use by the Employer.
  - The Bidder shall get the Employer's equipment audited from a security point of view once a year from a network audit and certification agency as identified by DoT. The audit of the equipment shall be carried out once in a financial year till the maintenance service contract in the bid.

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- In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Bidder as per guidelines of DoT and any other Government department.

## General Network Characteristics

### Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH) having a bit rate of STM-16. The network shall consist of overhead fibre optic links with a minimum bit rate of Synchronous Transport Module-16 (STM-16). The Bidder can propose a system based on higher bit rate systems, if required, to meet the link budget requirements or any other specification requirement.

The Bidder shall develop a numbering plan for the proposed voice communication system equipment.

### Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS, RTUs & PMUs and for new technological requirements of Power System Operation such as Special Protection Scheme, Grid Security Expert System, Load Management, Advanced Protection System & Substation Automation System. The communications support requirement for SCADA/EMS, RTUs, PMUs system & EPABX system is for low & high-speed data, express voice circuits and administrative voice circuits as defined in appendices. A summary of the communication system requirements is as follows:

- High speed E1 channel support
- 64kbps & nx64kbps data channel support
- Low speed (300 -1200 bps) data channel support
- Voice (2 wires, 4 wires) channel support and integration with EPABX system. The details of EPABX System shall be provided during detailed engineering.
- Data transport supporting Network Management channels.
- The connectivity envisaged between Substation and Control Centre over TCPIP using Ethernet interface for various services of data and voice such as for PMUs, RTUs, VOIP.


### General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

### System Synchronization

- The Bidder shall synchronize the equipment under the contract using Master clock procured under the Substation Package. The Bidder shall submit the synchronisation plan as per standard



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ITU-T G.811. All sync equipment proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

- The Bidder shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipment new & existing. The Bidder shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803.
- The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interfaces(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Bidder.

#### **System Maintainability**

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed locally by Craft Terminal. Such testing shall not affect the functional operation of the system.

#### **System Upgradeability and Expandability**

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies shall be sized for maximum equipped system capacity.

#### **Equipment Availability**

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. 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. For this analysis, an MTTR of at least 4 hours shall be assumed. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations. The calculated failure rates of the units and the calculated availability of the equipment being offered shall be provided by the Bidder during detailed engineering.

#### **Revision Levels and Modifications**

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 the Employer, prior to the completion of SAT.

#### **Equipment Capacities**

Equipment supplied shall be sized and equipped with sufficient capacity and configuration to meet complete system requirement.. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

#### **Redundancy Requirements and Protection Schemes**



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Equipment redundancy and Automatic Protection Schemes (APS) are specified in Table The failure of one element shall not prevent the use of any other that has not failed.

<b>Fiber Optic transmission</b>	
<b>Equipment:</b>	
<b>SDH equipment</b>	1:1 APS or distributed power supply
<b>Power Supply &amp; Converters -----</b>	1:1 APS
<b>Common Control* Cards-----</b>	
<b>* = Common control cards which are essentially required for operation of the equipment.</b>	

The offered equipment shall support at least SNCP as per standard ITU-T G.841 equipment offered by the Bidder does not support the above-mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy, and functionality at no additional cost to Employer. The bidders shall provide details of protection schemes supported in the Bid document

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switchover shall be provided by the Bidder.

#### Lost Signal Recovery

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 signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

#### Software Upgrades

The Bidder shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if an upgrade in the hardware/software of the supplied item is required, the same shall be done by the Bidder without any additional cost to the Employer.



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### General Site Considerations

All fiber optic links up to 150kms/175kms/200kms/225kms/250kms transmission line length (as applicable) shall be implemented by the Bidder without repeaters. To meet the link budget requirement, the Bidder shall provide all the necessary equipment for remote end stations as well. The Bidder may provide the optical amplifier, wavelength translator, optical cards, or high capacity SDH equipment with suitable rack/sub rack to meet the maximum distance limit. The Bidder will have to integrate all the new equipment with the existing NMS.

### Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibre conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:

Table-2-2 Optical Fibre Characteristics	
Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 $\mu\text{m}$ ( $\pm 0.6 \mu\text{m}$ )
Cladding Diameter:	125.0 $\mu\text{m}$ + 1 $\mu\text{m}$
Mode field Concentricity Error:	< 0.6 $\mu\text{m}$
Core-Clad concentricity error:	< 1.0 $\mu\text{m}$
Cladding non-circularity	< 1%
Cable Cut off Wavelength:	< 1260 nm
1550 loss performance	As per G.652D
Proof Test Level	0.69 Gpa
Attenuation coefficient	@1310nm < 0.35 dB/Km @1550nm < 0.21 dB/Km



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<b>Attenuation variation with wavelength</b> 1285 nm - 1330 nm 1525 nm – 1575 nm	Attenuation coefficient @1310 ± 0.05 dB Attenuation coefficient @1550 ± 0.05 dB
<b>Point discontinuities</b>	< 0.1dB
<b>Chromatic Dispersion; Max.:</b>	18.0 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) @ 1288-1339nm 5.3 ps/(nm x km) @ 1271-1360nm
<b>Zero Dispersion Wavelength:</b>	1300 to 1324nm
<b>Zero Dispersion Slope:</b>	0.092 ps/(nm <sup>2</sup> xkm) maximum
<b>Polarization mode dispersion coefficient</b>	< 0.2 ps/km <sup>1/2</sup>
<b>Temperature Dependence:</b>	Induced attenuation < 0.05 dB (-60 deg C - +85 deg C)
<b>Bend performance:</b>	@1310nm (75+2 mm dia Mandrel), 100 turns; Attenuation rise 0.05 dB  @1550nm (30+1 mm dia Mandrel), 100 turns; Attenuation rise 0.10 dB  @1550nm (32+0.5 mm dia Mandrel), 1 turn;  Attenuation rise 0.50 dB


#### Fibre Optic Link Lengths

The exact cable lengths shall be provided during detailed engineering.

#### Fibre Optic Transmission System

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-4/STM-16 and equipped with minimum 16nos. E1 interfaces (G.703) and 802.1D) quality of service. The protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032.

The Bidder shall provide (supply and install) connectorized jumpers (patch cords) for FODPto-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided

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for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

## **SDH Equipment**

### **Functional Requirement**

For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary interfaces (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary interfaces).

If bidder is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, the main and protection channel shall be terminated on separate cards and there shall not be a single point of failure.

The equipment shall be configurable as Terminal Multiplexer (TM) as well as ADM with software settings only.

### **SDH ADM**

The aggregate interfaces shall be (at least) STM-16 towards at least three protected directions. At present the equipment shall be equipped with a minimum of 16 nos. E-1 electrical tributary interfaces & minimum 16 nos. Ethernet interfaces. The equipment shall provide access to full STM-16payload.


### **Redundancy and Protection**

Two fibre rings shall be installed wherever the network permits. On linear sections of the network, protected links using 4 fibers shall be implemented.

### **Service Channel**

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. There shall be a facility to extend the line system order wire to any other system or exchange lines.

### **Supervision and Alarms**

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ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsman terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station.

#### **Synchronisation**

The equipment shall provide synchronisation as per Table 2-3. One 2MHz synchronisation output from each equipment shall be provided.

#### **Electrical and Optical I/O Characteristics and General Parameters**

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

<b>Table 2-3</b> <b>Electrical and Optical I/O Characteristics and General Parameters</b>	
<b>Optical Wavelength NOTE (1)</b>	1310/1550 nm
<b>Optical Source NOTE (2)</b>	Laser
<b>Optical Source Lifespan</b>	Better than 5X10 <sup>5</sup> Hours
<b>Optical Fibre Type</b>	G.652 D
<b>Optical Connectors</b>	Type FC-PC
<b>Transmission Quality</b>	Per ITU-T G.821, G.823, G.826
<b>Source Primary Power</b>	-48 Vdc
<b>Equipment Specifications</b>	Per ITU-T G.783
<b>Tributary, Electrical Interface</b>	Per ITU-T G.703, 75Ω
<b>Ethernet Interface</b>	10/100 Mbps
<b>SDH Bit Rates</b>	Per ITU-T G.703
<b>Optical Interfaces</b>	Per ITU-T G.957, G.958
<b>Frame and Multiplexing Structure for SDH</b>	Per ITU-T G.707
<b>Synchronization</b>	Per ITU-T G.813
<b>Management Functions</b>	Per ITU-T G.774, G.784
<b>Protection Architectures</b>	Per ITU-T G.841
<b>Built In Testing and Alarms</b>	Per ITU-T G.774, G.783, G.784



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**NOTE (1)** Optical wavelength shall be finalised during detailed engineering.

**NOTE (2) Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

**NOTE (3)** In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector is to be provided to connect with FODP.

#### **FODP to SDH Equipment**

The Bidder shall be responsible for connectivity between the FODP and the SDH equipment. The Bidder shall provide FC PC coupled patch cords. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

#### **DDF and Cabling**

For the purposes of the specification, the Bidder shall provide cabling, wiring and DDF patching facilities to the wideband telecommunications system. Equipment and material components for DDF and cabling are also part of this procurement. It shall be the Bidder's responsibility to provide all cable support required for full supplied equipment interconnection and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.


#### **Digital Distribution Frame Functional Requirements**

The Bidder shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

- (i) "Normally thru" circuit routing
- (ii) Circuit rerouting via patch cord assemblies
- (iii) Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

#### **Patch Cords**

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The Bidder has to supply FC PC coupled Patch cords. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

#### **Craft terminal based /Telecommunication Management Network/Network Management System**

Each equipment on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Using this PC and local displays/controls, the operator shall be able to:

- Change the configuration of the station & the connected NEs.
- Perform tests
- Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with the necessary system and application software to support the functions listed above, shall be supplied to the employer.

#### **Hardware Requirements - Craft Terminal**

Craft Terminal shall be a laptop. The craft terminal shall have minimum configuration of 2.4 GHz, 2 GB RAM, 256 MB Video Graphics Memory, DVD RW drive, 160 GB Hard Disk Drive, keyboard, mouse etc., LAN port, serial/USB (2.0) ports to accommodate printers, and Data/Fax modem and a battery back-up of at least 60 minutes. VDUs shall be 15" TFT active-matrix color LCD with a minimum resolution of 1024 X 768.

#### **General Software/Firmware Requirements**

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.


#### **Operating System Software**

Operating system software shall be provided to control the execution of system programs, application programs, and management devices, to allocate system resources, and manage communications among the system processors. The Bidder shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

#### **Applications Software**

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The



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Bidder shall make no modifications to the applications program except as provided as USER development tools.

#### **Software Utilities**

A utility shall be provided to convert all reports into standard PC application formats such as excel.

#### **Revisions, Upgrades, Maintainability**

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user-expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly, recompilation or revision upgrades of the software or components of the software shall not be necessary to accommodate full system expansion.

The software provided shall be compliant with national and international industry standards.

#### **List of Type Tests**

Test reports for following type tests shall be submitted. Reports / Certificates of tests conducted in accredited Laboratories (accredited by the national accrediting body of the country where the lab is located) are also acceptable.

(a) SDH Equipment with all types of cards (optical card & Tributary card) **List of type test to be conducted on Telecom equipment**

The type tests for SDH Equipment with all types of cards are described below:


#### **Temperature and Humidity Tests**

The tests listed below are defined in IEC Publication 60068.

##### **(a) Low Temperature Test: Operation to Specifications**

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.

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- (2) Degree of Severity: Test shall be done at 0°C
- (3) Acceptance Criteria: No degradation of performance during and after the test.

**(b) Low Temperature Test: Operation without Damage**

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).
- (2) Degree of Severity: Test shall be done at -10° C
- (3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

**(c) Dry Heat Test: Operation to Specifications**

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.
- (2) Degree of Severity: As per table 3-1: operation to specification range.
- (3) Acceptance Criteria: No degradation of performance during and after the test.

**(d) Dry Heat Test: Operation without Damage**


Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).
- (2) Degree of Severity: Test shall be done at 55°C.
- (3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

**(e) Damp Heat Test**

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-78 with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.
- (2) Degree of Severity: Test shall be done at (40 ± 2) °C & (93 ± 3) % RH.

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(2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**(f) Temperature Variation Test**

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on, and various parameters shall be monitored continuously during the test period.

- (1) Number of cycles required is five (5)
- (2) The degree of severity: temperature TL:0°C, TH: As per table 3-1 (Operation to specification range)
- (3) Cycle duration for each temperature is three (3) hours.
- (4) Ramp: 1 oC/minute.
- (5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**Power Supply and EMI/EMC tests**

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

**(a) Immunity Tests**

The list of Immunity tests is specified below in Table 4-4:

Table 4-4: Recommended Immunity Tests						
S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control Signal &	Telecom Line	Parameters
1.	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 608702-1: 1995 <b>Level: 1</b>
2.	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	
3.	1.2/50 - 8/20 $\mu$ s surges	Yes	Yes	N/A	N/A	Table 12 of IEC 608702-1: 1995 <b>Level: 4</b>
4.	Fast transient bursts	Yes	Yes	Yes	N/A	
5.	Damped oscillatory waves	Yes	Yes	Yes	Yes	



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6.	10/700 $\mu$ s	N/A	N/A	N/A	Yes	
	surges					
7.	Electrostatic Discharge	Yes				Table 12 of IEC 608702-1: 1995 <b>Level: 4</b>
8.	Power frequency magnetic field	Yes				Table 14 of IEC 608702-1: 1995 <b>Level: 4</b>
9.	Damped oscillatory magnetic field	Yes				


Table 4-4: Recommended Immunity Tests

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters
10.	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-21: 1995 <b>Level: 4</b>
11.	Power Frequency voltage on control and signal lines	N/A	N/A	Yes	Yes	IEC 61000-4-16: 2002-07 <b>Level:4</b>
12.	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-416:2002-07 <b>Level:4</b>

(b) Emission Tests

The list of Emission tests is specified below in Table 4-5

Table 4-5: Recommended Emission Tests						
S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters

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1.	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A	N/A	Table 17 of IEC 608702-1: 1995 <b>Class: B</b>
2.	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
3.	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
4.	RF radiated fields CISPR 22	Yes				

#### Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class: VW1 of Table 18.

#### Mechanical Tests

##### (a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained. The endurance test conditions are selected according to the vibration withstand requirements.

Transportation tests shall be performed with the equipment packed according to the Bidder's specifications.


##### (b) Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi-sinusoidal shape .

The recommended severity shall be A = 294 m/s<sup>2</sup>, D = 18 ms. Three shocks per axis per direction shall be applied to the equipment packed according to the Bidder's specifications.

#### Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Bidder's specifications. The drop height shall be defined in accordance with IEC 682-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

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### Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

Hands-on training shall be provided to CAMC/End customer/BHEL personnel at site.

### Optical Fibre & Approach Cable Parameters

#### 1. Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics:

##### 1.1 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a):

##### 1.1.1 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities more than 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.



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Table 1-1(a)

DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter @ 1310nm:	8.6 to 9.5 $\mu\text{m}$ ( $\pm 0.6\mu\text{m}$ )
Cladding Diameter:	125.0 $\mu\text{m} \pm 1 \mu\text{m}$
Mode field concentricity error	$\leq 0.6\mu\text{m}$
Cladding non-circularity	$\leq 1\%$
Cable Cut-off Wavelength $\lambda_{\text{cc}}$	$\leq 1260 \text{ nm}$
1550 nm loss performance	As per G.652 D
Proof Test Level	$\geq 0.69 \text{ Gpa}$
Attenuation Coefficient:	@ 1310 nm $\leq 0.35 \text{ dB / km}$ @ 1550 nm $\leq 0.21 \text{ dB / km}$
Chromatic Dispersion; Maximum:	18 ps/ (nm x km) @ 1550 nm 3.5 ps/ (nm x km) 1288-1339nm 5.3 ps/ (nm x km) 1271-1360nm  1300 to 1324nm
Zero Dispersion Wavelength:	0.092 ps/(nm <sup>2</sup> xkm) maximum
Zero Dispersion Slope:	
Polarization mode dispersion coefficient	$\leq 0.2 \text{ ps/km}^{\frac{1}{2}}$
Temperature Dependence:	Induced attenuation $\leq 0.05 \text{ dB}$ (-60°C to +85°C)



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Bend Performance:

@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise □ 0.05 dB/km

@ 1550 nm (75±2 mm dia Mandrel), 100 turns.  
Attenuation Rise □ 0.10 dB/km

@ 1550 nm (32±0.5 mm dia Mandrel), 1 turn.  
Attenuation Rise □ 0.50 dB/km

## 2 Fibre Optic Approach Cables

A fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building.

### 2.1. Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

### 2.2. Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering, and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

### 2.3. Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

**Note – The ABT /PQM/TEM meters at POI and all the PMUs - supply , I&C , with all accessories , wiring , integrating with EMS / SAS/Scada , warranty till CAMC completion in the bidders scope.**

**Switchyard SAS , Meters at POI , PMU interfacing with EMS/Scada at BESS level is in Bidder's scope. Any extra hardware requirement , FO / Cable laying , interfacing for the same is in Bidder scope.**

**All the communication to End customer AGC , Main control room , END CUSTOMER PI server , External monitoring , LDC , State networks of the entire plant including Switchyard Data is in Bidder's scope. Internet for communication , All Approvals an studies till CAMC completion is in bidder scope.**

**TIE Transformer , Switchyard , CRP , SAS Supply , I&C , civil is in BHEL/customer scope.**





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## 28. BATTERY CHARGER (SCR/SMPS)

### CODES AND STANDARDS

ANSI-C 37.90a	Guide for surge withstand capability tests
IS:5	Colours for ready mix paints.
IS : 694	PVC Insulated Cable for working voltages upto and including 1100 V.
IS : 1248	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Part-1	Degree of protection provided by enclosures for low voltage switch gear and control gear.
IS : 13947	Specification for low voltage switch gear and control gear
IS : 3231	Electrical relays for power system protection.
IS : 3842	Application guide for Electrical relays for AC System
IS : 3895	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	Code of practice for phosphating of Iron and Steel.
IS:6619	Safety Code for Semi-conductor Rectifier Equipment.



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IS:11171/ IS:2026	Rectifier Transformer
IS:6875	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 V AC or 1200 V DC.
IS : 9000	Basic environmental testing procedures for electronic and electrical items.
IS:13703	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
EEUA-45D	Performance requirements for electrical Alarm Annunciation System
	Indian Electricity Rules
	Indian Electricity Act.
EN 61000-6 -4:2007 (CE& RE CLASS A)	Emission For SMPS module
EN 61000-6-2:2005	Immunity For SMPS module
EN 60950-1(CE).	Safety Standard For SMPS module

**Technical Parameters**

1.	<b>Mode of Charging</b>	Float cum Boost Charger (Automatic and Manual Mode)
2.	<b>Charger Ambient Temp / RH</b>	50 deg C, 95%
3	<b>I/P Voltage Rating (AC)</b>	415V +15%/-20% 3 Phase 3W
4.	<b>Voltage Rating (DC)</b>	220V/110V/48V (As per Part-A, Scope)
5.	<b>Trickle Charging</b>	1.4-1.42V per cell(Ni-Cd) 2.25V per cell(Lead-Acid)
6.	<b>Boost Charging Mode</b>	1. 53-1.7V per cell(Ni-Cd) 2. 3-2.7 V per cell(Lead-Acid) 3. Boost mode enable only with DCDB incomer OFF.
7.	<b>Automatic Voltage regulator (trickle Mode)</b>	±0.5% at 415 ± 10% and 0-100% Load



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a.	<b>Load Limiter current setting Range (Trickle Mode)</b>	80%-100%
b.	<b>% Stabilization of the output DC voltage</b>	1% for +15%/-20% input supply variation and 0-100% DC load
c.	<b>Voltage Range and Stabilizing time for momentary load changes from 20%-100% and vice versa</b>	+/- 3% and less than 1 secs
d.	<b>Dynamic Response Time</b>	Less than 1 secs

**Technical Parameters**


1.	<b>Mode of Charging</b>	Float cum Boost Charger (Automatic and Manual Mode)
2.	<b>Charger Ambient Temp / RH</b>	50 deg C, 95%
3.	<b>I/P Voltage Rating (AC)</b>	415V +15%/-20% 3 Phase 3W
4.	<b>Voltage Rating (DC)</b>	220V/110V/48V (As per Part-A, Scope)
5.	<b>Trickle Charging</b>	1.4-1.42V per cell(Ni-Cd) 2.25V per cell(Lead-Acid)
6.	<b>Boost Charging Mode</b>	3. 53-1.7V per cell(Ni-Cd) 4. 3-2.7 V per cell(Lead-Acid) 3. Boost mode enable only with DCDB incomer OFF.
7.	<b>Automatic Voltage regulator (trickle Mode)</b>	±0.5% at 415 ± 10% and 0-100% Load
a.	<b>Load Limiter current setting Range (Trickle Mode)</b>	80%-100%
b.	<b>% Stabilization of the output DC voltage</b>	1% for +15%/-20% input supply variation and 0-100% DC load
c.	<b>Voltage Range and Stabilizing time for momentary load changes from 20%-100% and vice versa</b>	+/- 3% and less than 1 secs
d.	<b>Dynamic Response Time</b>	Less than 1 secs
8.	<b>Current setting range in Boost Charging Mode</b>	50-120% of rated Boost current
9.	<b>Voltage limit setting range in Boost Charging Mode</b>	Boost charging limit

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10.	<b>Rectifier Type</b>	Static Type Full wave Rectifier / SMPS
11.	<b>Ripple Content</b>	1% Peak-Peak at 0-100% of DC Load
12.	<b>Transformer (power frequency)</b>	Dry and Air Cooled(AN) type Class-F Insulation with temp rise limited to Class-B at 50deg C Ambient
13.	<b>Transformer (high frequency)</b>	Ferrite core type
14.	<b>Power Factor</b>	0.9 at Rated Load
15.	<b>Efficiency</b>	≥ 85% at Full Load
16.	<b>THDi</b>	10% at 90-100% load, ≤ 15% at 0-90% load
17.	<b>Charger Enclosure</b>	IP42

#### **EQUIPMENT DESCRIPTION (SCR/SMPS)**

- (a.) The Battery Chargers as well as their automatic regulators shall be of static type Either SCR Based or SMPS Based Modular. Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC lead-acid . / Ni-cad Batteries while supplying the D.C. loads.
- (b.) All Battery Chargers shall have provision to receive two input supplies (415V +15%/20% 3 Phase 3 Wire) along with suitable automatic changeover between the sources. Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. Trickle or Boost charging and automatic/manual mode.
- (c.) The chargers shall be capable of limiting the voltage or current in case 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 DC System shall be ungrounded and float with respect to the ground potential when healthy. An earth fault relay shall be provided by the Employer in the DC distribution board for remote annunciation.
- (d.) For SMPS/SCR Based Charger all indication & metering values to be provided in LCD Display (Min. 7 Inches) and 4-20mA transducer to be provided for analog output for current and voltage respectively. 76mmx76mm (min) Voltmeter (DC) and Ammeter (DC) is to be provided for local display.

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- (f.) Blocking diode shall be provided in the output circuit of each Charger to prevent current flow from the D.C. Battery into the SCR Based Charger.
- (g.) In SMPS based chargers, blocking diode shall be provided in each rectifier module. It can be part of rectifier module itself.
- (h.) Digital Outputs shall be configured for connection to the DC health monitoring system for real-time charger status updation.
- (i.) For all Power Components (contactors, MCCBs, fuses, relays, metering instruments etc) and constructional details (sheet thickness, paint shade, gland plate thickness etc) of charger enclosure and internal wiring details.
- (j.) Live busbars, parts etc shall not be accessible while the charger is in energized condition. Suitable safety interlocks to be ensured.
- (k.) Surge protection device of Class -C type shall be provided in input side of charger. N+N/5 no of SMPS modules shall be provided in each chargers

#### **Semiconductor Assembly For SCR Based Charger**

- The rectifier cells shall be provided with their own heat dissipation arrangement along with forced air cooling for above 400A rating chargers and fan shall be temperature controlled with 100% standby redundancy. The rectifier shall utilize diodes/thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85°C absolute duly considering the maximum charger panel inside temperature.
- Semiconductor Assembly For SMPS Based Charger
- Battery charger system shall be static type composed of switch mode power supply (SMPS) modules or SMR modules. The rectifier module shall be microprocessor controlled, Power MOSFET based, high frequency with active load sharing, modular in construction designed for single and parallel operation with battery and shall be provided with heat sink having their own heat Dissipation arrangements incase of forced air cooling of temperature based ON/OFF cooling system.

#### **Output Controller/Annunciation System**

The charger system shall be provided with HMI display unit having touch(Min 7 inch) facility to read all the charger parameters like input voltage, output & battery voltage, charging/discharging current, positive & negative earth leakage current with alarm, status & fault display. The selection setting like mode selection (Float/Boost), manual boost voltage & current adjustment can be done by this HMI. The HMI should have SCADA interface to communicate with DDCMIS over IEC 61850. Annunciations for A.C. supply failure, Rectifier fuse failure for SCR based Charger/SMPS Module Fail for SMPS based Charger, Surge circuit fuse failure, Filter fuse failure for SCR Based Charger/SMPS Fail for SMPS based charger, Load limiter operated, Charger trip, Battery on Boost shall be integrated in the same HMI. 4-20 mA Analog output for load current /voltage shall be provided for integrating to DDCMIS.



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**List of Type Tests**

Sl. No.	Type Test Description
1	Complete physical examination
2	Temperature rise test at full load (For chargers of up to 400A rating). Temperature rise test report for rectifier assembly at 200% of full load shall also be submitted.
3	Insulation resistance test
4	High voltage (power frequency) test on power and control circuits except low voltage electronic circuits
5	Automatic voltage regulator operation test at specified A.C. supply variations at no load, half load and full load
6	Load limiter operation test
7	Efficiency, power factor measurement & THDi
8	Surge withstand capability test at the following points of the Charger: i) Across each A.C. input phase ii) Across A.C. input line to ground iii) Across D.C. output terminals iv) Across each D.C. output terminal to ground
9	Environmental Tests: i) Soak Test ii) Degree of protection test
10	Dynamic response test and Temperature rise test at full load to be carried out on each charger before dispatch at manufacturer's works
11	Short Circuit Test at No Load

**Commissioning Tests**

Bidder shall submit commissioning test procedure including details of all commissioning checks before commissioning the system at site.



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## 29. BATTERY

### BATTERY RATINGS


1. For Ni-Cd Type Battery		
a)	Battery Voltage	220V /110V/48VDC (As per Part-A,Scope)
b)	No. of Cells	As per Sizing Calculations
c)	Battery type	Stationary Nickel-Cadmium Pocket Plate High discharge type (KPH)
d)	Capacity for five(5)hour rate	During detailed Engineering -details shall be submitted for approval
e)	Nominal discharge voltage per Cell	1.2 V
f)	Float voltage	As per manufacturer's standards for float application
2. For Lead Acid Plante type Battery		
a)	Battery Voltage	220V /110V/48VDC (As per Part-A,Scope)
b)	No. of Cells	As per Sizing Calculations
c)	Battery type	Stationary Lead Acid Plante high discharge type
d)	Capacity for ten(10)hour rate	As per Chapter B0, Section VI
e)	Nominal voltage per cell discharge	2.0 V
f)	Float Voltage	As per manufacturer's standards for float application

#### Note:

DC health monitoring system shall be offered integral with each battery set for Main Plant & Switchyard batteries.

#### Commissioning of Battery

Commissioning of each battery at site shall only be carried out either by the battery manufacturer himself or under the supervision of the battery manufacturer.

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## **PART-A: NICKEL-CADMIUM BATTERY**

### **CODES AND STANDARDS**

IEC 60623 / IS 10918	Specification for vented type Nickel Cadmium Batteries.
IS 1069	Quality tolerances for water for storage batteries
IEC 60993	Electrolyte for vented Nickel-Cadmium cells

### **TESTS**

For conductance/report submission/validity of type tests, of technical specifications.

The Bidder shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for all applicable tests for containers) / IS-10918 (for Ni-Cd batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier.

Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.


Commissioning Checks: Bidder shall submit commissioning test procedure including details of all commissioning check before commissioning the system at site

## **LEAD –ACID PLANTE BATTERY**

### **CODES & STANDARDS**

IEC 60896	Stationary Lead-Acid Batteries
IS 266	Specification for sulphuric acid
IS 1069	Specification for water for storage batteries
IS 1146	Specification for rubber & plastic containers for lead acid storage batteries.
IS 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates).
IS 3116	Specification for sealing compound for lead acid batteries.
IS 8320	General requirements and methods of tests for lead acid storage batteries
IS 6071	Specification for synthetic separators for lead acid batteries.
	Indian Electricity Rules
	Indian Electricity Acts



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## TESTS

For conductance/report submission/validity of type tests, refer technical specifications.

The Bidder shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for rubber & plastic containers for lead-acid storage batteries)/IS 1652 (for lead-acid plante batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier.

Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

Commissioning Checks: Commissioning of each battery at site shall only be carried out either by the battery manufacturer himself or under the supervision of the battery manufacturer.

## DC HEALTH MONITORING SYSTEM (IF APPLICABLE)

DC Health Monitoring System shall include microprocessor-based hardware and software to monitor the condition of each battery cell of 220V DC systems battery banks on-line on 24x7 basis. With DC Health Monitoring System it shall be possible to measure & analyze the individual cell and battery parameters so that any damage to battery shall be prevented by pro-active maintenance. A typical Architecture is shown in drawing no. 0000-209-POE- A-002. Each Battery set shall have its own independent DC Health Monitoring System.

DC Health Monitoring System shall measure and store the following parameters at pre-determined time interval as decided by the employer during detail engineering: a) Each Cell Voltage


b) Battery DC Current

c) Ambient temperature (1No.) and Cell temperature (1No.)

Further, DC Health Monitoring System module shall have provision of accepting at least 6 Nos. of Digital inputs and 2 Nos. of Analog inputs(4-20mA). DC Health Monitoring System shall also be able to store these inputs status for future reference.

## Technical Parameters

a)	Input Power Supply	230V AC(UPS) / 220V DC
b)	Voltage Measurement Accuracy	0.5% or better
c)	Current Measurement Accuracy	0.5% or better
d)	Operating Temperature Range	0-50° C
e)	Mounting	Panel Mounting

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f) IP Protection IP42



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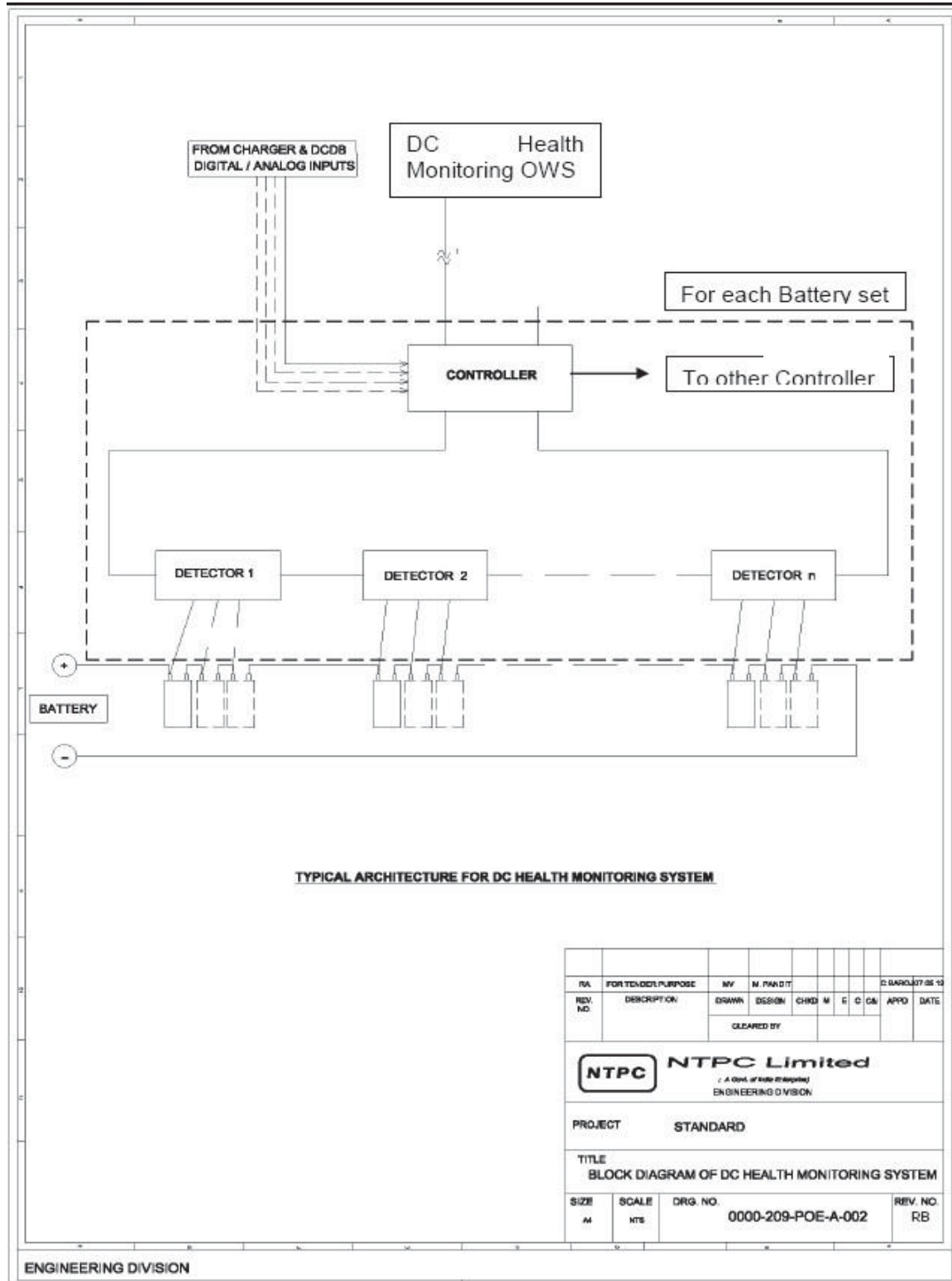
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### 30. NITROGEN INJECTION FIRE PROTECTION SYSTEM

**Technical Specification for Nitrogen Injection Fire Protection System (NIFPS) applicable for All Transformers as per CEA (Measures relating to Safety and Electric Supply) Regulations, 2023.**

#### GENERAL


All equipment provided under the specification shall in general, conform the latest issue International standards or following standards Indian standards:

Indian Standards No.	Title
IS: 10028	Code of practice for selection installation & maintenance of transformers
IS: 3034	Fire Safety of Industrial Buildings Electrical Generating and Distributing Stations-Code of Practice
CBIP	Guidelines for Fire Protection of Power Transformers

The electrical installation shall meet the requirements of Indian Electricity act 2003 & IS: 10028 'Code of practice 'for selection, installation & maintenance of transformers' and relevant CEA regulations as named up to date.

#### PERFORMANCE

- Nitrogen injection fire protection system (NIFPS) shall be capable of preventing tank explosion due to internal fire and acts as fire preventer. It shall also extinguish the external fire on tank cover due to tank explosion or external failures due to bushing, tap changer etc. Tank needs to be depressurized in such a duration so as to avoid damage to transformer.
- The system operate based upon a control logic derived by various signals from transformer protection system and other associated sensors.
- A provision shall be provided thru an isolation valve to block conservator tank oil and prevent further escalation of fire. It shall not hinder normal breathing of transformer.
- System shall have automatic, remote and manual mode of operation to extinguish fire. Components and various accessories used should be of industrial grade.
- Suitable system for draining of insulting oil from tank be provided.
- There shall not be any leakage of nitrogen gas in energized transformer or otherwise.
- Necessary provisions for testing of NIFPS system on an energized transformer to be provided.
- Offered NIFPS shall be complete in terms of control, monitoring and protection systems.

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- (i.) There shall be monitoring of nitrogen injection pressure as well as cylinder pressure be provided.
- (j.) System must have mechanical release devices and provision for oil drain and nitrogen release to operate manually in case of operation supply failure.


All outdoor panels shall have IP 55 degree of protection.

- (l.) Fire extinguishing cubicle shall be mounted suitable distance away from transformer so as to avoid any damage during fire incident.
- (m.) System shall be complete and integrated in terms of Fire detectors, Control box, Fire extinguishing cubicle, Conservator isolation valve (as applicable), Piping, FRLS armoured cable, Alarms signal, Trip signals, push buttons, switches, audio signals etc.
- (n.) Marshalling box/cubicle shall be located in such a way that, the same shall not face towards the transformer. Wiring scheme shall be engraved in a plate (MS) and the same shall be fixed inside Marshalling box.
- (o.) The cable between the M. Box/Cubicle & transformer shall be laid by the supplier through GI conduits/pipes.
- (p.) The piping & its accessories shall preferably be hot dip galvanized or corrosion resistant paint should be applied to it.
- (q.) Following alarm/lamp indications shall be provided in M. Box:
  - (1.) Oil drain valve closed
  - (2.) Cylinder pressure low
  - (3.) PRV/RPRR operated
  - (4.) System out of service
  - (5.) Fire extinction in progress
  - (6.) Control supply failure
  - (7.) System on Auto/Manual
  - (8.) TCIV (Transformer Conservator Isolation Valve) closed (as applicable)

All above signals shall be communicated upto the BESS Control room. All hardwares, cables, software, protocol (as per owner's required) etc. for the communication shall be in Bidder's scope.

The Bidder shall also indicate if any additional alarm/indication lamp is required to be provided in Central control room/Cubicle/MB.

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of M. Box/Cubicle exclusively for Employer's use.

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## INSPECTION AND TESTING AT SITE

The Bidder shall carry out a detailed inspection and testing program for field activities covering areas right from the receipt of material stage up to commissioning stage. The test plan along with owner's witness and inspection requirement shall be finalized during detail engg. as per owner's approval.


## GENERAL INFORMATION TO BIDDER

The bidder is advised to visit project site and get detail information/drawings and make comparative study of connections, orientation of marshalling box/cubicle & conservator, foundation plan and location of fire wall etc.


### SCOPE OF SUPPLY AND SERVICES (CIVIL)

The scope of civil works shall include design, engineering & construction of all civil, structural and architectural works. The broad scope of work under this package shall include Civil works related to but not limited to the following areas. Bidder is advised to visit the site for better understanding of the quantum of civil work required before bidding.

- i. Topography survey
- ii. Geotechnical investigation (additional data wherever required beyond details as provided).
- iii. Site clearance including cutting of trees of girth less than 30 centimeters. Cutting of trees of girth more than 30cm shall be done by the Owner after finalization of location. However, removal and disposal of roots of trees of all girths (including trees of girth less than 30cm or more) and other vegetation is in Bidder's scope.
- iv. Site Preparation: Site grading including slope protection, ground preparation/ filling/levelling, Ground improvement of the identified area. Levelled area with finished ground as provided in project information shall be provided by the Owner, however, Area grading upto (+/-) 300mm as per proposed FGL including slope protection, Ground improvement (if required) of the identified area will be in the bidder scope.
- v. Removal, and disposal of identified facilities/ structures/ substructures/ foundations of dismantled quarters/buildings/structures, reinforcement, pavement/paving, pipes and any underground structure/materials, debris etc. all complete. All existing foundations/below ground facilities interfering with new facilities are to be dismantled up to minimum 10m or technical/system requirement, whichever is greater, from the extreme outline of the new underground foundation/ structure. No drawing for substructures are available. Bidder may assess the same as per actual site conditions without any additional time and cost implication to owner.
- vi. Construction of approach pathway (heavy duty paving) connecting to the existing Road (if required).
- vii. Area Paving in and around BESS facilities/ structure to be provided as per Technical Specifications and Layout.
- viii. Storm water drain in BESS area and connecting the same with existing Nearby drain. Design and construction of Drainage system as per General Layout & Topography.
- ix. Civil works for Water supply system for toilets and office in building in BESS Area and connecting water supply line to END CUSTOMER's nearest located water supply line.

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- x. Package type Sewerage Treatment plant and connection of all Sewage lines of all buildings. Storage or handling of effluent after tertiary treatment is excluded from bidder's scope of work.
- xi. Construction of requisite foundation and structures for BESS containers/equipment, PCS, and any other associated equipment in Bidders' scope, system including material supply and other related activities.
- xii. Civil and structural works associated with foundations for Inverter Duty Transformers with fire walls, including oil soak pit, sump pit, stone filling, concrete encasement of pylon supports, pipe, manhole, etc. as required, all complete.
- xiii. Civil and structural works associated with foundations for Tie Transformers including rail cum road extending up to unloading point in peripheral road, fire barrier wall, oil soak pit, sump pit, common oil retention /Oil- water separation pit, stone filling, concrete encasement of pylon supports etc. all complete.
- xiv. All pipe and cable supporting arrangement/structures, pipe and cable trenches etc.
- xv. All culverts (i.e. pipe culverts/ duct-banks, pull pit ) at the crossing of cable trenches/drains with roads, rail cum roads and drains, etc. as required.
- xvi. Civil, structural and architectural works associated with RCC framed Service Building and Switchgear Building with brick wall cladding including substructure, superstructure and all other related works like cable trench etc., complete as per system requirement.
- xvii. All necessary embedment, inserts, supporting structures, supporting members as per requirement. All cable tray and switchgear/control panel supporting structures including angles/bends/insert plates etc. inside building as required are also in scope of bidder
- xviii. Civil and structural works associated with switchyard gantry structures (Towers & Girders) and Lightning Mast including proto assembly and substructure as required complete in applicable projects.
- xix. Civil and structural works associated with switchyard equipment supporting structures and cable sealing ends, including substructure as required complete in applicable projects.
- xx. Civil and structural works associated with foundation for AC kiosk inside Switchyard including supporting fixing arrangements complete as per electrical requirements.
- xxi. Removal of existing gravel within the designated equipment foundation/erection bays is required, followed by relaying new gravel as necessary. This work shall be carried out completely in Switchyard all applicable projects.
- xxii. Site Preparation, soil sterilization /anti-weed treatment including gravel filling but excluding major levelling wherever required in switchyard of applicable projects.
- xxiii. Chain Link Fencing with Gate along with Guard room for BESS Area wherever required.
- xxiv. Precast Boundary with Gate along with Guard room for BESS Area where ever required.
- xxv. All protection measures to prevent any damage to the adjoining structures / facilities.
- xxvi. **Scope of the Bidder shall also include supply and laying of 40mm dia MS Rods as earthing mat as per requirement. ( till 33kV end if required)**

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- xii. **Disposal of surplus excavated soil up to a lead of 5.0 km as directed by the Engineer.**
- xiii. Any other facility / structure that would be required as per system requirements.
- xiv. Detailed design criteria including basis of design shall be prepared by the Bidder based on various requirements specified elsewhere in the specifications. The documents shall be submitted for Owner's approval and the same shall form the basis of Detailed Engineering Work. Design basis which will include all design philosophy, seismic and wind criteria as per specification, foundation type along with bearing capacity as per Geotechnical Report, materials of construction, loading details, finishing schedule etc.
- xv. Supply of earth for filling, disposal of surplus earth/ debris including arranging the borrow pit/ disposal site and making payment of Seigniorage, royalty, levies, taxes and any other applicable charges etc. shall be in bidder's scope.


#### **Construction Facility**

The following are also in the Bidder's scope of work pertaining to construction facilities for the project.

1. Bidder has to make his own arrangement for providing and maintaining Hygienic and safe accommodation for his worker and staff. The facilities for occupational safety, healthy environment, first aid, drinking water, resting place & toilets, canteen, crèche, etc. shall be provided at the workplace for construction workers by the bidder.
2. Construction of following temporary facilities of bidder
  - a. Construction office,
  - b. Construction stores (covered) & open stores as per his requirement.
  - c. Material/field testing laboratory facilities and any other temporary building.
3. All tools and tackles required for the work.
4. Providing first aid facilities at the construction / erection sites, workshops, laboratories, fabrication, pre-assembly & storage yard, Offices and other places of work as per the requirement.
5. Use of ash and ash-based products.  
In line with Gazette Notification on Ash Utilization issued by Ministry of Environment & Forest and its amendments, Bidder shall use ash and ashbased products in all construction. He shall furnish a compliance report along with all details of use of ash and ash-based products along with each bill. The above requirements shall be applicable to his sub-vendors also and Bidder shall be responsible for enforcing the same on his sub-vendors.
6. Repair & Maintenance Facilities by the Bidder: Bidder has to make his own arrangement for repair and maintenance of Construction/erection equipment.
7. Dewatering in construction area during construction period for any seepage water as well as accumulated rainwater.
8. Housekeeping of all construction area and disposal of construction/demolition waste. This also includes cutting and removal of vegetation including dry vegetation to avoid fire hazard in the entire project construction area.

Area lighting at the construction / erection site, fabrication, pre-assembly and storage yard, office areas, worker and staff accommodation etc.



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### Construction Power

Construction power supply for the installation BESS system and associated construction activities for each project shall be arranged independently by the Bidder.

### Facilities to be Provided by BHEL/End customer

Water for construction purposes shall be provided by BHEL/End customer at one point on free of cost basis. Bidder shall arrange for further distribution/transportation to required location by their own.

Construction of any shed/closed area required for storage of material/equipment in End customer premises shall be in Bidders scope. Identification of land for the referred purpose shall be done in consultation with End customer EIC before the start of site work.

Land for Installation of BESS and other equipment shall be provided by End customer. Bidder shall indicate the land requirement against each identified location for installation of BESS in the bidding documents.

## 31. FDPS AND HVAC

### (A) FIRE PROTECTION AND DETECTION SYSTEM

#### GENERAL DESCRIPTION

A comprehensive fire detection and protection system covering all the equipment/system/ buildings of entire BESS & Aux. areas of each BESS project at respective thermal project.


The complete fire detection and protection systems shall be as per the guidelines/codes/ standards / rules of TAC/ NFPA / IS: 3034 /OISD, etc.

A dedicated and integrated fire detection and suppression system shall be provided for the BESS installation to ensure early detection and effective control of fire incidents. Fire protection system shall be designed in accordance with NFPA and applicable IS standards and shall conform to national and local codes, good engineering practices and latest CEA guidelines. The fire protection system design and associated alarms shall take into account that the BESS will be unattended. Separate fire protection systems may be used in the battery, PCS, and control areas.

#### Fire Detection, Alarm and Control System

#### Design Philosophy (Fire Alarm and Detection System)

- The addressable type of fire alarm panel at control room shall receive signal from sensors from various areas/ equipment.

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- ii. The PC based monitoring station to be located at BESS control room shall cover the fire detection and protection system of the complete BESS plant. This shall give audio-visual annunciations for fire in each of the risk area / equipment / status of the fire protection system as well as system operator open / short circuit status of detector or control cabling, etc. Further, this shall activate a hooter/sounder in each of the area provided with fire/smoke detection system.
- iii. The addressable panel shall evaluate the signals received from the detectors, transmit the fire or trouble alarms (audio-visual) to prearranged points, supervise and monitor the complete fire detection & extinguishing circuits, initiate control functions like shutdown of closure of fire dampers , etc. Opening smoke extraction vents switching on smoke extraction equipment, emergency lighting, tripping of transformer lockout relays, etc.
- iv. All the circuits, from the detectors to the panels and the circuits from the panels to the actuating devices, shall be closed loop type and shall be supervised for open and short circuiting. The trouble signals also be annunciated in the fire alarm panel.
- v. Facilities shall be provided on the fire alarm panel for simulating fire conditions, sensitivity adjustment, isolation of detectors etc. from the panel.

#### **Codes and Standards**

- a. The design, manufacture, testing, performance, etc. of the various components of the analog addressable Fire Detection and Alarm System shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the Bidder of this responsibility.
- b. Unless otherwise specified, the Fire Detection and Alarm System and the components shall conform to the latest applicable Indian or IEC Standards. Equipment complying with any other authoritative National Standards such as British, USA, VDE, etc. will also be considered, provided the parameters specified are equivalent or better than the corresponding IS.
- c. The Bidder shall be solely responsible for obtaining the required approval and clearance for the different components and systems of the Fire Detection and Alarm System from the following authorities, as applicable:
  - i. Department of Atomic Energy (Certification of safety from Radioactivity).
  - ii. Central Building Research Institute, Roorkee.
  - iii. Central Mining Research Station, Dhanbad.
  - iv. Local Fire Authorities.

The equipment and the system shall be of types approved by any of the following bodies, as applicable:

- a. Loss Prevention Council, (LPC), U.K.
- b. National Fire Protection Association, (NFPA), USA
- c. Under-writers laboratories, (UL), USA
- d. Factory mutual (FM)

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#### General requirements for all types of Detectors

- Detectors shall be provided with the necessary compression type cable terminating glands for the incoming cables of flameproof type or PVC/metallic flexible/rigid conduits.
- The detector shall be located where the largest combustion gas concentration can be expected.
- Adequate compensation and considerations shall be made for effects for wind velocities such as air-conditioning system and exhaust fans where dilution of particles of combustion is greater.
- The exact location of detectors shall be coordinated with other services like air-conditioning grills, light fittings, cable trays etc. to provide aesthetically pleasing appearance. The return air paths of air-conditioning shall be avoided for detector location.
- The detectors shall not be affected by temperature, humidity; air flow or by drift failures and shall not give any false alarm due to above.
- The detectors shall not be sensitive to vibrations. Any special mounting arrangements required to counteract vibration shall be included in the Bidder scope.
- The quantity of multi- sensor detectors in each zone shall be based on the coverage factor of 25-sq. meter per detector. However, the actual quantity of detectors required, taking into consideration obstructions due to floor beams, ventilation, doors, windows etc., shall be worked out and supplied (based on the actual layout) and installed by the Bidder.
- The detectors shall not give false alarm due to high humidity, temperature, and velocity of air in the surroundings and static electricity conditions.

#### Addressable Analog Intelligent Detectors


In addition to the features specified under the item General requirements for all types of Detectors, the Addressable Analog Intelligent Detectors shall be provided with the following features:

- a) Detectors not specifically listed for sensitivity testing from the control panel are not acceptable due to the expense involved with manual testing as required by NFPA 72E.
- b) Each detector in a loop shall have short circuit isolator suitable for style-7 wiring as per NFPA-72.
- c) The fire alarm control panel shall permit detector sensitivity adjustment through field programming of the system.

#### Multi sensor Detectors (MSD)

Multi sensor detectors shall incorporate a heat detection element and a photoelectric detection element. Both the elements shall be incorporated in a single unit. Both the elements shall be operative at all times and the fire signal shall be available from any or both elements combined together. Multi-sensor detectors shall be approved as per UL 7th Edition or EN5429:2015.

The detectors shall be sensitive to very low smoke densities of the order of say 0.05 g/m<sup>3</sup>. Also it shall be possible to adjust this sensitivity on a step less basis over a range so that the optimum sensitivity

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could be selected at site to suit the conditions of installations. The coverage area of the smoke detection under standard NFPA test conditions shall not be less than 80-90m<sup>2</sup>.

In areas such as false ceiling where detectors themselves are not easily accessible, the remote response indicators outside the enclosed areas shall be provided to indicate the fire condition.

### System Configuration

Each of the Addressable Fire Alarm panel shall be able to communicate with one another as well as with repeater annunciation panel located at different places. The detectors or other devices of any other unit/area shall be addressable only from the respective Addressable Fire Alarm Panel, so that each of the Addressable Fire Alarm Panel is under the control of designated operating personnel at that location.

At least one spare loop shall be provided in each of the addressable type fire alarm panel located in control room with complete loop card and all other accessories so that Employer can expand the system in future. Further, at least 10% of loop capacity be left free in each of the connected loop in all the panels, so that, additional devices may be connected to the system in any of the loop by Employer in future.

### Analog Addressable Fire Detection and Alarm System

#### General Requirements

Bidder shall provide isolators at the start & end of the loop.


The complete system shall include, but not be limited to the following:

- a) Master system CPU.
- b) Analog Addressable Fire Detection and Alarm System panels including alarm modules, system supervisory control modules, auxiliary output control modules etc.
- c) PC based monitoring station with color graphic display terminal with programming and historical archiving facility along with laser printer.
- d) Power supplies, batteries and battery chargers.
- e) Analog addressable type multi-sensor detectors.
- f) Non-addressable type switching devices each with its own addressable interface modules.
- g) Software and hardware as required for complete operation of the system.
- h) Complete Wiring/cabling including its conduits/trays/fixtures etc.

### System Functional Requirements

The fire alarm panel shall evaluate the signals received from the detectors and shall handle the following functions:

1. Supervising of unauthorized removal of a detector head from its base and giving a fault alarm on the control panel.

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2. Supervising and monitoring the detection cabling, to indicate fault conditions in case of open/short circuit in the wiring.
3. Supervising by a separate annunciation window, changeover from mains supply to battery supply. “Mains On” indication shall be continuously on, as long as the main supply is available.
4. Facilitating simulation of fire conditions to enable the testing of circuits (without creating actual fire) under the test mode from the fire alarm panel.

#### **Panel Display Requirements.**

System display shall consist of minimum 80 character back lighted alphanumeric LCD display readable at any angle. Thirty-two character customer defined custom messages shall describe the location of the active device. In addition to the above, the following features shall be available.

- a. The system shall be capable of programming to allow troubles occurred and restored in the system to be automatically removed from the display queue, eliminating the necessity for individual acknowledging of these events. This feature shall not affect the historical logging of events as programmed.
- b. As a minimum an LED display for “Alarm”, “Audible Silenced”, “Supervisory”, “Trouble”, “Security”, “Power On”, And “Partial System Disabled”.
- c. Touch activated membrane switches for “Alarm Acknowledge”, “Audible Silence”, “Supervisory Acknowledge”, “Security Acknowledge”, “Reset”, “Display Hold”, And “Display Next”.
- d. All membrane switches shall be tactile with audible feedback when pressed.

#### **Power Supply for Fire Alarm Panel**

One set of 24V DC redundant power supply system comprising of 2 x 100% chargers and 1 x 100% batteries shall be provided for each fire alarm panel. The batteries for fire alarm system shall be sealed maintenance free lead acid type. The battery backup for each fire alarm panel and repeater alarm panel shall be 24 hours and 30 minutes (in alarm conditions). At least 25% of the devices shall be considered to be active in alarm conditions. Each of the redundant chargers shall be sized to meet connected load requirements and keep the connected batteries full charged (Float Mode). Furthermore, the charger shall be sized to enable the boost charge of a fully discharged battery in 10 hours while feeding the load.


The batteries shall be sized as per relevant IEEE standard. For battery sizing calculation, an aging factor of 0.8, a temperature correction factor (based on temperature of 4 deg. C), voltage drop of 2V in cables. Capacity factor, Float Correction Factor, as per Battery Supplier Standard, shall be taken into consideration, if applicable and ambient temperature shall be considered as the electrolytic temperature. The sizing of the battery shall be as approved by Employer during detailed engineering.

i)

#### **Control & Instrumentation requirements**

The specification for PC, printer and other HMI items shall be as specified in other sections of the technical specification.

#### **Cabling for fire alarm system**

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All instrumentation cables twisted & shielded, FRLS PVC insulated control cables, power cables including prefabricated cables (with plug-in connectors) etc. shall be provided by Bidder.

The Bidder shall follow the cable philosophy as below:


Application		Type of cable
From	To	
Detectors (including detectors mounted inside panels) /Any loop device	Detector (including detectors mounted inside panels) / Isolator/ Interface unit	Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 2, 3, 4 below.
Detectors (including detectors mounted inside panels) / Isolator / Interface Unit	JB	Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 2, 3, 4 below.
JB	Fire alarm Panel	Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 2, 3, 4 below.

**Notes:**

- 10% spare pair shall be provided for all cables having more than four pairs.
- Type "S" cable shall be multicore control cable having overall shielding & specification similar to instrumentation cable except insulation thickness and voltage grade which shall be 1100 V. Type "S" cable shall also satisfy requirements of Article 760 of NFPA 70.
- Cable size of 2 core 1.5 sq.mm shall be used for loop wiring in-case of both control cable and short term fire proof cable.
- Cable size of 2 core 2.5 sq.mm shall be used to provide power supply to various devices in the loop in-case of both control cable and short term fire proof cable.
- The detailed specification of instrumentation cables and optical fiber cable shall be as specified in other sections of the technical specification.
- Detector cables outside the building shall be corrugated steel taped armoured laid through cable trays wherever available and for rest of the areas, cable shall be buried at 600 mm depth with sand filling and brick covering at the top.
- Detector cable within the building shall be either unarmoured & laid through galvanized iron (GI) conduits or armoured cables, as per the standard and proven practice of the manufacturer.

**Portable Fire Extinguishers:** Fire extinguishers shall be installed in all the buildings/equipment in the scope of the Bidder as per TAC requirement. However, the Bidder shall supply the following quantities (*minimum*) of fire extinguishers (for each station) and install the same at various locations:

Pressurized water type (9 lit. cap.) (IS:15683 operated by CO2 cartridge type)	10 Nos.
Foam type (9 lit. cap. IS: 15683)	10 Nos.

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CO2 type (4.5 kg. Cap. IS: 15683)	10 Nos.
Dry Chemical powder (6 kg. Cap. IS: 15683)	10 Nos.

## **(B) AIR CONDITIONING & VENTILATION SYSTEM**

### **GENERAL**

This section of specification covers details of system specifications, basis of design, brief description of the system, equipment and services to be furnished by bidder.

The Design, Engineering, Supply, Construction, Erection, and Testing & Commissioning of all the equipment & works listed here shall be on the basis of single point responsibility in bidder's scope of work for satisfactory completion of the system in all respect.

### **DESIGN PHILOSOPHY OF AIR CONDITIONING AND VENTILATION SYSTEM**

#### **AIR CONDITIONING SYSTEM**

1. Design ambient conditions for all air conditioning system shall be as per site conditions:
2. All equipment of Air Conditioning system shall be designed for continuous duty.
3. Air-conditioned areas like Water system control room and area served by Package air conditioner shall be maintained at 24 deg. C  $\pm$  (plus or minus) 1 deg. C and relative humidity of 50%  $\pm$  (plus or minus) 5%.
4. The fresh air quantity for air-conditioned areas of Water System Control room building and other control room building etc. shall be 0.45 M3/minutes/person or 1.0 air change per hour whichever is greater. However, for office areas quantity of fresh air shall be minimum 1.5 air changes per hour.
5. Lighting load shall be one (1) Watts/Sq.feet or actual whichever is higher.
6. The occupancy for general area shall be minimum one person per 10 Sq. M and for conference room/meeting room the same shall be one per 3 Sq.M. In the control rooms, control equipment rooms, VFD rooms, etc. the occupancy may be one person per 25 Sq.M (Minimum).
7. A minimum design margin of ten (10) % shall be considered in design of AC Plant Capacity for each area.
8. For areas, where A/C load is of the order of 5-25TR, ductable split/package A/C shall be provided. Smaller areas which may require air conditioning up to 5 TR rating shall be served with Hi-wall Split/Cassette air conditioner units as per requirement.
9. Refrigerant should be CFC/HCFC free. All types of Insulation used for HVAC application shall be CFC/HCFC free.



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10. At least one (1) no. unit, capacity same as each working unit as a common standby shall be provided for control rooms/RIO room/etc. operating 24 hours a day, served by non-ductable split (cassette / Hi-wall) and ductable type air conditioners. No standby shall be provided for office areas of various buildings.

### Ventilation System

1. Minimum Air changes per hour in mechanically ventilated areas shall be as follows:

i) General areas - 20 ii) MCC/ Switchgear rooms and Battery rooms - 30

& other areas where gaseous fumes/ vapors are generated.

2. However, in areas producing lot of heat, temperature shall be the criteria as follows:

a) Inside Temperature shall be maximum 3 deg.C above the design ambient temperature during summer for mechanically ventilated areas.


**Note:** (i) Dry bulb temperature during summer season is as mentioned in air conditioning above. The criterion which gives higher number of air changes/higher quantity of air of either of condition, flow shall be selected.

3. All ventilation systems shall operate on 100% fresh air. Fan envisaged for MCC, Switchgear rooms shall be provided with pre-filters and fine filters and for other areas shall be provided with pre-filter only.
4. All the equipment of ventilation system shall be designed for continuous duty.
5. All mechanically ventilated areas shall be positively ventilated. For positively ventilated areas, the exhaust air quantity shall be approximately 60% of total discharge of supply air fans. However, Battery rooms and other fumes/odour generating areas shall be negatively ventilated. Type of ventilation for various buildings shall be as follows:

S.No.	Area	Type of Ventilation system
(i)	General area	Combination of Supply air fan & Exhaust air fans
(ii)	MCCs and Switchgear room, Cable Vault etc.	Supply air fans & Exhaust air fans
(iii)	Battery rooms & other fumes / Odor generating areas	Exhaust air fans
(iv)	Toilet/pantry etc.	Exhaust air fans

For fans, compressors, and blowers (as applicable), the continuous motor rating (at 50°C ambient) shall be at least 10% above the maximum load demand at the design duty point



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However, for V-belt driven fans, continuous motor rating (at 50°C ambient) shall be at least 15% above the maximum load demand at the design duty point.

7. Supply air fans, exhaust air fans & ventilations of each area shall be provided with local starter panels.

**NON DUCTABLE SPLIT (HI-WALL/CASSETTE), DUCTABLE SPLIT AIR CONDITIONERS:**

Air conditioners shall in general consist of the following:

- i) Casing
- ii) Hermetically sealed rotary/scroll Compressor iii) Air-cooled condenser
- iv) Evaporator and condenser cooling fan v) Cooling coil vi) Filters vii) Piping, valves, refrigerant strainer, insulation, etc. viii) Controls, instruments, control panel/starter panels. ix) Vibration isolator pads, ducting (if applicable), etc. as required. x) Refrigerant as per manufacturer practice.

**Note:** (1) Humidity control inside air-conditioned space served by split air conditioners is not envisaged. (2) Air conditioners shall conform to minimum star rating as per latest code/ standard/ guidelines issued by Bureau of Energy Efficiency (BEE), Ministry of Power, Govt of India. However, for non-ductable split (hi-wall/cassette) Air conditioners, minimum star rating shall be as below:

- a) Capacity up to and including 3TR: 5 Star
- b) Capacity from 3TR to 5TR: 4 Star

Indoor unit of Ceiling Mounted Cassette Type Unit (Multi Flow Type):

The housing of the unit shall be powder coated galvanized steel. All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view.

Unit shall have four-way supply air grills on sides and return air grill in center.

Each unit shall have high lift drain pump and very low operating sound.

**AIR FILTERS**

**Pre Filter**



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1)	Type: Flange / Cassette		
2)	<b>a) Fabric Filter:</b> Pre-filter shall contain washable non-woven synthetic fiber or High-density Polyethylene (HDPE) media having 18G GSS / 16G Al alloy frame. The filter media shall be supported with HDPE mesh on air inlet side & Aluminium expanded metal on exit side or G.I. wire mesh on both sides.  <b>b) Metallic Filter (if applicable):</b> Filter medium, aluminium alloy shall be supported on galvanized expanded metal casing. Frame shall be fabricated from aluminium alloy of minimum 16G thickness conforming to IS: 737 or 18 gauge.		
2)	<b>Other requirements: (as applicable)</b>		
	b)	Casing shall be provided with neoprene sponge rubber sealing.	
	c)	Capable of being cleaned by water flushing.	
	d)	Density of filter medium shall increase in the direction of air flow in case of metallic filter.	
	e)	Filter media shall be fire retardant and resistant to moisture, fungi, bacteria & frost.	
4)	<b>Efficiency:</b>		
	Average arresstance of 65 - 80 % when tested in accordance with BS:6540/ASHRAE – 52 – 76 / EN-779.		
5)	Minimum thickness	:	50 mm
6)	Face Velocity	:	Not more than 2.5 m/sec.
7)	Pressure drop	:	Initial pressure drop - Not to exceed 5.0 mm WC at rated flow. Final pressure drop – Up to 7.5 mm WC.
8)	Location	:	a) At the suction of each AHUs
		:	b) At the discharge of each Fresh air fan
		:	c) At the discharge of each Supply air fan
<b>Fine Filters (Microvee type)</b>			
1)	Type	:	Flange / Cassette
2)	Fine filter shall contain washable non-woven synthetic fibre or High density Polyethylene (HDPE) media having 18G GSS / 16G Al alloy frame. The filter media shall be supported with HDPE mesh on air inlet side & Aluminium expanded metal on exit side or G.I. wire mesh on both sides.		
3)	Other requirements	:	a) A neoprene sponge rubber sealing shall be provided on either face of the filter frame. b) Capable of being cleaned by air or water flushing. c) Filter media shall be fire retardant and resistant to moisture, fungi, bacteria & frost.
4)	Efficiency	:	Average arresstance > 90% when tested in accordance with BS:6540/ASHRAE–52-76 / EN-779.



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5)	Minimum thickness	:	150 mm or 300 mm.
6)	Face Velocity	:	Not more than 1.2 m/sec for 150 mm and not more than 2.4 m/sec. for 300 mm.
7)	Pressure drop	:	Initial pressure drop - Not to exceed 10 mm WC at rated flow. Final pressure drop-Up to 25 mm WC.
8)	Location	:	i) At the discharge of each individual AHU. ii) At the discharge of each Fresh air fan. iii) At the discharge of each supply air fan having static pressure 30mm wc or more.

**Axial Fans**

- These fans shall have fixed / variable pitch cast aluminum blades of aerofoil design.
- The fan casing shall be of heavy gauge sheet steel construction.
- Necessary rain protection cowl, inlet and outlet cones, bird protection screen, adjustable damper, vibration isolators, back draft dampers etc. shall be provided.
- The speed of the fan shall not exceed 1000 rpm for fan with impeller diameter above 450 mm and 1500 rpm for fan with impeller diameter 450 mm or less. However, for fans having static pressure of 30 mm WC or above the speed of the fan shall not exceed 1500 rpm for fan with impeller diameter of above 450 mm and 3000 rpm for fan with impeller diameter of 450 mm or less. The first critical speed of rotating assembly shall be at least 25% above the operating speed.
- All other accessories like supporting structure etc. as required shall be provided.
- Fans of capacity 1000 m<sup>3</sup>/hr & lower shall be of propeller exhaust type.
- Battery rooms shall be provided with spark proof (with flame proof motor) fans.

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## 32. CIVIL

### GENERAL

This chapter includes the technical requirements for the package including associated design and preparation of all civil, structural & architectural drawings and execution of all associated civil works.

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 / IRC or CPWD 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 British Standards or to the instructions of Engineer. The List of IS standards / IRC or CPWD specifications to be followed are mentioned in the technical specifications. They shall be latest edition / version of the same issued 15 days prior to the date of opening of this tender. 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 Employer in respect of interpretation of any portion of this document.

This specification covers design, preparation of general arrangement drawings, construction and fabrication drawings, supply of materials and construction of all civil, structural and architectural works.


Description of various items of work under this specification and nature of work in detail are given hereinafter. Complete work under this scope is referred to as civil works. List of various civil works covered under the scope is given in Part-A and herein.

The work to be performed under this specification consists of design, engineering and providing all labour, materials, consumable, equipment, temporary works, temporary storage sheds, temporary labour 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 plant, all in strict accordance with the specifications and including revisions and amendments thereto as may be required during execution of the work.

All materials including cement, reinforcement steel, 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 Employer.

The work shall be carried out according to the design/ drawings to be developed by the Bidder and approved by the Employer. 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. 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 Employer.

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-

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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

The Bidder shall take all necessary precautions to protect all the existing equipment, structures, facilities & buildings if applicable etc. from damage. 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 his own cost to the satisfaction of the Engineer. The Bidder shall also take all necessary safety measures, at his own cost, to avoid any harm / injury to his workers and staff from the equipment & facilities.

Before submitting the bid, the Bidder shall inspect and examine the site and its surroundings and shall satisfy himself as to the nature of the ground and subsoil, the availability of materials necessary for completion of the work, means of access to site and in general shall himself obtain all necessary information as to risks, contingencies and other circumstances which may influence or affect his offer. No extra claim consequent on any misunderstanding or otherwise shall be allowed.

The layout and levels of all structures etc. shall be made by the Bidder at his own cost from the general grid of the plot and benchmarks given by the Engineer. The Bidder shall give all help in instruments, material and men to the Engineer, at no extra cost, for checking the detailed layout & correctness of the layout and levels. However, the Bidder shall be solely responsible for their correctness.


Proposed location of BESS area are within existing Plant premises and are safe wrt HFL. Storm water drain of BESS area to be connected to nearest owner's drain. For FGL, bidder to refer specification/amendments.

Approach road and Existing Drain : Paving area of BESS plant to be connected with nearby available Road with suitable provision of culvert on existing drain is in Bidder's scope of work. As such any structure demolition is not envisaged, however, any foundation or underground obstructions shall be demolished.

#### **SUBMISSIONS**

The following documents shall be submitted by the Bidder for approval of the Employer, prior to commencement of fabrication and erection / construction. This list is not exhaustive but indicative only:

1. Foundation Layout showing Coordinates of Battery energy storage cum power conditioning system / transformer yard.
2. G. A. drawing showing co-ordinates of various Gantry structures and facilities if applicable.
3. Drawing showing underground facilities with co-ordinates of all facilities such as Tower/LM foundations (if applicable), equipment foundations, Transformer foundations, R.C.C cable trenches, cable ducts, drains, sump pits, culverts, other foundations etc. if applicable.
4. Proposed erection / construction scheme for various structural and civil works envisaged as per design requirement.
5. Foundation design & drawing for Towers & Lighting Mast (LM)(if applicable)
6. Foundation design & drawing for equipment supports, their control cubicles, bus post supports and bay marshalling kiosks (if applicable).

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7. Details of RCC cable trenches and duct banks with necessary precast RCC removable covers with lifting facility, sump pits, cable tray supports etc.
8. Foundation design & drawing for Transformers as required including associated rail tracks, oil soak pits, oil collection pits, sump pits, firewall etc.
9. Design & drawing of drains within BESS area including road/drain/trench crossings.
10. Site preparation, soil sterilization / antiweed treatment including gravel filling, but excluding major leveling where ever required.
11. **One Guard PEB Room shall be provided within the BESS area. minimum built-up area of 5 sqm shall be provided near the main gate of BESS or boundary wall/ fencing. It should be RCC framed super structure and RCC Slab with Bricks/concrete blocks masonry wall. Unless specified, the wall shall be with minimum one brick thick on exterior side in cement mortar (1:6).**
12. Fencing along with gate and Guard room .
13. Design & drawings for new RCC framed Switchgear Building and Service building for installation of new panels, as applicable
14. All architectural drawings required for execution of construction work such as detail floor plans, detail elevations, detail sections and other miscellaneous architectural details such as finishing schedule (internal and external), color schemes (both internal and external), doors and windows, flooring details and pattern, false ceiling etc., architectural facia and projections, miscellaneous details and architectural details like coping, khurras, water proofing, surface drain, rain water down comers, sanitary and plumbing etc.
15. If the BESS is located outside the plant boundary, a precast boundary wall shall be constructed around it as per the applicable technical specifications. However, if the BESS is situated within the plant boundary, it shall be enclosed with chain link fencing.
16. Structural steel fabrication drawings and Reinforcement bar bending schedules for reference.
17. Electronic soft copy of all the approved drawings/calculations in Cat-II / Cat-I.
18. The bidder shall be responsible for assessing the groundwater table and acquiring any supplementary geotechnical data necessary for the foundation system, beyond what is provided in the Geotechnical Chapter of the Technical Specifications .


All documents including design calculations shall be prepared in MS office (latest version) and all drawings shall be drafted using autocad (latest version). The analysis shall be done by using STAAD PRO / ANSYS/SAP2000 (latest version). However, design may be carried out manually, using computer work sheets or by using suitable software programs, as mutually agreed by employer. Final calculations and drawings shall be submitted as mentioned in general technical requirements chapter

## DESIGN CRITERIA

### General

Structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, piping loads (static and dynamic), wind loads, seismic loads and temperature loads.

### Loading:

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The different load combinations shall be taken as per IS: 875 (Part-V) and other relevant IS Codes.

#### Dead Loads

Dead loads shall include the weight of structure complete with finishes, fixtures and partitions and shall be taken as per IS: 875 (Part - I).


#### Imposed Loads

Imposed loads in different areas shall include live, erection, operation and maintenance loads. Equipment loads (which constitute all loads of equipment to be supported on the building frame) are not included in the imposed loads furnished below and shall be considered in addition to imposed loads.

For consideration of imposed loads on structures, IS: 875 (Part – II). The following minimum imposed loads as indicated for some of the important areas shall, however,

be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

a )	Roofs	150 Kg / Sq.m
b)	Building floors	1000 Kg / Sq.m
c )	RCC floors (General) outdoor platforms	500 Kg / Sq.m
d )	Stairs, Landing and Balconies	500 Kg / Sq.m
e )	Toilets	200 Kg / Sq.m
f )	Chequered plates, Grating Floors etc.	500 Kg / Sq.m
g)	Walkways	300 Kg / Sq.m
i )	Road Culverts and its allied structures including RCC pipes Crossings & Road Crossings of Trenches	Design for Class - 'AA' loading (wheeled and tracked both) and checked for Class - 'A' loading as per IRC standards.
j )	Underground structures such sumps, pits, trenches, drains etc.	In addition to the earth pressure and ground water pressure, the surcharge of 2000 Kg / Sq.m shall also be considered.
k )	Cable Trench Covers	400 Kg / Sq.m ( General )

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### Equipment loads

Loads of all equipment like Electrical control and relay panels, cable load, Tanks, etc. shall be considered over and above the imposed loads. Cable and piping loads not less than 5 kN/sq.m hanging from the underside, shall also be considered additionally for floors where these loads are expected.

### Wind Load

- a) Switchyard gantries, towers, equipment supporting structures and lightning mast shall be designed as per IS: 802 considering the basic wind speed ( $V_b$ ) as stipulated in “Criteria for wind resistant design of structures and equipment”
- b) All other structures covered under the present package shall be designed as per IS: 456 / IS: 800. The wind load calculations to be made as per IS: 875 shall be with the parameters as stipulated in “Criteria for wind resistant design of structures and equipment” of this specification.

### Seismic Load

Seismic forces shall be considered as specified in this specification.

### Geo-technical Data & Foundation System

Geo-technical Data & Foundation System shall be considered as specified in specification.

### Design consideration


#### RCC Concrete Pedestal /slab

- i) Finished Level of the top of concrete of BESS/PCS foundation shall be minimum 450 mm from Finished paved level in BESS area.
- ii) BESS yard shall be as per recommendation of Battery energy storage Manufacturer. Layout of yard shall be such that crane movement for placing, lifting of battery units PCS unit, Transformer etc. shall not disturb the adjacent facilities.
- iii) Adjacent and Surrounding area of BESS, PCS etc to be paved. All system, room and building shall be connected by rigid pavement.
- iv) RCC trenches shall be constructed in reinforced cement concrete of M25/M35 grade.

#### BESS- Service Building and Switchgear Room – in Customer scope

- i) The building shall have RCC framed super structure and RCC Slab with Bricks/concrete blocks masonry wall. Unless specified, the wall shall be with minimum one brick thick on exterior side in cement mortar (1:6). For internal walls shall be 230/115 thick as per requirement



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- ii) Design of RCC structures shall be done using limit state method as per IS 456. Detailing for ductility shall be followed as per guidelines of IS13920 to be effective against seismic load.
- iii) The building shall consist of rooms/facilities/equipment as per system requirement.
- iv) Open space shall be provided on the periphery of the panel rows and equipment to allow easy operator movement and access for maintenance purposes.

#### **Architectural concepts**

The building shall be architecturally treated in such a way that it presents a pleasing composition of mass and void with suitable and functionally designed projections and recesses.

The buildings shall also be designed:


- i) To the requirements of the National Building Code of India, and the standards quoted there in. The building shall be designed on the principle of providing barrier free environment for physically disabled person.
- ii) To adequately suit the requirements of the equipment and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.
- iii) With, wherever required, fire retarding materials for walls, ceilings and doors, which would prevent supporting or spreading of fire.
- iv) With materials preventing dust accumulation.

Following Details to be followed for RCC works.

#### **2) Floor Finishes**

- a. Control room: Heavy Duty Vitrified Ceramic Tiles with skirting
- b. Battery Room : Acid/Alkali Resistance tile Flooring and Dado (2100mm)
- c. Toilet : Heavy Duty Anti-skid ceramic tiles and dado upto 2100 mm
- d. Steps: Kota stone/Granite-18 mm minimum thick.
- e. Material loading/unloading bay : 50 mm Metallic hardener topping over grade slab in ground floor to be provide.
- 3) Plinth level of all buildings shall be kept at least 500 mm above the finished grade/ formation level. PCC paving of nominal M-15 , 100mm thick laid over 75mm thick bed of dry brick aggregate shall be provided for 750mm wide plinth protection around buildings.  
  
Concrete ramp shall be provided at rolling shutter gate. RCC steps to be provided for main entrance of all RCC buildings.
- 4) 50mm DPC in Cement concrete (1:1.5:3) with water proofing compound followed by two layers of bitumen coating 85/25 grade as per IS: 702 @ 1.7 kg./sq.m. shall be provided at plinth level before starting the masonry work.

#### **5) Water supply and sanitation:**

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- Water Tank: Polyethylene water storage tanks conforming to IS:12701 shall be used of adequate capacities of 24 hr requirement (minimum 500 litres) complete with all fittings
- Potable /Service Water: Chlorinated Polyvinyl Chloride (CPVC) pipes, confirming to IS 15778, having thermal stability for hot & cold water supply including all CPVC plain & brass threaded fittings.

- Sanitary works:

- Above ground -UPVC pipe conforming to IS 13592 for sewerage.

- Below ground- Cement concrete pipes of Class NP-3 as per IS 458 shall be used.
- Bidder shall provide Complete sewerage system including Sewage
- Treatment Plant for facilities within the BESS area. Bidder shall provide 'Decentralized Sewage Treatment' units. The capacity of the Decentralized Sewage Treatment' unit should be as per the design requirements, subject to minimum combined capacity of 10 Cum/day.
- Design of Sewage treatment plant shall be as per CPHEEO manual. Primary, Secondary and Tertiary treatment to be provided. Treated sewage water shall be used for horticulture purpose as per quality requirement of CPHEEO manual.
- Cement concrete pipes of class NP-3 as per IS 458 shall be used below ground level for sewage disposal. RCC manholes with CI cover shall be provided at every 30m along the length, at connection points, and at every change of alignment, gradient or diameter of a sewer pipeline. This shall be as per IS 4111. Bidder shall have to provide complete arrangement for sewage disposal up to the sewage treatment plant including pumping facilities.
- Manual electrically operated control system shall be provided.


iii) **Toilet:** Service Building shall have one Ladies Toilet and One Gents Toilet . IS:1172 shall be followed for working out the basic requirements for water supply, drainage and sanitation.

Each Toilet block shall have following minimum facilities. All fittings, shall be of chromium plated brass as per relevant IS code.

- a) One number wall mounted coloured glazed vitreous China European water closet and dual flushing valve system, health faucet, toilet paper holder as per IS:2556.
- b) Ceramic Wash basin (450x550 mm approx.) above platform with all fittings
- c) Bathroom Mirror (600x900x6 mm thick) hard board backing.
- d) Urinal (only for Gents toilet) as per IS 2556.
- e) CP brass towel rail(600x20 mm ) with CP brass.
- f) Soap holder and Liquid soap dispenser.

#### 5) Roof :

- a) Roof of the Building shall be cast in situ RCC slab. The runoff gradient for the roof shall not be less than 1:100 and the roof shall be provided with RCC water gutter, for efficient disposal of water.
- b) Unplasticized PVC rainwater pipes conforming to IS 13592, Type A with joints with seal ring confirming to IS 5382 shall be provided to drain off rain water from the roof

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c) The Roof of building shall be waterproofed. Top surface of sloped R.C.C. slab shall be finished with 15mm thick cement plaster (1:4). Over the finished surface elastomeric membrane shall be laid. The elastomeric shall comprise of high solid content liquid applied urethane laid over reinforcing layer of polyscrim cloth or non-woven geo-textile. The top of the elastomeric membrane shall be finished with 20 mm thick cement: sand (1:4) mortar with chicken wire mesh and pressed precast concrete tiles of 20 mm thickness where applicable shall be laid over mortar at dry stage. Provision for thermal expansion of roofing tiles shall be kept by providing an expansion gap in both directions filled up with polysulphide joint sealant. The expansion gap shall be provided in the cement sand mortar underbed layer also.

- The elastomeric membrane mentioned above in (a) and (b) for waterproofing shall be of two component, instant setting, 100% solids spray applied hybrid polyurea polyurethane liquid applied elastomeric seamless waterproofing. membrane meeting the requirements of LAM as per ASTM C836 and having excellent tensile strength of 15MPa (As per ASTM D412), elongation more than 450% (as per ASTM D 412), tear strength of 60 Kn/m (As per ASTM D1004/ASTM D624), adhesion to concrete of 2MPa (as per ASTM D 4541), abrasion resistance of 60mg loss (1 Kg,CS 10 Wheels,1000 cycles - As per ASTM D4060), Shore A Hardness of 85 (As per ASTM D2240), resistance to hydrostatic pressure head of 7 Bar (As per ASTM D 5385/ DIN 16726), puncture resistance of 1000N (As per ASTM E154), water vapour permeability of 25 mg/m2/day (As per ASTM E96), Impact resistance of 17 N.m (As per ASTM D2794), Low temperature crack bridging ability up to 3.2mm (As per ASTM C
- 1305), dynamic crack bridging ability class B 3.2 (as per EN 1062-7 Method B- B3.2) with no crack observed in the coating after 20000 sinusoidal cycles, resistance to root (As per CEN TS/14416) and fire resistance of class B (As per EN 13501-1).The coating shall be applied with a total consumption of 1.6 Kg/Sqm to achieve a total system DFT of 1.5mm, thereby satisfy the requirements of LAM as per ASTM C898 and shall be applied on the entire horizontal surface extending up to 300mm above the FFL on the vertical surface as per the methodology.
- The application system includes base preparation of cleaning, brushing and removal of flacky materials, grouting the porous area with cementitious grout, proper coving between slab and wall junctions and priming the surface with two component solvent free epoxy primer which is applied with a consumption of 200 grams per Sqm, followed by spray application of hybrid polyurea waterproofing coating.Protective geo textile fabric of minimum 150GSM over the entire membrane with proper overlaps shall be applied.

d) Parapet wall of 900 mm above Finished roof level of roof.

e) Roof of all buildings shall be provided with access/approach through staircase or ladder. All rungs and ladders shall be galvanised.


## 6) Windows, Doors, Ventilators And Rolling Shutter

Doors, Windows and Ventilators of air conditioned areas , entrance lobby of all buildings shall have powder coated (minimum thickness of powder coating 50 micron) aluminium framework with glazing.

Window shall be provided with Suitable aluminium grill.

Toilet door will be Fibre reinforced plastic (FRP) type.

For Single glazed aluminium partitions and doors, toughened float glass of 10mm thickness shall be used. All Windows and Ventilators shall be provided with minimum 6 mm thick toughened glass to used. All

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glazing work shall conform to IS: 1083 and IS: 3548. The Glass used should be from reputed brand / manufacturer and as approved by End customer. The glass should be free from distortion and thermal stress.

Minimum size of door provided shall be 2.4 m high and 1.2 m wide. However, for toilets minimum width shall be 0.75 m and 2.1 m high and office areas minimum width shall be 1.20m.


Fire-Proof doors with panic devices shall be provided at all fire exit points as per requirements. These doors shall be as per IS 3614 Part-II. Fire rating of the doors shall be of minimum 2 hours of integrity and 30 minutes of insulation. These doors shall be double cover plated type with mineral wool insulation

Wherever functionally required Rolling shutter (fully closed/partly grilled) with manual operating arrangement shall be provided to facilitate smooth operations. Rolling shutters shall conform to IS: 6248. M.S sliding doors with suitable mechanical operations fixtures as per requirement for shall be used.

Door Windows and Rolling shutter on external wall of the buildings shall be provided with RCC Sunshed over the opening. Projection of Sunshed of 450mm of window, 600mm over door except main entrance door where projection shall be 1000mm. Projection of 900 mm over rolling shutter shall be provided.

#### 7) Painting of wall and ceilings

- Internal Wall surface: Acrylic Distemper.
- External faces of wall : Exterior Emulsion paint.
- Ceiling(Except in Control room/Entrance/Lobby) : Acrylic Distemper
- Ceiling in Control room/Entrance/Lobby : Aluminum False Ceiling
- The Paint shall be antifungal quality of reputed brand suitable for masonry. All painting on masonry / 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 two finishing coats of paint shall be applied over a coat of Primer.
- A standard color scheme for the different building/structures shall be prepared by the Bidder and the approval of the owner shall be obtained before commencement of work.
- The design and fabrication of steel structures shall be as per provisions of IS: 800:2007(Limit State Design) and other relevant IS standards.
- Welding shall be used fabrication and joints. For Site connections, Welding or High Strength friction Grip (HSFG) bolts shall be used. In few cases. For shear connections or removable beam connections bolts joints with M.S. Black bolts may be adopted. IS 4000 shall be followed for HSFG bolt connection. IS 816 and IS 9595 shall be followed for welding of structures.
- All structures close to railway line shall have clearances conforming to Railway norms.
- The design and construction of RCC structures shall be carried out as per Limit State Method as per provisions of IS: 456 – 2000.
- Two layers of reinforcement (on inner and outer face) shall be provided for RCC wall sections having thickness more than 150mm.
- For design of all underground structures/ foundations, ground water table shall be considered at the finished ground level.
- Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest, coefficient of active or passive earth pressure whichever is applicable depending upon the structural configuration.

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- The storm water drainage shall be designed considering the finished grade level of the surrounding area, area drainage pattern around the area


#### **Design Parameters for Gantry Towers & Beams, Lightning Mast and Equipment Supporting Structures (if Applicable)**

- Gantry structure, consisting of open web towers connected by girders, shall be made of structural steel conforming to Grade IS:2062 and duly galvanized conforming to IS: 2629 and IS: 4759. All joints shall be bolted connections.
- The analysis of towers and gantries shall be carried out with combined model of critical configurations of towers and gantries using any established structural analysis software like STAAD Pro, SAP2000, ETABS, SAFE.
- All bolts for connections shall be of 16mm dia conforming to IS: 12427, property class
  - as per IS: 1367 (Part 3). Nuts shall conform to I.S 1363 (Part 3) of property class 5. Foundation bolts shall conform to IS: 5624, and property class shall be 4.6 as per IS: 1367 (Part 3).
- Butt splice shall be used for splicing the main members and splice shall be located away from the node point.
- IS: 802 “Code of practice for use of structural steel in overhead transmission line towers” shall be followed for design of structures. Height & type of towers shall be established based on electrical requirements. A provision of minimum  $\pm 30$  degree angle of deviation of line in horizontal plane and minimum  $\pm 20$  degree deviation in vertical plane as per electrical requirement is considered and the resulting worst combination of forces shall be considered for design. For all outgoing and incoming feeders, the conductor span shall be taken as 200m for design purpose.

#### **Loads and Loading Conditions**

Switchyard structures shall be designed for the worst combination following loads:

- 1) Dead loads (load of wires/conductors, insulator, electrical equipment and structural members),
- 2) live loads,
- 3) Wind load on bus bars, shield wires, insulator strings, electrical equipment, structural members etc as per IS:802, and other structures as per IS 456/IS 800.
- 4) seismic loads,
- 5) loads due to deviation of conductor (gantries shall be checked for min.  $\pm 30$  deg. deviation in horizontal plane and min.  $\pm 20$ -degree deviation in vertical plane),
- 6) loads due to unbalanced tension in conductor/wire,
- 7) Torsional load due to unbalanced vertical and horizontal forces,

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- 8) Erection loads,
- 9) Short circuit forces including snap in case of bundled conductors, etc.

Note:

- (i) The occurrence of earthquake and maximum wind pressure is unlikely to take place at the same time. The structure shall be designed for either of the two. However, temperature stresses can be ignored, as these towers are freestanding structure in open space.
- (ii) Short circuit force and wind shall be considered to act simultaneously for the purpose of structure design.
- (iii) Direction of wind shall be assumed such as to produce maximum stresses in any member for the combination of wind load with conductor tensions. The wind acting perpendicular and parallel to bus conductor and shield wire shall be considered separately
- (iv) The conductor tension shall be assumed as acting on only one side of the gantry for the analysis and design of switchyard gantries for both normal and short circuit condition.
- (v) The distance between terminal and dead end gantry shall be taken as 200 meters.


#### Minimum Thickness of Members & Galvanization

All steel work used in construction of switchyard structures such as Towers & Beams, Lightning mast and equipment supporting structures including nuts, bolts and washers shall be galvanized.

Minimum section thickness shall not be less than 4 mm. Weight of zinc coating shall be at least 0.610 kg/m<sup>2</sup> and foundation bolts shall have heavier zinc coating of at least 0.80 kg/m<sup>2</sup>, for C3 category and at least 0.900kg/m<sup>2</sup> of C5 category.

#### Wind Load Evaluation

- Along-wind forces shall generally be computed using the Peak Wind Speed Method (3-second gust) as defined in IS:875 (Part-3).
- For slender or wind-sensitive structures and elements, along-wind forces shall also be computed for dynamic effects using the Gust Factor or Gust Effectiveness Factor Method as defined in the standard.
- Structures shall be designed for the higher of the wind forces obtained from the Gust Factor Method or the Peak Wind Speed Method.
- Dynamic wind analysis must be undertaken for any structure having:
  - A height-to-minimum lateral dimension ratio greater than 5, and/or
  - A fundamental frequency less than 1 Hz.

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### Corrosive Environment Classification (for BESS Sites)

#### Corrosive Category Reference:

- Classification as per ISO 12944-2 (Atmospheric Corrosivity Categories).
- Paint systems and protective coatings as per ISO 12944-5, selected based on environmental exposure conditions.


#### CRITERIA FOR WIND RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT

- All structures shall be designed for wind forces in accordance with IS:875 (Part-3) and as specified in this document.
- Along wind forces shall generally be computed by the Peak (i.e. 3 second gust) Wind Speed method as defined in the standard.
- Along wind forces on slender and wind sensitive structures and structural elements shall also be computed, for dynamic effects, using the Gust Factor or Gust Effectiveness Factor Method as defined in the standard. The structures shall be designed for the higher of the forces obtained from Gust Factor method and the Peak Wind Speed method.
- Analysis for dynamic effects of wind must be undertaken for any structure which has a height to minimum lateral dimension ratio greater than “5” and/or if the fundamental frequency of the structure is less than 1 Hz.
- Susceptibility of structures to across-wind forces, galloping, flutter, ovalling etc. should be examined and designed/detailed accordingly following the recommendations of IS:875(Part-3) and other relevant Indian standards.
- It should be estimated if size and relative position of other structures are likely to enhance the wind loading on the structure under consideration. Enhancement factor, if necessary, shall suitably be estimated and applied to the wind loading to account for the interference effects.

#### Protective Measures:

- Outdoor equipment enclosures shall be engineered with adequate ventilation and protection from harsh environments (sunlight, rainfall, dust).
- Thermal considerations: Radiation and absorption effects of outdoor environments must be evaluated. Temperature rise shall not exceed the working temperature limits of components.
- Protective structures: Suitable sheds or canopies shall be provided for outdoor equipment, including inverters and containerized systems.
- All exposed steel structures shall be either:
  - Painted to comply with C3/C5 corrosion category requirements, or
  - Hot-dip galvanized, as per the applicable technical specification.



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#### Across-Wind and Interference Effects

- Susceptibility to across-wind forces, galloping, flutter, and ovalling shall be assessed and addressed in design per IS:875 (Part-3) and relevant Indian Standards.
- The influence of nearby structures on wind load shall be evaluated.
  - If found significant, an appropriate enhancement (interference) factor shall be applied to wind loading.

#### Structural Damping Values

Type of Structure	Damping Factor (% of Critical Damping)
Welded steel structures	During detailed engineering as per customer requirement
Bolted steel or RCC structures	During detailed engineering as per customer requirement
Prestressed concrete structures	During detailed engineering as per customer requirement

#### CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT


All structures and equipment shall be designed for seismic forces adopting the site specific seismic information provided in this document and using the other provisions in accordance with IS:1893 (Part 1 to Part 4). Pending finalization of Part 5 of IS:1893, provisions of part 1 shall be read along with the relevant clauses of IS:1893:1984, for embankments.

A site specific seismic study has been conducted for the project site. The peak ground horizontal acceleration for the project site, the site specific acceleration spectral coefficients (in units of gravity acceleration 'g') in the horizontal direction for the various damping values and the multiplying factor (to be used over the spectral coefficients) for evaluating the design acceleration spectra are as given at Annexure-I.

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

Since most structures in a Substation are irregular in shape and have irregular distribution of mass and stiffness, dynamic analysis for obtaining the design seismic forces shall be carried out using the response spectrum method. The number of vibration modes used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 percent of the total seismic mass and shall also meet requirements of IS:1893 (Part 1). Modal combination of the peak response quantities shall be performed as per Complete Quadratic Combination (CQC) method or by an acceptable alternative as per IS:1893 (Part 1).



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In general, seismic analysis shall be performed for the three orthogonal (two principal horizontal and one vertical) components of earthquake motion. The seismic response from the three components shall be combined as specified in IS:1893.

The spectral acceleration coefficient shall get restricted to the peak spectral value if the fundamental natural period of the structure falls to the left of the peak in the spectral acceleration curve

For buildings, if the design base shear ( $V_B$ ) obtained from modal combination is less than the base shear ( $\square V_B$ ) computed using the approximate fundamental period ( $T_a$ ) given in IS:1893:Part 1 and using site specific acceleration spectra with appropriate multiplying factor, the response quantities (e.g. member forces, displacements, storey forces, storey shears and base reactions) shall be enhanced in the ratio of  $\square V_B / V_B$ . However, no reduction is permitted if  $\square V_B$  is less than  $V_B$ .

#### **Design/Detailing for Ductility for Structures**

Structures shall be engineered and detailed in accordance with relevant Indian/International standards to achieve ductility.

**SITE SPECIFIC SEISMIC PARAMETERS FOR DESIGN OF STRUCTURES AND EQUIPMENT is given in annex**


#### **FOUNDATION SYSTEM AND GEOTECHNICAL DATA**

##### **Soil Data**

Bore logs data and Bearing capacity for design of foundations are given at Annexure - C of this specification. The geotechnical investigation report comprising of Boreholes, Laboratory tests, Chemical analysis, etc for the sub-strata prevailing at site would be made available for the Bidder's study at the Owner's office, if required. The onus of correct assessment / interpretation and understanding of the existing subsoil condition / data lies with the Bidder. **In case, bidder feels that the available data is inadequate, he may carry out his own geotechnical investigation at no cost to Owner. Further , if any change in layout the bidder has to carry out Geotechnical investigation in the area at no cost to Owner.** Geotechnical investigation work shall got executed by the Bidder shall be as per specification. However, no time extension shall be given on account of soil investigation carried out by the Bidder. The geotechnical investigation report shall be prepared with detailed recommendations regarding type of foundation and allowable bearing pressure for various structures/ facilities and other soil parameters. Net allowable bearing pressure shall be limited to Table-1 of Annexure-C. The report shall be submitted for Owner's approval prior to commencement of design of foundation.

Bidder may refer enclosed Topographical survey drawings and General layout plan along with borelogs for variation in existing ground level(EGL)/ Natural Ground level(NGL) and Finished ground level(FGL).

To conduct topography survey of the identified area for BESS using total station. The benchmark with local co-ordinate system will be provided by EIC considering the same Bidder shall carry out spot level surveying at an interval of 5 meters for contouring the area. Contours are to be interpolated at 0.5 M intervals after the above points are plotted. The contours shall not be just interpolated but properly surveyed on the ground so that features falling between the two successive levels are also picked up.

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The scope of survey will also include survey for nearest existing road/drains for interconnection of approach/drain from BESS area. Drains of minimum clear depth 30 cm shall be provided along both sides of the road.


**The furnished borelog details are specific to the co-ordinates where the boreholes have been carried out and are provided for bidder's information only. Soil profile in the proposed area may vary with respect to the borelogs enclosed for bidder's information. Bidder has to consider all such variations in his estimation, over the extent of the work to be carried out. The Bidder should note that nothing extra whatsoever on account of variation between soil data collected by Owner and that found by the Bidder during geotechnical investigation by him or during execution of works, shall be Payable.**

#### **Foundation System**

The requirements for the foundation system to be adopted are as given in specification. Depending upon the depth of competent strata/stratum, type of structures, functional requirement of facility, extent of cutting / filling, suitable open or pile foundation shall be adopted with approval of owner.

#### **General Requirements**

- a) All structures/equipment shall be supported on suitable open foundations (isolated, combined, raft) or pile foundations depending on type of structures/facilities, substrata, topography etc.
- b) The roads, ground floor slabs, trenches, pipe pedestals (except thrust blocks), channels/drains and staircase foundation with foundation loading intensity less than 4 T / M2 may be supported on open / shallow foundations resting on virgin / controlled compacted filled up soil.
- c) No other foundation (other than as mentioned in (b) above and (i) below) shall rest on the filled up ground / soil.
- d) No foundation shall rest on the black cotton soil.
- e) Before execution of work, the bidder shall ensure that there is no obstruction to underground/overground facilities like sewer lines, pipe lines etc. Any such damage and remedial/ rectification measures shall be at the Bidders cost.
- f) Bidder shall also ensure that there is no damage to existing nearby foundations and the foundations pertaining to this package are not placed at shallower depth than the nearby foundations. If required depth of foundation is deeper than the existing foundations, proper protection shall be provided to existing foundations. **If required bidder may carry out GPR survey to locate existing underground facilities at no extra cost to owner.**
- g) All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian Standards.
- h) The water table for design purpose shall be considered at Finished Ground Level.

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- i) A combination of open and pile foundations shall not be permitted under the same equipment / structure / building.

- j) Foundation for equipment's on ground floor

For equipment's of static weight upto 1.5 T, the equipment may be supported on the ground floor slab by locally thickening the slab. Thickening of the ground floor slab shall be done upto an extent of about 0.6 m beyond the plan area of the equipment on all the sides. Further, the load intensity below the equipment shall be limited to 4T/m<sup>2</sup>. Other requirements of floor slab and compaction below the floor slab shall be adhered, as specified elsewhere in the specifications.

For equipment's of static weight between 1.5 T and 20 T, the equipment may be supported on compacted sand filling from Natural Ground Level (NGL) or excavation level of nearby footing whichever is deeper with the load intensity below the equipment limited to 4T/m<sup>2</sup>. The minimum depth of foundation is 1.0m below FFL. Other requirements of sand compaction below the foundation shall be adhered, as specified elsewhere in the specifications.

For equipment of static weight more than 20 T, the equipment foundation shall be taken to the founding level or shall be built up with PCC from the level as mentioned in the Table 1. The pedestal of equipment foundation or the foundation Block shall be isolated from the adjoining floor slab by providing bitumen impregnated fiber board of minimum 50 mm thick, conforming to IS: 1838 all around the equipment pedestal for the full depth of the floor slab.

#### Open Foundations

In case open foundations are adopted, following shall be adhered to.

- The minimum width of foundation shall be 1.0 m.
- The minimum founding level shall be 1.0m below Finished ground level (FGL) or, 1.0m below Natural ground level (NGL) whichever is lower.  
For meeting the bearing capacity and /or functional requirement lower depth to be adopted based on requirement.
- It shall be ensured that all foundations of a particular structure/ buildings/ facility shall rest on one bearing stratum.
- Wherever the intended bearing sub-strata is virgin soil stratum but the actual stratum encountered during foundation excavation consists of filled up soil at founding level, under such cases either the foundation shall be lowered completely into the virgin stratum or the filled up soil upto the virgin layers shall be removed and built up through PCC (1:4:8) up to designed foundation level.
- The last layer of about 300 mm before reaching the founding level shall be excavated carefully by such equipment so that soil at the required level will be left in its natural condition.
- Wherever the new facilities (excluding roads, ground floor slabs, trenches, pipe pedestals, channels/drains and staircase foundation) are to be constructed after dismantling existing facilities; it is to be ensured that the new foundations shall be taken at least 1m below the existing founding depth of the dismantled structures.

**PILE FOUNDATIONS – In case piles are adopted, following shall be adhered to:**



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- i) The pile foundation shall be of RCC, Cast-in-situ bored piles as per IS:2911. Pile boring shall be done using Rotary Hydraulic Rigs/conventional tripod rig. Two stage flushing of pile bore shall be ensured by airlift technique duly approved by the BHEL/End customer .  
If required, temporary or permanent MS liner may be provided for piling.
- ii) The allowable load capacity of the pile in different modes (vertical compression, lateral and pullout) shall be least of the two values i.e. as per the values furnished in following table and pile capacity achieved in pile load tests:

Pile	Dia. (mm)	Minimum Length of Bored Pile Below Cut-off Level (m)	Vertical compression capacity (T)	Uplift capacity (T)	Lateral capacity (T)
Bored cast-insitu pile	600	26	100	40	4.0
	760	26	150	70	7.0

Cut off Level (COL) is assumed at 2.0 m below FGL.

- iii) Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.
- iv) The Bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, pile load test arrangement, locations of initial test piles etc.) for Engineer's approval.
- v) The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Bidder for Engineer's approval.
- vi) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical

Lateral

Minimum of 1 Nos. in each mode.

Uplift

- vii) The initial pile load test shall be conducted with test load three times the estimated pile capacity. In case of vertical compression test (initial test) the method of loading shall be cyclic as per IS:2911 (relevant part).



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- viii) Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable dewatering methods. Alternatively, the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter.
- ix) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under:
- i) Vertical : 0.5% of the total number of piles provided.
  - ii) Lateral : 0.5% of the total number of piles provided.
- x) The routine tests on piles shall be conducted with test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the BHEL/End customer .
- xi) In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Bidder shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.
- xii) Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Bidder shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.
- xiii) The test load on initial and routine test piles shall be applied by means of reaction from anchor piles / rock anchors alone or kentledge with concrete blocks alone or combination of anchor piles / rock anchors and kentledge with concrete blocks.

Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency to be approved by Engineering department of Owner. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM.

- xv) High Strain Dynamic Load Test may be carried out for routine vertical load test of working piles. However, at least three numbers of static routine vertical load tests shall be carried out on pile on which high strain dynamic load test has already been carried out for establishing the correlation between the two tests. In case of discrepancy if any between dynamic and static vertical load tests, then additional static routine vertical load tests shall be conducted as decided by the Engineer and the results of static routine vertical load shall prevail. Number of routine vertical pile load tests shall be as per specification. (ix) shall be total of static routine vertical load test and high strain dynamic load tests.

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The procedure to carry out the test shall be submitted to the Engineer. The test and equipment shall conform to ASTM D4945-00. The test shall be conducted by an experienced independent test agency approved by the owner. Field data shall be submitted to the site engineer and shall include force velocity curves, pile capacity, simulated static load test curve, net and total pile displacement, pile integrity. A (Case pile wave analysis) CAPWAP or equivalent software analysis shall be conducted on the field data for correct capacity estimation and to evaluate end bearing and skin friction components of the pile.

- xvi) From load considerations, single pile may be used under a column/tower. In that case, pile shall be connected with tie beams at pile cut off level in both directions.
- xvii) Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.
- xviii) Reinforcement for job piles shall be designed as following:
  - (a) Compression + bending piles: For these piles, the allowable safe pile capacities in compression and bending shall be considered.
  - (b) Tension + bending piles: For these piles, the actual pile forces to be considered. However, maximum 3 types of combinations for varying percentage of tension capacity + bending case may be designed & adopted by Bidder for the entire scope of work under this package.


#### **Excavation, Filling and Dewatering**

For excavation works, comprehensive dewatering with well point or deep wells arrangement, if required, shall be adopted. Scheme for dewatering and design with all computations and back up data for dewatering shall be submitted for the owner's information. The water table shall be maintained at 0.5m below the founding depth.

Excavation for shallow foundations shall be covered with PCC immediately after reaching the founding level. In case of any local loosening of soil or any loose pockets are encountered at founding level during excavation the same shall be removed and compensated by PCC M7.5. The final layer of about 300 mm thickness above the founding level shall be excavated by suitable means, so as to avoid disturbance to founding stratum.

Backfilling around foundations, pipes, trenches, sumps, pits, plinths, etc. shall be carried out with approved material in layers not exceeding 300 mm compacted thickness (higher thickness of layers upto 500mm with heavy mechanical compacting equipment) and each layer shall be compacted to 90% of standard proctor density for cohesive soils and to 80% of relative density for non cohesive soils. Founding level for trenches/channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches / channels.

CBR tests for pavement/road design shall be carried out by the Bidder after earth filling (if applicable) has been completed upto the formation level.

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The Bidder shall take all necessary measures during excavation to prevent the hazards of falling or sliding of material or article from any bank or side of such excavation which is more than one and a half meter above the footing by providing adequate piling, shoring, bracing etc. against such bank or sides.

Adequate and suitable warning signs shall be put up at conspicuous places at the excavation work to prevent any persons or vehicles falling into the excavation trench. No worker should be allowed to work where he may be stuck or endangered by excavation machinery or collapse of excavations or trenches.

#### Sheeting & Shoring

The Bidder shall ascertain for himself the nature of materials to be excavated and difficulties, if any, likely to be encountered in excavation while executing the work. Sheet piling, sheeting and shoring, bracing and maintaining suitable slopes, drainage, etc. shall be provided and installed by the Bidder, to the satisfaction of the Engineer.

For excavation depth upto 6.0 m from FGL, Bidder shall make arrangements like shoring, strutting or any other method duly approved by the Engineer to retain the sides of excavated area. Bidder may also use sheet piling to protect the sides of excavated area if he so desires. For excavation 6 metres below FGL, sheet piling shall be provided. The design of the sheet pile shall be done by Bidder as per relevant IS codes. The Bidder shall submit the design of sheet piling for Engineers information

#### Ground Improvement below structures/facilities using stone columns:

i) The work broadly involves installation of stone columns for mitigation of liquefaction hazard, improvement in bearing capacity of the soil and to bring down the residual settlements so that the facilities that may be constructed over the stone column area shall stand safely and perform satisfactorily throughout their lifetime. The stone columns shall be installed using bottom feed Vibroflotation techniques **without water jetting** i.e. dry method (displacement method) in accordance with these specifications.

The bidder shall submit the construction methodology giving information regarding details of equipment, type and energy rating of vibratory probe, details of power output, compaction criteria etc.


The parameters shall be so chosen to give stone column of specified diameter and load carrying capacity.

The quantity of stones shall be placed in such that the column is filled in stages of height not exceeding 1m. Each stage shall be compacted to ensure uniform consumption of stones throughout the depth.

The method of placement of stone shall be such that it is possible to measure the total consumption of stones in a column.

ii) All materials and workmanship shall be in accordance with this specification and



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IS: 15284: Part 1: 2003. “Design and Construction for Ground Improvement – Guidelines, Part 1 Stone Columns”.

iii) Ground improvement without piling provision after it Dia of column (d) = 500mm/600mm/760mm/800mm Spacing = 2.75d (Triangular pattern), where d=dia of column  
Depth of stone column shall be 13m below EGL

iv) Ground improvement with stone column shall be carried out minimum d/2 distance beyond the footprint of buildings(minimum 2 rows beyond the building footprint), where d is the depth of improvement. The ground improvement shall be carried out below the entire building/structure rather than restricting it to just below the foundations.

v) Initial load tests shall be performed at the trial site as identified by Engineer to evaluate load settlement behaviour of the stone columns. These tests shall be conducted on a single as well as on a group of three columns. Load testing procedure, equipment and interpretation shall confirm to IS 15284 (Part-I).

vi) Fill material for stone columns shall comprise of stones. The individual particles should be clean, chemically inert, hard and resistant to breakage. Well graded stones of size from 75mm down to 12mm with not more than 5% fines passing 12mm sieve shall be used. The uniformity coefficient shall be greater than 5.

vii) A sand / granular blanket of 500mm compacted thickness shall be laid over the top of exposed stone columns. The blanket shall spread over the entire area of treatment cleaned off muck, slush etc. The blanket shall be laid in layers of 250mm (maximum compacted thickness) and compacted to 85% relative density. Sand/gravel blanket of minimum of 1.0 m beyond the outer edge of the stone columns shall be ensured

For Sand/gravel blanket, the sand shall be coarse to medium sand free from shingle, salts, organic matter etc. In case of gravel, fines less than 75 microns shall not be more than 20%.

vii) Boreholes shall be drilled prior and after the installation of stone columns and frequency shall be minimum 1 borehole under each structure/facility or 2000 Sqm whichever is less. The performance of the stone column(s) shall be considered acceptable and approved by the Engineer based on the SPT ‘N’ values of the improved ground.


The minimum load intensity after ground improvement shall be as mentioned.

#### **Ground Improvement below roads, drains and Pipe pedestal:**

**Minimum 1000mm thick compacted moorum/Non-Expansive Soil shall be provided replacing existing ash/soil below and 1000mm from the outer edges of the roads & drains.**

**Geotechnical investigation work shall be got executed by the Bidder**



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## 32a.FOUNDATION SYSTEM

### Factor of safety:

- The factor of safety for the design of members for switchyard structures shall be considered as 1.5 for normal condition and 1.2 for short circuit condition.

### Design consideration for Equipment support:


- The supporting structure for B.P.I., LA, CVT and Isolator equipment's shall be comprised of GI (ERW) pipe of grade YST:210 or of higher grade conforming to IS: 1161 & shall be designed as per IS:806
- Minimum diameter of the pipe type support for 400kV structure shall be 250NB, for 220kV & 132kV structures shall be 200NB and that for 66kV & 33kV shall be 150 NB.
- The supporting structure for CT, CSE & Wave Trap equipment shall comprise of lattice structural steel conforming to IS 2062 and shall be designed as per IS: 802.
- Common raft foundation shall be provided for each pole of isolator.

### Special design consideration for Lightning Mast:

- Diagonal wind condition shall be considered for Lightning Mast. Diagonal wind shall be taken as 1.2 times the wind calculated on longitudinal/transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and an external cage ladder for climbing purpose shall be provided up to the platforms. Top of platform shall have grating, railing and two guard plates. The minimum width of platform shall be 900mm.
- Live load of 300kg/m<sup>2</sup> above platforms shall be considered for design of Lightning Mast.
- The fabrication and erection of the switchyard works shall be carried out generally in accordance with IS: 802 and IS: 800. All materials shall be completely shop fabricated and galvanized.
- Minimum Thickness of Members & Galvanization**
- All steel work used in construction of switchyard structures such as Towers & Beams, Lightning mast and equipment supporting structures including nuts, bolts and washers shall be galvanized.
- Minimum section thickness shall not be less than 4 mm. Weight of zinc coating shall be at least 0.610 kg/m<sup>2</sup> and foundation bolts shall have heavier zinc coating of at least 0.80 kg/m<sup>2</sup>, for C3 category and at least 0.900kg/m<sup>2</sup> of C5 category.

### Design consideration for Foundation

- The F.O.S. for foundation shall be 1.5 in both Normal and Short circuit condition.
- Factor of Safety for stability of tower and equipment foundation will as per IS 1904.


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#### **TRANSFORMER/REACTOR FOUNDATIONS**

- Foundations of transformers/reactors shall be designed for seismic, and wind loads in addition to other applicable load. Block foundations shall be provided for the main transformer block. Alternatively, transformer shall be supported on a RCC foundation comprising of common raft for rail supporting walls up to rail-cum-road along with pedestals for jacking pad, roller lock etc. Tie beams connecting roller lock pedestals at rail level shall also be provided. Common raft/solid RCC block shall be supported on soil or pile based on requirement specified elsewhere in the specification.
- The oil soak pit, if provided, shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer/ reactor along with 10 minutes of fire water considering only 40% the volume as available voids between gravel filling. However, in case a separate oil collection tank is provided for the transformer/reactor, oil soak pit of volume equivalent to one-third (1/3) the oil volume of transformer/reactor shall be provided around transformer/reactor. The oil collection tank, in such cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. The oil soak pit shall also be provided with a sump at the corner to allow drainage of water/oil from the soak pit.
- For calculating effective capacity of oil-water separation pit, effective depth excluding 200 mm freeboard below invert level of inlet pipe shall be considered. Plan area and depth of oil-water separation pit shall be decided based on above consideration. Oilwater Separation pit shall be provided with five separate chambers interconnected by pipes. First chamber shall be for collecting oil-water mix from transformers' soak pits in case of fire. After entering into first chamber, oil being the lighter in density floats above the water. The water from lower elevation flows into subsequent chambers interconnected through galvanized MS pipes. The accumulated oil in the first chamber to be pumped out for subsequent usage or disposal. Water collected in the last chamber to be pumped out for subsequent disposal after treatment. Invert level of inlet Hume pipes (of NP-3 grade and adequate capacity), carrying oil and water from transformers soak pits, shall be designed for gravity flow. Freeboard of 200 mm shall be provided below the invert level of inlet pipes. Invert levels of interconnecting pipes of subsequent chambers shall be decided accordingly.
- Arrangement for moving the transformer into place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer/reactor foundations.
- RCC Firewall shall also be provided between the transformers wherever required.
- 300 mm thick PCC M20 encasement all around the Pylon supports inside soak pit for firefighting system shall be provided up to top of gravel filling. However, the supply and erection of Pylon supports with anchor fasteners for HVW spray system are not under the scope of this package. Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

#### **PCC LAYER AND GRAVEL FILLING (IF APPLICABLE)**

- PCC Layer of and Gravel filling shall be provided as specified elsewhere in the specifications. Before laying of PCC layer, the subgrade shall be properly compacted, and the top layer of the soil shall be

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treated for anti-weed considering the type of weeds found in the vicinity. The anti-weed - soil sterilization details such as manufacturer's name, their specification, test certificate, etc. shall be furnished for Owner's approval. Any modification if required in the proposed anti-weed treatment chemical shall have to be done by the Bidder at no extra cost to the Owner. The Bidder shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall be commenced from the date of completion of work or date of handing over, whichever is later. Stone/gravel shall be chemically inert, hard, strong durable against weathering, of limited porosity and free from deleterious materials. It shall be properly graded and shall meet the requirements of IS: 383.

#### **CABLE TRENCHES**

- Cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches shall project at least 300 mm above the finished formation level so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits. The precast covers shall not be more than 300mm in width and shall not be more than 65 kg. Lifting hooks shall be provided in the precast covers. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided on the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. All cable trenches shall be provided with suitable insert plates for fixing support angles of cable trays. All internal cable trenches shall have minimum 6mm thick (o/p) chequered plate covers while external cable trenches shall have pre - cast RCC covers. However, the portion of the cable trench behind and sides of control panel / MCC shall be provided with suitable chequered plate covers as directed by the Engineer. Cable trenches inside switchyard, having depth more than 500mm, shall have wall thickness of minimum 150mm with two-layer reinforcement.

#### **STORM DRAINS**

Open RCC storm water drains shall be provided on both sides of the paving and inside BESS area for proper drainage. All drains shall be designed for maximum runoff velocity of 1.8 m/sec. The thickness of side wall and bottom slab of RCC drains shall be minimum 150 mm or as per design considerations whichever is higher for drains upto depth of 1m from formation level. For depth of drain more than 1m from formation level, the thickness of side walls and bottom slab of RCC drains shall be minimum 200mm or as per design considerations whichever is higher. RCC pipe culvert shall be provided for road, rail and trench crossings.

#### **RAIL TRACK CUM ROAD**

- Arrangement for moving the transformer into place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer/reactor foundations.



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- Jacking points shall be provided at all the intersections of Rail Tracks with minimum 300mm x 300mm x 16mm thick MS Plates.
- Mooring posts shall be provided along centre line of Rail tracks at maximum interval of 15m spacing.
- Rail track cum road shall consist of minimum 500mm thick RCC M25/M35 base slab over an under bed as specified below. The under bed for base slab shall consist of 75mm thick PCC of M 7.5 grade on stone soling of 230mm compacted thick with 63 mm and down aggregate with interstices filled with well graded selected sand/ moorum/ non-expansive soil on compacted and dressed sub - grade. Reinforcement for the slab shall consist of minimum 16mm diameter bars @ 200 mm c/c at bottom of the slab in both directions and minimum 12mm diameter bars @ 200 mm c/c at middle and top in both directions.
- The rails shall be 52 kg/m Industrial Use (IU) as per Indian Railway Specification IRS T-12.
- Width of Rail track cum road with three rails and two rails shall be 5.0M and 3.5M respectively.

**CHAIN LINK FENCING**

- Fencing with gate shall be provided around areas wherever necessary due to security, safety, and statutory requirements as per following specifications.
- The fencing, with gate (unless specified otherwise) shall comprise of PVC coated G.I. welded wire mesh fencing of minimum 4 mm diameter (including PVC coating) of mesh size 75mmX75mm of height 2.4m above the toe wall with a 600mm high galvanised concertina at the top such that total fence height of 3 mt above the tow wall is achieved. The diameter of the the steel wire for chain link fence (excluding PVC coating) shall not be less than 2.5 mm
- The PVC coated chain link will be stretched by the clips at 0.5m intervals to three strands of galvanised high tensile spring steel wire (HTSSW) of 2.5 mm diameter interwoven with chain link wire mesh and kept under tension which in turn are attached to the fence post with security nuts and bolts. On very fourth post a clamping strip will be threaded through the links of chain link and bolted to the fence post with the help of security nuts and bolts.
- Above the chain link a 600 mm high tensile serrated galvanized wire (HTSW) concertina made with wire diameter of 2.5 mm will be stretched to 6 m and attached to two strands of galvanized HTSSW of 2.5 mm diameter by means of clips at 1 m intervals. These two HTSSW strand will be attached to the fence posts with 12mm security fasteners.
- All nuts, bolts, fasteners, clamping strips, clamps ,clips.etc shall be galvanized..
- All fence posts shall be of 75 x 75 x 6 MS angles spaced at 2.5m c/c distance. All corner posts will have two stay posts and every tenth post will have transverse stay post. Suitable R.C.C. foundations for the post and stays shall be provided based on the prevailing soil conditions. All posts of fencing shall be painted with chlorinated rubber paint over a suitable primer.
- Toe walls either of brick masonry with bricks of minimum 50 kg./sq.cm. Crushing strength or of hollow concrete block masonry shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200mm above the formation level with 50mm thick P.C.C. coping (1:2:4) and shall extend minimum 300mm below the formation level. Toe wall shall be plastered with cement sand mortar (1:6) on both sides and shall be painted with two

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coats of textured cement point of approved colour and shade. Toe wall shall be provided with weep holes at appropriate spacing.

#### **GATE ALONG FENCING**

- All gates shall be of structural steel of minimum 6 metre width. The height of gate shall be same as that of the fence unless noted otherwise.
- The gate frame and post shall be fabricated from medium class MS pipe of nominal diameter not less than 75 mm. The panel plate shall be of minimum thickness 2.5 mm conforming to IS: 513. The gate shall be complete with fabricated hinges, MS aldrops with locking arrangement, tempered steel pivot, guide track of MS tee, bronze aluminium ball bearing arrangement, castor wheel, etc.
- The gate frame and post shall be fabricated from medium class MS pipe of nominal diameter not less than 75 mm. The panel plate shall be of minimum thickness 2.5 mm conforming to IS: 513.
- The gate shall be complete with fabricated hinges, MS aldrops with locking arrangement, tempered steel pivot, guide track of MS tee, bronze aluminium ball bearing arrangement, castor wheel, etc.

#### **PRE-CAST BOUNDARY WALL**

- A pre-cast boundary wall all around the BESS wherever required shall be provided. The total height of boundary wall shall be 3600mm above formation level (natural ground level in case formation level is less than natural ground level). Upto height of 3000mm it shall be constructed with precast reinforced cement concrete panels / cast in situ RCC panels and over that for 600mm concertina coil with maximum loop spacing of 125mm shall be provided with Y-shaped MS angle. The RCC precast/cast in situ reinforced concrete columns shall be provided at spacing not more than 2500mm centre to centre.
- The RCC precast/cast in situ reinforced concrete columns and footing shall be minimum 1500mm below finished formation level with suitable foundation designed for horizontal and vertical loads. The precast reinforced concrete panels/ cast in situ RCC panels shall be at least 600mm below formation level. The RCC precast concrete columns/ cast in situ RCC panels of minimum size 300mmX350mm shall be provided with two grooves of minimum size 115mmX50mm, so as to receive Precast Concrete RCC panels spanning from column to column with minimum width of 600mm and minimum thickness of 100mm as filler wall. The grade of concrete for all precast/cast in situ work shall be of M30 grade conforming to IS 456.
- The boundary wall shall be designed as per relevant IS codes and as per standard practices. The same shall be submitted to Owner for approval at the time of detailed engineering, The architecture of boundary wall shall be finalized in consultation with Owner. The precast/ cast in situ reinforced cement concrete coping with minimum projections of 150mm on each side shall be provided at the top of the precast reinforced cement concrete panels / cast in situ RCC panels with suitable provision

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for MS angle Post for concertina throughout the boundary wall. Opening for gates/drains and for other crossing shall be suitably provided as per the requirement.

- All exposed concrete surfaces of all precast members/ cast in situ RCC members have high quality shuttering finish with tolerance of +/- 5mm. Plinth protection of 150mm thickness PCC (M20) shall be provided on both side of boundary wall extending upto 300mm from centre line of boundary wall. High quality shuttering to be approved by Owner.

#### • AREA PAVING

RCC paving of minimum 150 mm thick with M25/M35 grade concrete, over an under bed as specified herein shall be provided for areas mentioned below. RCC paving shall be designed as rigid reinforced concrete pavement for the crane/ vehicular/ equipment movement loads which the paving has to bear. The under bed for paving shall consist of preparation and consolidation of sub-grade to the required level, laying of stone soling of 200mm compacted thickness for normal duty paving and 400mm compacted thickness for heavy duty paving with 63 mm and down aggregate with interstices filled with selected moorum/ non-expansive soil followed by 75 mm thick M 7.5 grade of PCC. For normal duty paving, reinforcement of the RCC paving shall consist of minimum 8mm diameter bars @ 200 mm c / c in both directions at the centre of the slab. For heavy duty paving/ passage, reinforcement of the RCC paving shall consist of minimum 10mm diameter bars @ 200 mm c / c in both directions at the centre of the slab.

Suitable open RCC drains shall be provided to dispose off storm water drain. The paving shall be provided with slope of 1:500 to dispose the surface water/wash water to the nearest storm water drain. **The paved area of the BESS plant shall be connected to the nearest available plant road through a heavy-duty approach pathway with a width of 7 meters, incorporating a suitable turning radius at junction points to ensure smooth vehicular movement. The scope also includes the construction of a culvert over any existing drain encountered along the pathway alignment.**


**At road or drain crossings, provide NP3-class hume pipes at a minimum soil cushion of 1100mm below the finished ground level (FGL) for cable routing.**

#### GROUND FLOOR SLAB OF BUILDINGS

In all buildings, the ground floor slab shall consist of minimum 150mm thick RCC M25/M35 grade base slab over an under bed as specified below. The under bed for ground floor slab shall consist of 75mm thick M 7.5 grade PCC on stone soling of 200mm compacted thick with 63 mm and down aggregate with interstices filled with well graded selected sand/ moorum/ non-expansive soil on compacted and dressed sub - grade. Reinforcement for the slab shall consist of minimum 8mm diameter bars @ 200 mm c/c at top & bottom of the slab in both directions. However, at passages, unloading & maintenance bays, stone soiling of minimum 400mm thick and minimum 10mm diameter bars @ 200 mm c/c at top and bottom in both directions shall be provided.

#### CORROSION PROTECTION MEASURES

All structural steel and RCC members/ structures shall have to be provided with corrosion protection treatment unless specified otherwise.

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## Structural Steel Corrosion protection

### i) General

- All Steel structures shall be provided with painting system as mentioned below in this specification for the Corrosivity category mentioned in Part A.

Painting system for steel surfaces embedded in Concrete is given separately.

- All Painting shall be done as per Technical Specification Painting scheme shall submitted by the Bidder.
- All steel structures shall be designed by following basic design considerations in ISO 12944 Part 3. Where steel is fully accessible for cleaning and repainting and where it is feasible to follow design criteria given in ISO 12944 part 3, minimum thicknesses of structural members shall be:

Structural Sections	Minimum thickness	Minimum Flange thickness	Minimum Web thickness
Plates	6		
Built up Sections		6	6
Angle sections	6		
ISMB /ISMC		6	4.5
NPB/ WPB		6	4.5
RHS/SHS/ Tubular Sections	4		
All dimensions in mm			


Where steel surfaces are inaccessible for cleaning and repainting (such as backto-back sections, lap joints etc.) or where it is not feasible to follow design criteria given in ISO 12944 part 3, corrosion allowance of 1.5 mm shall be kept in thickness (over the design thickness or minimum thickness specified above, whichever is more). The minimum thickness consideration shall apply for both web and flange.

However minimum gusset plate thicknesses shall be followed as mentioned elsewhere in the specification and minimum angle section to be used is ISA 50x50x6. Ends of tubular sections to be effectively sealed at both ends. Also, tubular handrail thicknesses will be as governed shall be as per specification.

Minimum thickness of tubular/ hollow steel sections conforming to IS 4923 shall be 4.0 mm, provided the ends of such steel sections are effectively sealed unless higher thickness is specified elsewhere for specific structure.

### ii) Painting of Steel Surfaces embedded in Concrete

- For the portion of Steel surfaces embedded in Concrete, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of Chlorinated Rubber based Zinc Phosphate Primer of Minimum 50 Micron Dry Film Thickness (DFT).

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- b) All threaded and other surfaces of foundation bolts and its materials, insulation pins, Anchor channels, sleeves, etc. shall be coated with temporary rust preventive fluid and during execution of civil works, the dried film of coating shall be removed using organic solvents **iii) Painting of Steel Surfaces (Other Than Those Embedded In Concrete)**

Following painting system corresponding to corrosion category as mentioned in Part I Civil Works of this specifications shall be adopted for the project.





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CORROSSIVITY CATEGORY(as per ISO 12944-2)	PRIMER COAT	INTERMEDIATE COAT	FINAL COAT
C3	All steel surfaces shall be provided with two component moisture curing zinc (ethyl) silicate primer coat (having minimum 80% of metallic Zinc content in dry film, solid by volume minimum 60% $\pm 2\%$ ) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2 $\frac{1}{2}$ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique. Zinc dust composition and properties shall be Type-II as per ASTM D520-00.	Primer coat shall be followed with the application of Intermediate coat of two component polyamide cured epoxy with MIO Content (containing lamellar MIO minimum 30% on pigment, solid by volume minimum 80% $\pm 2\%$ ) of minimum 100 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.	Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% $\pm 2\%$ ) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 $\Delta E$ ) and minimum 70 micron DFT. This coat shall be applied shop after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.



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C5	<p>All steel surfaces shall be provided with two component moisture curing zinc (ethyl) silicate primer coat (having minimum 80% of metallic Zinc content in dry film, solid by volume minimum 60% <math>\pm 2\%</math>) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2 ½ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique. Zinc dust composition and properties shall be Type-II as per ASTM D520-00.</p>	<p>Primer coat shall be followed with the application of Intermediate coat of two component polyamide cured epoxy with MIO Content (containing lamellar MIO minimum 30% on pigment, solid by volume minimum 80% <math>\pm 2\%</math>) of minimum 180 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.</p>	<p>Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% <math>\pm 2\%</math>) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 <math>\Delta E</math>) and minimum 70 micron DFT. This coat shall be applied shop after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.</p>
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**Notes:**

1. For Primer, high quality surface preparation is necessary and good amount of moisture is required for proper curing. Below 70 % relative humidity, curing time may go up to 7 days or more. In such a case additional water sprinkling may be ensured for completion of curing. Additionally Inorganic Zinc silicate cannot be recoated, even with itself. Typically, it should be used when coating bare steel surface for the first time.
2. The most frequent problem associated when top coating Primer is bubbling/ pin holing especially with non-weathered zinc silicate coatings. To great extent, this bubbling of finish paint can be

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eliminated by applying a mist coat of intermediate/topcoat as the first pass of the product, allow the bubbles to subside and then apply a full coat, as required.

3. In case top coating of zinc silicate with epoxy/polyurethane coatings, is expected to be delayed, it is advisable to use a suitable tie coat to avoid formation of white rust. However, if white rust forms, then clean the surface with high pressure water, dry and apply the subsequent coat as required.
4. Touch up paintings on damaged areas: Surface preparation by manual tools, wire brush/ emery paper etc. Minimum 6 inches peripheral area, adjoining to damaged area to be covered. If metal surface is exposed, it is to be painted with Zinc rich epoxy (70 micron) or suitable primer with existing paint scheme. If primer is intact, intermediate & topcoat to be done with specified DFT in scheme.

**iv) Coating for Mild Steel parts in contact with Water.**

- a) All mild Steel parts coming in contact with water or water vapour shall be hot dip galvanised. The Minimum Coating of Zinc shall be 610 g/ Sq.m for C3 category (C5 category 900 gms/sqm) for galvanised Structures and shall comply with IS: 4759 and other relevant Codes. Galvanising shall be checked and tested in accordance with IS: 2629.
- b) The galvanising shall be followed by the application of an etching Primer and dipping in black bitumen in accordance with BS: 3416, unless otherwise specified.

**v) Gratings**

All gratings shall be blast cleaned to Sa 2 ½ finish or cleaned by acid pickling as per ISO 8501-1 and shall be hot dip galvanized at the rate of 610 gm/sqm for C3 category 900gm/sqm for C5 category.

**vi) Hand Railings and Ladders**

All handrails and ladders shall be galvanised at the rate of 610 gms / Sq.M for C3 and 900gm/sqm for C5 category as per IS: 4736.


**RCC Members (Superstructure)**

The following preventive measures are required to be adopted by the bidder as minimum requirement.

**For Indoor/Outdoor(exposed) RCC Members**

- a) Dense and durable concrete is to be used. Minimum grade of concrete shall be M35.
- b) Water/ cement ratio shall generally be restricted to 0.5. Plasticizer, if required may be used.

**RCC Members (Underground Sub-Soil Condition)**


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The type of corrosion protection measures for concrete reinforcement steel and structural steel for underground structures/ facilities shall be as specified elsewhere in specification.

All foundations and surfaces of substructures coming in contact with earth shall be applied with Minimum two coats of hot bitumen of Industrial grade V30, conforming to IS: 702 (latest), mixed with 1% anti-stripping compound at the rate 1.7 Kg/Sq.m (for sum of all coats). In addition Water/ cement ratio shall generally be restricted to 0.45.

#### MISCELLANEOUS SPECIFICATIONS

- In design of all buildings fire safety requirements conforming to IS: 1641 and IS: 1642 shall be followed in addition to TAC requirements. The height of RCC fire protection wall between transformers shall be as per system requirement.
- MS Angles 75 x 75 x 6 mm (minimum) with MS lugs of 8mm diameter and 150mm long @ 150 c/c shall be provided for edge protection all around cut outs/openings in floor slabs. Angles 50 x 50 x 6mm with effective anchor lugs shall be provided for edges of concrete drains supporting grating/covers, edges of RCC cable / pipe trenches, supporting cover slabs / chequered plates/ grating, edges of manholes supporting covers, supporting edges of precast RCC covers and any other place where breakage of corners of concrete is expected.
- Grouting of all pockets, blockouts, sleeves and the openings around the embedment, inserts, bolts etc. and under pinning below the base / sole plate shall be with non - shrink flowable grout. Grade of grout shall be one grade higher than concrete. However minimum grade of grout shall be M - 30.
- Peripheral drains by side of plinth protection around building shall have perforated precast RCC covers of minimum 50mm thickness with provision of openable steel grating cover at about 4.0m interval. In areas where vehicular loads would be coming precast RCC covers of suitable thickness without perforations and designed for the vehicular loading shall be provided.
- Anti termite constructional measures and chemical treatment shall be given to all areas susceptible to termite including column pits, wall trenches, foundations of buildings, filling below the floors etc. as per IS: 6313 and other relevant Indian Standards.
- Wherever possible minimum 1000 mm high hand railing shall be provided around all floor/ roof openings, projections/ balconies, platforms, walkways etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) conforming to IS: 1161 and shall be galvanized as per IS: 4736 and IS: 1239. All rungs and ladders shall also be galvanized.
- Duct banks consisting of PVC conduits conforming to IS 4985 for cables shall be provided with proper sealing arrangement consisting of fire retardant sealing compound.
- The building auxiliary services like air conditioning and ventilation systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements specified in relevant section or elsewhere in this Specification.
- The building lighting shall be designed in accordance with the requirements of relevant section. All electrical conduits in building shall be concealed type.
- Plywood formwork shall be used for all concrete works

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- Design, construction and joints of all the structures shall be as per relevant Indian Standard Codes unless specified otherwise.
- All foundation embedments, inserts, blockouts required for mounting of equipment and supporting any other facility like pipes etc. shall be provided.
- All internal cable trenches shall have minimum 6mm thick (o / p) chequered plate covers while external cable trenches shall have pre - cast RCC covers. However, the portion of the cable trench behind and sides of control panel / MCC shall be provided with suitable chequered plate covers as directed by the Engineer.
- Earthing mat shall be provided around buildings and structures as per specifications / approved drawings.
- Detailed scheme for dewatering shall be prepared before starting of deep excavation work. IS: 9758 shall be followed as general guidance for dewatering.
- Broad gauge rail (52kg/m minimum) shall be used for rail tracks required for movement of Transformer if applicable.

#### **REQUIREMENTS FOR CONCRETE**

- Concrete work shall be of grade as per IS 456. Mix design concrete shall be used for all areas other than lean concrete work and plain cement concrete where nominal/volume mix can be permitted. Design mix shall be carried out as per IS10262. Specific approval of the Engineer shall be obtained regarding degree of quality control to be adopted for design mix . All Structural (reinforced)concreting shall be carried out using centralized batching plant, transit mixers and concrete pumps.
- Minimum grade of structural concrete shall be M25 unless otherwise noted.
- Blinding concrete below foundations, cable trenches shall be 75mm thick PCC of minimum grade M-7.5 and under brick foundations minimum 150mm thick PCC of minimum grade M-10.

#### For Project

- Minimum grade of concrete shall be M35.
- Coarse and fine aggregates shall be specially selected to ensure that they are not susceptible to alkali/ chloride attack or prone to disintegration at high temperatures. The maximum size of coarse aggregate shall not be larger than 1/8th of narrowest dimension between reinforcement bars nor more than 20 mm.
- The maximum water cement ratio by weight shall be 0.45 or 0.50 as specified elsewhere, including moisture in the aggregates, and slump should be suitably decided to provide good quality concrete work, as specified elsewhere in the specification.

Unless indicated otherwise the clear concrete cover for reinforcement shall be as per IS Codes.



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## MATERIALS

- Cement, Aggregates, Bricks, Water etc:
- Ordinary Portland Cement conforming to IS 269 or Fly ash based portland pozzolana cement conforming to IS: 1489 (Part-1) shall be used for all areas.
- For Foundation/ Substructure: Cement shall be Ordinary Portland Cement with C3A content from 5 to 8 percent / Portland slag cement confirming to IS 455 having more than 50% slag. Minimum cement content shall be 370 kg/m<sup>3</sup> and maximum free water-cement ratio shall be 0.45 for foundation works.
- Aggregates: Coarse aggregate shall meet the requirements of IS 383. Fine aggregate in concrete shall conform to IS 383.

Plastering: Outer face (i.e. rough side) of all brick walls shall have 18 mm thick and inner face (i.e. smooth side) of all walls shall have 12 mm thick cement sand plaster 1:6. Acrylic wall putty in two coats shall be applied over cement plastered surfaces in interior of building. The finish surface shall be smooth and shall be of 2 mm nominal thickness. All RCC ceilings (except areas provided with false ceiling, cable vault ceiling and metal decking) shall be provided with 6mm thick cement sand plaster 1:4. For plaster, it shall conform to IS 1542.

Masonry work shall conform to IS 2116. Brick work of at least class designation 5 shall be used. Fly ash bricks shall preferably be used in all construction.

Potable water shall generally be considered satisfactory for all masonry and concrete works, including curing.

### Reinforcement Steel

Reinforcement steel shall be of corrosion resistant grade high strength deformed TMT steel bars of grade Fe-415/ Fe-500/ Fe500D/ Fe550D and shall conform to IS 1786 and IS 13920. However, minimum elongation shall be


14.5%.

### Structural Steel

Structural Steel (including embedded Steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects. Structural steel shall comprise of mild steel, medium strength steel and high tensile steel as specified below.

#### Mild Steel

- Rolled sections shall be of grade designation E250, Quality A/BR, Semi-killed/ killed conforming to IS 2062. All steel plates shall be of Grade designation E250, Quality BR (fully killed), conforming to IS 2062 and shall be tested for impact resistance at room temperature. Plates beyond 12mm thickness and up to 40mm thickness shall be normalized rolled. Plates beyond 40mm thickness shall be vacuum degassed & furnace normalised and shall also be 100% ultrasonically tested as per ASTM – A578 level B-S2.
- Pipes shall conform to IS: 1161.
- Hollow (square and rectangular) steel sections shall be hot formed conforming to IS: 4923 and shall be of minimum Grade Yst 240. and minimum thickness shall be 4 mm

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- Chequered plate shall conform to IS 3502 and shall be minimum 6 mm thick excluding projection. Steel for chequered plate shall conform to grade E250A semi killed of IS: 2062 or equivalent grade conforming to ASTM & BS standards only.

#### **Medium and High Tensile Steel**

Rolled Sections and plates shall be of grade designation E350 or higher, Quality B0 (Fully killed), conforming to IS 2062. Plates beyond 12mm thickness and up to 40mm thickness shall be normalized rolled. Plates beyond 40mm thickness shall be vacuum degassed & furnace normalised and shall also be 100% ultrasonically tested as per ASTM –A578 level B-S2.

#### **Grating**

All gratings shall be electroforged types. Minimum thickness of the grating shall be 40 mm The opening size shall not be more than 30mmx100mm. The minimum thickness of the main bearing bar shall be 5 mm or as per design requirement whichever is higher. All gratings shall be hot dip galvanised at the rate of 610 g. per sq.m.(C5 category 900gm/sqm) after surface preparation by means of shot blasting or cleaned by acid pickling.

#### **Colour coated and other sheeting work**

##### Wall Cladding & Roofing Material

Troughed permanently colour coated sheet of approved shade and colour shall be:-

- Either of steel with minimum 0.6mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade Y250 as per IS 15961 / grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275(For C5 Category Z350) / aluminium-zinc alloy coating to class AZ150 (For C5 category AZ200)
- Or of minimum 0.5mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade Y350 as per IS15961/ grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275 (for C5 category Z350) / aluminium-zinc alloy coating to class AZ150( for C5 categoryAZ200 )
- Or of steel of minimum 0.4mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade Y550 as per IS 15961/ grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275(for C5 Category Z350) / aluminium-zinc alloy coating to class AZ150 (for C5 category AZ200).

Alternatively aluminium feed material of minimum bare metal thickness of 0.7 mm of aluminium alloy of Series 31000 and above as per IS 737 and IS 1254.

All materials brought for incorporation in works shall be of best quality as per IS unless specified otherwise.


#### **CODES AND STANDARDS**

All standards, specifications, acts and code of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of conflict between this specification and those (IS standards, codes etc.) referred to here - in, the former shall prevail.

Some of the relevant Indian standards, Acts and Codes are referred to here below:



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### **LIST OF CODES AND STANDARDS**

#### **Excavation and Filling**

IS :2720 Methods of test for soils(relevant parts) IS:4701 Code of practice for earth work on canals.

IS:9759 Guide lines for dewatering during construction.

IS:10379 Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.

#### **Properties, Storage and Handling of Common Building Materials**

IS:269 Ordinary Portland cement.

IS:383 Coarse and fine aggregates for concrete.

IS:432 Specification for mild steel and medium tensile steel bars and (Part 1&2)  
hard drawn steel wires for concrete reinforcement.

IS:455 Portland slag cement.

IS:702 Industrial bitumen.

IS:712 Specification for building limes.

IS:1077 Common burnt clay buidling bricks.

IS:1161 Steel tubes for structural purposes.

IS:1239 Mild steel tubes, tubulars and other wrought steel fillting - MS tubes.

IS:1363 Hexagon head bolts, screws and nuts of productions (Part 1-3) grade - C.

IS:1364 Hexagon head bolts, screws and nuts of productions (Part 1-5) grade-A & B.

IS:1367 Technical supply condition for threaded fasteners. (Part 1-18)

IS:1489 Portland-pozzolana cement. (Part-I) Fly ash based

IS:1542 Sand for Plaster.

IS:1566 Hard drawn steel wire fabric for concrete reinforcement.

IS:1786 High strength deformed steel bars & wires for concrete reinforcement.

IS:2062 Hot Rolled Low, Medium and High Tensile Structural Steel

IS:2116 Sand for masonry mortars.

IS : 2185 Hollow & solid concrete blocks.

(Part 1)

(Part 2) Hollow & solid light weight concrete blocks.

IS:2386 Testing of aggregates for concrete.

(Part I-VIII)

IS:3812 Specification for fly ash for use as pozzolona and admixture.

IS:4082 Recommendation on stacking and storage of construction materiel and components at site

IS:8112 43 grade ordinary portland cement.

IS:8500 Structural steel-Microalloyed (Medium and high strength qualities).

IS:12269 53 grade ordinary portland cement.

IS:12894 Specification for fly ash lime bricks.

IS:13757 Burnt clay fly ash building bricks.





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**Cast in-situ Concrete and Allied Works**

IS:280	Mild steel wire for general engineering purpose.
IS:456	Code of practice for plain and reinforcement concrete.
IS:457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS:516	Method of test for strength of concrete.
IS:1199	Methods of sampling and analysis of concrete.
IS:1791	General requirement for batch type concrete mixers.
IS:1834	Hot applied sealing compound for joints in concrete.
IS:1838	Preformed fillers for expansion joints in concrete pavement and structures.
IS:2438	Specification for roller pan mixers.
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:2505	Concrete vibrators - immersion type.
IS:2506	General requirements for screed board concrete vibrators.
IS:2722	Specification for Portable Swing weigh batchers for concrete (single and double bucket type).
IS:2750	Steel scaffoldings
IS:2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
IS:3366	Specification for pan vibrators.
IS:3370	Code of practice for concrete structures for the (Part 1-4) storage of liquids.
IS:3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS:4014	Code of practice for steel tubular scaffolding. (Part-1&2)
IS:4326	Code of practice for earth quake resistant design and construction of buildings.
IS:4656	Form vibrators for concrete.
IS:4925	Concrete batching and mixing plant.
IS:4990	Plywood for concrete shuttering work.
IS:4995	Criteria for design of reinforced concrete bins for storage of granular and powdery materials
IS:5256	Code of practice for sealing expansion joints in concrete lining on canals.
IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works.
IS:6461	Glossary of terms relating to cement concrete.
IS:6494	Code of practice for water proofing of underground reservoir and swimming pools.
IS:6509	Code of practice for installation of joints in concrete pavements.
IS:7861	Code of practice for extreme weather concreting.
(Part -1&2)	
IS:9012	Recommended practice for shotcreting.
IS:9103	Admixtures for concrete.
IS:9417	Recommendations for welding cold worked bars for reinforced concrete construction.
IS:10262	Recommended guidelines for concrete mix design.
IS:11384	Code of practice for composite construction in structural steel and concrete.
IS:12118	Two parts polysulphide based sealants.
IS:12200	Code of practice for provision of water stops at transverse construction joints in masonry and concrete dams.
IS:13311	Non destructive testing of concrete - methods of test.

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- (Part 1) Ultrasonic pulse velocity.  
(Part 2) Rebound hammer.

- SP-16 Design codes for reinforced concrete to IS:456-1978.  
SP-23 Hand book of concrete mixes.  
SP-24 Explanatory handbook on Indian standards code for plain and reinforced concrete.  
(IS : 456)  
SP-34 Hand book on concrete reinforcement and detailing.  
ACI-318 American Concrete Institute code for structural concrete.

#### **Precast Concrete Works**

- SP:7 National Building Code - Structural Design  
(Part 6/Sec.7) Prefabrication and system building and mixed / composite construction.  
IS:10297 Code of practice for design and construction of floors and roofs using precast reinforced/prestressed concrete ribbed or cored slab units.  
IS:10505 Code of practice for construction of floors and roofs using pre-cast reinforced concrete waffle units.  
IS:15658 Pre-cast concrete block for paving.  
IS 15916 Building Design and Erection using Pre fabricated concrete

#### **Masonry & Allied Works**

- IS:1905 Code of practice for structural use of unreinforced masonry.  
IS: 2185 Part-1 Concrete Masonry Units - Specification Part 1 Hollow and Solid Concrete Blocks  
Part-3 Specification for concrete masonry units: Part 2 Hollow and solid light weight concrete blocks  
IS:2212 Code of practice for brick work.  
IS:2250 Code of practice for preparation and use of masonry mortars.  
IS:2572 Code of practice for construction of hollow concrete block masonry.  
SP:20 Hand book on masonry design and construction.

#### **Sheeting Works**

- IS:277 Galvanised steel sheets (Plan & corrugated).  
IS:513 Cold-rolled low carbon steel sheets & strips.  
IS:730 Hook bolts for corrugated sheet roofing.  
IS:801 Code of practice for use of cold formed light gauge steel structural members in general building construction.  
IS:2527 Code of practice for fixing rain water gutters and down pipe for roof drainage.  
IS:7178 Technical supply condition for tapping screw.  
IS:8183 Bonded mineral wool.  
IS:8869 Washers for corrugated sheet roofing.  
IS:12093 Code of practice for laying and fixing of sloped roof covering using plain and corrugated galvanised steel sheets.  
IS:12436 Preformed rigid Polyurethane (PUR) and isocyanurate (PIR) foams for thermal insulation.  
IS:12866 Plastic translucent sheets made from thermosetting polyester resin (glass fibre reinforced).  
IS:14246 Continuously pre-painted galvanised steel sheets and coils.



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BS:5950 Code of practice for design of light gauge profiled  
(Part-6) steel sheeting

**Fabrication and Erection of Structural Steel Works**

IS:800 Code of practice for General Construction of steel.  
IS:813 Scheme for symbols for welding.  
IS:814 Covered electrodes for manual metal arc welding of carbon & carbon manganese steel.  
IS:816 Code of practice for use of metal arc welding for general construction in mild steel.  
IS:817 Code of practice for training and testing of metal arc welders.  
IS:1024 Welding in bridges and substructured subject to dynamic.  
IS:1181 Qualifying tests for Metal Arc welders (engaged in welding structures other than pipes).  
IS:1182 Recommended practice for Radiographic examination of fusion welded butt joints in steel plates  
IS:1608 Mechanical testing of metals - tensile testing  
IS:1852 Rolling and Cutting Tolerances for Hot rolled steel products.  
IS:2016 Specification for Plain washers.  
IS:2595 Code of practice for Radiographic testing  
IS:2629 Hot dip galvanising of iron and steel  
IS:3502 Steel chequered plate.  
IS:3613 Acceptance tests for wire flux combination for submerged arc welding.  
IS:3658 Code of practice for liquid penetrant flaw detection.

IS:3757 High strength structural bolts.  
IS:4000 High strength bolts in steel structure - code of practice.  
IS:4353 Sub merged arc welding of mild steel and low alloy steel Recommendation  
IS:4759 Hot dip zinc coating on structural steel and other allied products.  
IS:5334 Code of practice for magnetic particle flaw detection of welds.  
IS:5369 General requirements for plain washers and lock washer  
IS : 6623 High strength structural nuts.  
IS:6649 Hardened and tampered washers for high strength structural bolts & nuts.  
IS:6911 Stainless steel plate, sheet and strip.  
IS:7205 Safety code for erection of structural steel.  
IS:7215 Tolerances for fabrication of structural steel.  
IS:7307 Approved test for welding procedures  
(Part - I) Fusion welding of steel.  
IS:7310 Approval test for welders working to approval welding procedure.  
(Part-I) Fusion welding of steel  
IS:9178 Criteria for design of steel bins for storage of bulk material. (Part-1to 3)

IS:9595 Recommendations for metal arc welding of carbon & carbon manganese steel.  
IS:12843 Tolerances for erection of steel structures.



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SP:6 ISI Hand book for structural Engineers.  
(Part 1 to 7)

**Plastering and Allied Works**

IS:1661 Code of practice for application of cement and cement lime plaster finishes.  
IS:2402 Code of practice for external rendered finishes.  
IS:2547 Gypsum building plaster.  
(Parts 1&2)

**Acid and Alkali Resistant Lining**

IS:158 Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali & heat resisting.  
IS:412 Expanded metal steel sheets for general purpose.  
IS:4441 Code of practice for use of silica type chemical resistant mortars.  
IS:4443 Code of practice for use of resin type chemical resistant mortars.  
IS:4456 Method of Test for chemical resistant tiles.  
(Part I & II)  
IS:4457 Ceramic unglazed vitreous acid resisting tiles.  
IS:4832 Specification for chemical resistant mortars.  
(Part - 1) Silicate type  
(Part - 2) Resin type  
(Part - 3) Sulfur type  
IS:4860 Acid resistant bricks.  
IS:9510 Bitumastic acid resisting grade.

**Water Supply, Drainage and Sanitation**

IS:458 Precast concrete pipes (with & without reinforcement).  
IS:554 Pipe threads where pressure tight joints are made on the threads – dimensions, tolerances and designation.  
IS:651 Salt glazed stoneware pipes and fittings.  
IS:774 Flushing cisterns for water closets and urinals.  
IS:775 Cast iron brackets and supports for wash basins and sinks.  
IS:778 Copper alloy gate, globe and check valves for water works purposes.  
IS:781 Cast copper alloy screw down bib taps & stop valves for water services.  
IS:782 Caulking lead.  
IS:783 Code of practice for laying of concrete pipes.  
IS:1172 Code of basic requirements of water supply, drainage and sanitation.  
IS:1230 Cast iron rain water pipes and fittings.  
IS:1239 Mild Steel tubes, tubulars and other wrought steel fittings (Part 1&2)  
IS:1536 Centrifugally cast (Spun) iron pressure pipes for water.  
IS:1537 Vertically cast iron pressure pipes for water, gas and sewage.  
IS:1538 Cast iron fittings for pressure pipe for water, gas and sewage.  
IS:1703 Copper alloy float valve for water supply fitting.



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IS:1729	Cast iron / Ductile iron drainage pipes and pipe/fittings for over ground non pressure pipeline socket and spigot series.
IS:1742	Code of practice for building drainage.
IS:2064	Selection, installation and maintenance of sanitary appliances.
IS:2065	Code of practice for water supply in buildings.
IS:2326	Automatic flushing cisterns for urinals.
IS:2548	Plastic seats and covers for water closets.
IS:2556	Vitreous sanitary appliances (vitreous china).
IS:3114	Code of practice for laying of cast iron pipes.
IS:3311	Waste plug and its accessories for sinks and wash basins.
IS:3438	Silvered glass mirrors for general purposes.
IS:3486	Cast iron spigot and socket drain pipes.
IS:3589	steel pipe for water and sewage (168.3 to 2540mm outside diameter)
IS:3989	Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS:4111	Code of practice for ancillary structure in sewerage system.
(Part 1 to 5)	
IS:4127	Code of practice for laying of glazed stone ware pipes.
IS : 4733	Methods of sampling and testing sewage effluents.
IS:4764	Tolerance limits for sewage effluents discharged into inland surface waters.
IS:1068	Electroplated coating of nickel plus chromium and copper plus nickel plus chromium.
IS:5329	Code of practice for sanitary pipe work above ground for buildings.
IS:5382	Rubber sealing rings for gas mains, water mains and sewers.
IS:5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS:5961	Specification for cast iron grating for drainage purpose.
IS:7740	Code of practice for construction and maintenance of road gullies.
IS:8931	Copper alloy fancy single taps combination tap assembly and stop valves for water services.
IS:9762	Polyethylene floats for float valves.
IS:10592	Industrial emergency showers, eye and face fountains and combination units.
IS:12592	Specification for precast concrete manhole covers and frames.
IS:12701	Rotational moulded polyethylene water storage tanks.
IS:13983	Stainless steel sinks for domestic purposes.
SP:35	Hand book on water supply and drainage with special emphasis on plumbing.
CPH&EEO	Manual on sewage and sewage treatment
Publication	- as updated.

**Doors Windows and Allied Works**

IS:204	Tower Bolts.
(Part 1)	Ferrous metals
(Part 2)	Non - ferrous metals
IS:208	Door Handles.
IS:281	Mild steel sliding door bolts for use with padlocks.
IS:362	Parliament Hinges.



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IS:419	Putty, for use on window frames.
IS:451	Technical supply conditions for wood screws
IS:733	Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes.
IS:1003 (Part I)	Timber panelled and glazed shutters (doors shutters).
IS:1003 (Part-1)	Timber panelled and glazed shutters door utters.
IS:1038	Steel doors, windows and ventilators.
IS:1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
IS:1285	Wrought aluminium and aluminium alloy extruded round tube & hollow section (for general engineering purposes).
IS:1341	Steel butt hinges.
IS:1361	Steel windows for Industrial buildings.
IS:1823	Floor door stoppers.
IS:1868	Anodic coatings on Aluminium and its alloys.
IS:2202	Wooden flush door shutters (solid core type) particle
IS:2209	Mortice locks (vertical type)
IS:2553	Safety glass.
(Part-1)	General purposes
IS:2835	Flat transparent sheet glass.
IS:3548	Code of practice for glazing in buildings.
IS:3564	Door closers (Hydraulically regulated) IS:3614


**Specification for fire check doors :**

(Part-1)	plate, metal covered and rolling type.
(Part-2)	Resistance test and performance criteria. IS:4351

**Specification for steel door frames.**

IS:5187	Flush bolts.
IS:5437	Figured, rolled and wired glass.
IS:6248	Specification for metal rolling shutters and rolling grills.
IS:6315	Specification for floor springs (Hydraulically regulated) for heavy doors.
IS:7196	Hold fast.
IS:7452	Hot rolled steel sections for doors, windows and ventilators.
IS:10019	Mild steel stays and fasteners. IS:10451 Steel sliding shutters (top hung type)
IS:12823	Prelaminated particle boards.

**Roof Water Proofing and Allied Works**

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- IS:3067 code of practice for general design details and preparatory work for damp proofing and water proofing of buildings.
- ASTM Standard specification for high solid content cold
- C836-89a liquid applied elastomeric water proofing membrane for use with separate wearing course.
- ASTM Standard guide for high solid content cold
- C898-89 liquid applied elastomeric water proofing membrane for use with separate wearing course.

#### Floor Finishes and Allied Works

- IS:5318 Code of practice for laying of flexible PVC sheet and tile flooring.
- IS:8042 White portland cement.
- IS:13755 Dust pressed ceramic tiles with water absorption of 3%, E 6% (Group B11a).
- IS:13801 Chequered cement concrete tiles.

#### Painting and Allied Works

- IS:162 Ready mixed paint, brushing fire resisting, silicate type for use on wood, colour as required.
- IS:428 Distemper, oil, emulsion, colour as required.
- IS:1477 Code of practice for painting of ferrous metals in buildings.
- (Part -1) Pretreatment. (Part -2)
- Painting.
- IS:1650 Specification for colours for building and decorative materials.
- IS:2074 Ready mixed paint, air drying, red oxide-zinc chrome, priming.
- IS:2338 Code of practice for finishing of wood and wood based materials.
- (Part -1) Operations and Workmanship.
- (Part -2) Schedule.
- IS:2395 Code of practice for painting concrete, masonry and plaster surfaces.
- (Part-1) Operations and Workmanship.
- (Part -2) Schedule.
- IS:2524 Code of practice for painting of nonferrous metals in buildings.
- (Part -1) Pretreatment
- (Part -2) Painting.
- IS:2932 Enamel, synthetic, exterior, (a) under coating and (b) finishing.
- IS:2933 Enamel exterior, (a) under coating, (b) finishing.
- IS:4759 Hot dip zinc coatings on structural steel and other allied products.
- IS:5410 Specification for cement paint.
- IS:15489 Plastic emulsion paint.
- IS:6278 Code of practice for white washing and Colour washing.
- IS:10403 Glossary of term related to building finish.
- IS:12027 Silicone based water repellent
- IS:13238 Epoxy based zinc phosphate primer (2 pack)
- IS:13239 Epoxy surfacer (2 pack)

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IS:13467 Chlorinated rubber for paints  
IS:14209 Epoxy enamel, two component glossy.  
BS:5493 Code of practice for protective coating of iron and steel structures against corrosion.

#### **Piling and Foundation**

IS:1080 Code of practice for design and construction of shallow foundations on soils.  
IS:1904 Code of practice for design and construction of foundation in Soils : General Requirements.  
IS:2314 Steel sheet piling sections.  
IS:2911 Code of practice for design and construction of pile foundations.  
(Relevant Parts)  
IS:2950 Code of practice for designs and construction of Raft foundation.  
(Part-1) Design  
IS:2974 Code of practice for design and construction of machine (Part-1 to 5) foundation.  
IS:4091 Code of practice for design and construction foundations for transmission line towers and poles.  
IS:6403 Code of practice for determination of Bearing capacity of Shallow foundations.  
IS:8009 Code of practice for calculation of settlement of foundation.  
(Part -1) Shallow foundations.  
(Part -2) Deep foundations.  
IS:12070 Code of practice for design and construction of shallow foundations on rocks.  
ISO 10816 Criteria for assessing mechanical vibrations of machines.  
ISO 1940 Criteria for assessing the st of balance of rotating rigid bodies.  
DIN : EN 13906-1 Helical compression spring made of round wire and rod : calculation and design of compression .  
DIN:2096 Helical compression spring out of round wire and rod : Quality requirements for hot formed compression spring.  
DIN:4024 Flexible supporting structures for machine with rotating machines.

#### **Roads**

IRC:5 Standard specifications and Code of practice for road bridges, (Section-1)  
General Features of Design.

IRC:14 Recommended practice for 2cm thick bitumen and tar carpets.  
IRC:15 Standard specifications and code of practice for construction of concrete roads.  
IRC:16 Specification for priming of base course with bituminous primers.  
IRC:19 Standard specifications and Code of practice for water bound macadam.  
IRC:21 Standard specifications and Code of practice for road bridges. (Section-III)  
Cement concrete (plain and reinforced).  
IRC:34 Recommendations for road construction in water logged areas.  
IRC:36 Recommended practice for the construction of earth embankments for road works.  
IRC:37 Guidelines for the Design of flexible pavements.  
IRC:56 Recommended practice for treatment of embankment slopes for erosion control.





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IRC:58 Guidelines for the design of rigid pavements for highways.  
IRC:73 Geometric Design standards for rural (non-urban) highways.  
IRC : 86 Geometric Design standards for urban roads in plains.  
IRC:SP:13 Guidelines for the design of small bridges & culverts.  
IRC - Ministry of Surface Transport (Road wing), Publication  
specifications for road and bridge works.  
IS:73 Paving bitumen.

**Loading**

IS:875 Code of practice for design loads (other than earthquake) for (Relevant parts) buildings and structures.  
IS:1893 Criteria for earthquake resistant design of structures.  
IS:4091 Code of practice for design and construction of foundation for transmission line towers and poles.  
IRC:6 Standard specifications & Code of practice for road bridges. (Section-II)  
loads and stresses

**Safety**


IS:1641 Code of practice for fire safety of buildings - General principles of fire grading and classification.  
IS:1642 Code of practice for fire safety of buildings - Details of construction.  
IS:3764 Excavation work - code of safety.  
IS:4081 Safety code for blasting and related drilling operations. IS:4130 Demolition of buildings - code of safety.  
IS:5121 Safety code for piling and other deep foundations.  
IS:5916 Safety code for construction involving use of hot bituminous materials.  
IS:7205 Safety code for erection of structural steel work.  
IS:7293 Safety code for working with construction machinery.  
IS:7969 Safety code for handling and storage of building materials.  
Indian Explosives (As updated)  
Act 1940)

**Architectural Design of Buildings**

SP:7 National Building Code of India  
SP:41 Hand book on functional requirements of buildings (other than industrial buildings)  
ECBC Energy Conservation Building Code  
GRIHA Green Rating For Integrated Habitat Assessment.

**Tall Structures, Chimneys**

IS:4998 Criteria for design of reinforced chimneys  
IS:6533 Code of practice for design and construction of steel chimneys  
ICAO International Civil Aviation Organisation (ICAO)  
DGCA Instruction of Director General of Civil Aviation , India  
ACI:307 Specification for the design and construction of reinforced concrete chimneys

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BS:4076 Specification for steel chimneys  
CICIND Model Code for concrete chimneys  
Model code for steel chimneys  
ASCE Code Design and construction of steel chimney liners prepared by Task committee on steel chimney liners. Fossil power committee, Power division published by ASCE - 1975.  
IS:1554 PVC insulated (heavy duty) electric cables  
IS:2606 Alloy lead anodes for chromium plating  
IS:3043 Code of Practice for Earthing  
IS:9537 Conduits for electrical installations.

#### The Indian Electricity Rules

The Indian Electricity Act  
The Indian Electricity (Supply) Act  
The Indian Factories Act  
IS:2309 Practice for protection of buildings and allied structures against lightning

#### Miscellaneous

IS:802 Code of practice for use of structural steel in overhead trans- (Relevant parts) mission line towers.  
IS:803 Code of practice for design, fabrication and erection of vertical mild steel cylindrically welded in storage tanks.  
IS:10430 Criteria for design of lined canals and guidance for selection of type of lining.  
IS:11592 Code of practice for selection and design of belt conveyors.  
IS:12867 PVC handrails covers.  
IS 11504 Criteria for structural design of reinforced concrete natural draught cooling towers  
BS:4485 (IV) British Standard : Code of design for water cooling towers  
CIRIA Design and construction of buried thin-wall pipes.  
Publication  
IS 4671 Expanded polystyrene for thermal insulation purposes.  
IS 18299 Structural design and proof checking consultancy services for structures

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### 33.QUALITY ASSURANCE

#### Introduction to the Quality assurance specification

For fulfilment of the relevant technical requirments (Test and inspection) of the General Conditions of Contract and General Technical Requirements of Contract, the Quality Assurance Specification acts as a part of the Technical Specification and is included in the Contract.

This part of the Technical Specification shall be read in conjunction with other parts of the technical specifications, General Technical Requirements and Erection Conditions of the Contract.

This document specifies the quality requirements, to be detailed in terms of Tests/Checks/Procedures at the times of manufacturing, Testing, Inspection and also during installation of various Equipment / Components at the place of manufacturer and / or on the site.

Various standards referred in this document shall be the latest revisions.

The quality requirements are spelt out in the following ways.

1. Through description
2. In the form of tables

In either of the above two forms the test /checks / procedures are mentioned against particular item/ equipment/ component/ system etc.

This specification also contains the Indicative vendor list (with disclaimer) mentioned against particular item/ equipment/ component/ system etc.

The quality requirements specified in this document and also the vendor list are only indicative and not exhaustive.

#### **AIR CONDITIONING AND VENTILATION SYSTEM**

##### **FANS:**

20% DPT of welding on fan hub, blades, casing and impeller as applicable shall be carried out.

DPT of fan shafts shall be carried out after machining.


UT of fan shafts (dia equal to or above 40mm) shall be carried out.

Rotating components of all fans shall be dynamically balanced to ISO-1940 Gr. 6.3/IS 21490

All Fans shall be subjected to run test for 4 hrs. or till temperature stabilization is reached. Vibration, Noise level, Temp. rise and current drawn shall be measured during the run test.

One fan of each type and size will be performance tested as per corresponding BIS code/ AMCA for Air flow, Static Pressure, Speed, Efficiency, Power Consumption, Noise, Vibration and Temp. Rise.

#### **LOW PRESSURE AIR DISTRIBUTION SYSTEM**

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Functional test for fire damper along with solenoid shall be done.

Prototype tests report of fire damper (duly approved/accepted by ENGG) for each type and size as per UL-555 for fire rating shall be furnished.

Site Test- After completion, all ducting system shall be checked/tested for air leakages/tightness (smoke test) at site.

#### **INSULATION:**

Insulation material shall be tested for all mandatory tests only as per relevant code/standard.

Resin bonded mineral wool/Glass wool: Thermal conductivity tests (for thermal insulation only) shall be done the same density of material as applicable as per IS:3346 or equivalent standard//Engg spec.

XLPE/Nitrile Rubber: Thermal conductivity tests (for thermal insulation only) shall be done as per relevant code for the same density and thickness of material and validity of test shall be as per relevant standard/Engg spec.

#### **AIR FILTERS:**

Pre/Fine filters shall be tested for initial and final pressure drop Vs flow, efficiency and average synthetic dust weight arrestance as per the requirement of BS 6540/ASHARE-5276/EN779. HEPA (Absolute) filters shall be tested as per applicable code.

#### **SPLIT, CASSETTE, WINDOW, /PRECISION/PACKAGED AC (PAC)**

Split/Cassette/ Window AC/PAC will be accepted on the basis of Manufacturer Standard Guarantee and Warrantee certificate.

PAC: Each Unit shall be subjected to production routine Test as per relevant standard.

Capacity, noise level and vibration of PAC unit shall be demonstrated as per relevant standard on one unit of each type and rating.


Performance test to be performed at site for PAC.

### **FIRE DETECTION & PROTECTION SYSTEM**

#### **PIPING, VALVE AND SPECIALITIES**

##### **SHOP TESTS**

- All pipes and fittings shall be tested as per applicable code.
- DPT of pipe welds (in case of rolled and welded pipes only) shall be carried out for root and finished welds.
- All strainers shall be subjected to hydraulic pressure test for leakage and Pressure drop v/s Flow for each type and size.

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- d) All valves shall be hydraulically tested for body, seat and back seat (if applicable) as per relevant standard. Check valves shall also be tested for leak tightness test at 25% of the specified seat test pressure.
- e) Valves shall be offered for hydro test in unpainted condition.
- f) Functional checks of the valves for smooth opening and closing shall also be done.

Anti-corrosive protection shall be tested as per applicable code.

#### **PORTABLE & MOBILE FIRE EXTINGUISHERS**

##### **SHOP TEST**

- a) All fire extinguishers shall be tested as per relevant standard.
- b) Performance / function test shall be carried out on sampling basis as per relevant code / standard.

##### **SITE TESTS:**

- Fire Extinguishers: A performance demonstration test at site of five (5) percent or one (1) number, whichever is higher, of each type and capacity of the extinguisher shall be carried out by the Bidder. All consumables and replaceable items require for the Bidder without any extra cost to employer would supply this test would be supplied by the Bidder without any extra cost to employer.
- Piping Protection:
- Thickness, Holiday by spark test, Adhesion test shall be carried out as per relevant standard.
- Complete piping shall be Hydro pressure tested, at 1.5 X DP or 2 X MWP whichever is higher, before protection.
- Welding of Pipes:

##### **1) ERW Black / rolled welded:**

100% DPT on root of butt and finish weld of butt and fillet.

RT on 10% randomly selected joints shall be carried out (for underground piping).

##### **2) GI Pipes**

Welding on GI Pipes in general shall not be done. Welding of GI Pipes, if permitted by design, (butt / socket / fillet weld) shall be done strictly as per approved drawing and procedure approved by End customer Engineering. For all such welds 100% DP test and random 1% RT shall be done.



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**IDT TRANSFORMER**

ATTRIBUTES / CHARACTERISTICS	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	NDT (DPT / RT / UT)	Functional check	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make / Type / Rating / Model / TC / General Physical Inspection.	Isolation test on core/clamp/tank	WPS & PQR	Routine Test as per relevant standard / END	Vacuum & Pressure Test
<b>ITEMS/COMPONENTS SUB SYSTEMS</b>															
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y				Y		Y		
Conservator / Radiator / Cooler / Pipes	Y	Y					Y				Y				
Copper Conductor (IS:191)	Y	Y	Y		Y										
Insulating Material	Y	Y	Y	Y	Y	Y									
CRGO Lamination & Built Core	Y	Y	Y		Y	Y					Y				
Porcelain Bushing / Insulator (IS: 2544 / 5621)	Y	Y												Y	
RIP - OIP Bushing (IS 12676, IEC 60137)	Y	Y	Y								Y			Y	
Gasket (IS 2712)	Y	Y			Y	Y			Y						
Air Cell	Y														Y
Transformer Oil									Y					Y	
On Load / Off-Circuit Tap Changer (IEC :214)	Y	Y	Y											Y	Y
Core Coil Assembly & Pretanking	Y									Y		Y			
Marshalling Box	Y							Y						Y	
WTI, OTI, MOG, Bucholz Relay, PRD, Thermistor, Breather, Terminal Connector, Bushing CT, Fan & Pumps with Drives, Valves								Y			Y				
Testing & Maintenance equipment											Y				
Welding (ASME Sect-IX)							Y						Y		





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LEAD ACID BATTERY

ATTRIBUTES / CHARACTERISTICS →								
ITEMS, COMPONENTS, SUB SYSTEM ASSEMBLY ↓	Dimensions & Finish	Conformance to relevant part drg. & Manufacturer's standards	Chemical composition	Lead coating thickness, IS: 1069 / 266	Conformance to CPWD Spec. for Teak Wood	Paint Process checks, Paint Shade, Thickness, Adhesion & Finish	Constructional requirements as per END C Spec.	Routine & acceptance tests as per relevant standard
Container & Lids (IS: 1146)	Y	Y						
Vent Plugs	Y	Y						
Sealing Compound (IS: 3116)		Y	Y					
Positive & Negative Plates		Y	Y					
Separators (IS: 6071)	Y	Y						
Electrolyte (Water / Sulphuric Acid) (IS: 1069 / 266)		Y	Y					
Inter-cell Connectors & Fasteners	Y	Y		Y				
Battery Stand	Y	Y			Y	Y		
Cell Insulators	Y	Y						
Stack Assembly	Y	Y						
Lead Acid Battery (IS: 1652)	Y						Y	Y

**Note:**

This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.









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Synthetic Rubber Gaskets	Y			Y										
Annunciator	Y								Y		Y			
Battery Charger	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

**Notes:**

1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents. 2) Makes of all major Bought Out Items will be subject to BHEL/End customer approval.

**BATTERY CHARGER**  
**(of capacity up to 24 V / 48 V, 150 A DC)**

<b>ATTRIBUTES / CHARACTERISTICS</b> 										
<b>ITEMS / COMPONENTS / SUB- ASSEMBLY</b> 	Make, Model, Type, Rating	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per approved drgs	Ripple Content Test, Load Limiter operation & AVR Operation Test	Operational & Functional Checks of aux. Devices like annunciator, switches, indicators etc.	HV & IR Test	Burn-In Test	Dynamic response test	AC input current measurement test	Temperature rise test
Battery Charger	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

**Note:**

- 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
- 2) Makes of all major Bought Out Items will be subject to BHEL/End customer approval.



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**DC HEALTH MONITORING SYSTEM**

ITEMS / COMPONENTS / SUB- ASSEMBLY →	ATTRIBUTES / CHARACTERISTICS									
	Make, Model, Type, Rating & Finish	Verification of Routine test reports as per relevant IS	Sheet Steel Pretreatment & Painting process checks	Conform to relevant Standard & END CUSTOMER	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per END CUSTOMER approved drgs & specification	Operational & Functional Checks	HV & IR Test	Burn-In Test at 50°C for 48 hrs in 5energized condition	Degree of Protection Test as per NTCP Spec.
Enclosure	Y		Y	Y	Y					Y
Synthetic Rubber Gaskets	Y			Y						
Control & Selector Switches, Indicating Meters, Indicating Lamps	Y			Y			Y			
Control Terminal Blocks, Push Buttons, MCB	Y			Y			Y			
MCB	Y			Y			Y			
PVC insulated Copper control / signal cables	Y	Y		Y						
Transducers / detectors	Y	Y		Y			Y			
PCB & racks for electronic cards	Y									
Electronic Cards	Y						Y		Y	
Microprocessor Based Controller	Y						Y		Y	
SCADA	Y						Y			
Software	Y						Y			
DC Health Monitoring System	Y			Y	Y	Y	Y	Y	Y	Y

**Notes:**

- 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
- 2) Makes of all major Bought Out Items will be subject to BHEL/End customer approval.



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**AUXILIARY / LT TRANSFORMER**

ITEMS/COMPONENTS	ATTRIBUTES / CHARACTERISTICS	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties		Chemical Composition	Compatibility with oil	NDT / DPT / MPI / UT	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make / Type / Rating / Model / TC / General Physical Inspection.	Functional check	WPS & PQR	Routine Test as per relevant standard / END CUSTOMER
Tank, H.V. & L.V. Cable Box / Flange throat		Y	Y						Y					Y	
Conservator / Radiator / Cooler / Pipes		Y	Y						Y						
Copper Conductor (IS:191)		Y	Y	Y			Y								
Insulating Material		Y	Y	Y	Y		Y	Y							
CRGO Lamination & Built Core		Y	Y	Y			Y	Y				Y			
Bushing Insulator (IS:2544 / 5621)		Y	Y									Y			Y
Gasket		Y	Y				Y	Y		Y		Y			Y
Transformer Oil (IEC296)				Y											Y
OLTC / Off-Circuit Tap Changer		Y										Y			Y
Core Coil Assembly & Pre-tanking		Y									Y	Y			
Marshalling Box		Y										Y	Y		Y
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Valves		Y										Y	Y		
Welding (ASME Sect-IX)		Y							Y					Y	
Complete Transformer (IS:2026/ IEC-60076)		Y													Y

Note:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. All major Bought Out Items will be subject to BHEL/End customer approval.



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**LT INDOOR TRANSFORMER (DRY TYPE)**

ATTRIBUTES / CHARACTERISTICS	Visual & Dimensional check	Mechanical properties	Electrical strength	Thermal Properties	Chemical Properties	NDT / DP / MPI	Voltage Ratio, Vector Group & Polarity	Make / Type / Rating / Model / TC / General Physical Inspection	WPS & PQR	Routine Test as per relevant standard	Measurement of capacitance & tan delta between winding	Routine Test
<b>ITEMS/COMPONENTS</b>												
<b>SUB SYSTEMS</b>												
Enclosure door, H.V. & L.V. Cable Box / Flange Throat	Y	Y						Y				
Copper Conductor	Y	Y	Y		Y							
Insulating Material	Y			Y	Y							
CRGO Lamination & Built Core	Y											
Bushing /Insulator (IS:2544 / 5621)	Y							Y		Y		
Gasket	Y							Y		Y		
Off-Circuit Tap Changer	Y							Y				
Core Coil Assembly	Y						Y					
Marshalling Box	Y									Y		
WTI, Thermistor, Terminal Connector	Y							Y				
Welding									Y			
Complete Transformer (IS:11171 / IEC 60076)	Y										Y	Y

**Notes:**

- Transformer Manufacturer has to submit a declaration regarding the compliance of all the inprocess checks such as Pocket to Pocket gaps, Centre gap (clearance between inner and outer layer of winding disc), Insulation of tapping leads & bends, brazing, casting parameters as well as all the design margins in line with the type tested similar rating transformer.**
- IR measurement of Shielding screen w.r.t LV, HV and body to be recorded and furnished along with other internal inspection reports.**
- This is an indicative List of test/checks. The manufacturer is to furnish a detailed Quality Plan indicating his practice and procedure along with relevant supporting documents during QP finalization for all items.**
- All major Bought Out Items will be subject to BHEL/End customer approval.**



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ATTRIBUTES/ CHARACTERISTICS	Make, model, Type & Rating, Test Certificate	Routine & Acceptance Test as per IS / IEC	Functional requirements as per End customer Specification
ITEMS/COMPONENTS, SUB SYSTEM ASSEMBLY			
Protection Relays	Y	Y	Y
Energy meter	Y	Y	Y

HT SWITCHGEAR																
ATTRIBUTES / CHARACTERISTICS <div>→</div>	<div>↓</div>	ITEMS, COMPONENTS, SUB-SYSTEM ASSEMBLY	Make, Type, Model, Rating & TC	Electrical Properties	Mechanical properties	Chemical Properties	Dimensions & Finish	Constructional, Functional & Operational Features as per END CUSTOMER	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint shade, thickness, adhesion & finish	Functional Checks	HV & IR Test	Degree of Protection Routine test as per END	CB Operation timing check	All Routine Tests as per relevant
CRCA steel sheet/ Aluzinc*/ Zinalum*/ Galvalum*		Y	Y	Y	Y	Y		Y								
Aluminum Bus bar material (IS: 5082)		Y	Y	Y	Y	Y		Y								
Copper Bus bar material (IS: 613)		Y	Y	Y	Y	Y		Y								
Bus bar Support Insulator		Y	Y	Y		Y		Y				Y				
HT Circuit Breaker (IEC-62271-100)		Y				Y	Y	Y				Y			Y	Y
HT Contactors (IS: 9046 / IEC 60470)		Y				Y	Y	Y				Y				Y
Protection & Auxiliary Relays		Y				Y	Y	Y				Y				Y
HT CT's & PT's (IS: 2705 / 3156)		Y				Y		Y								Y
HT Fuses (IS: 9385)		Y				Y	Y	Y								



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Surge Arrester (IEC: 99 –4)	Y				Y		Y							Y
LT Contactors (IS: 13947)	Y				Y	Y	Y			Y				
Control & Selector Switches (IS: 6875)	Y				Y	Y	Y			Y				
Indicating Meters (IS: 1248)	Y				Y	Y	Y			Y				Y
Indicating Lamps (IS: 13947)	Y				Y	Y	Y			Y				
Push Buttons (IS: 4794)	Y				Y	Y	Y			Y				
Control Transformer (IS: 12021)	Y				Y	Y	Y			Y				Y
LT Fuses (IS: 13703)	Y				Y	Y	Y							
Energy Meters (IS: 722)	Y				Y	Y	Y			Y				Y
Transducers (IEC: 60688)	Y				Y	Y	Y			Y				Y
Diodes	Y	Y				Y	Y			Y				
Terminal Blocks	Y	Y				Y	Y							
Synthetic Rubber Gasket (IS: 11149 / 3400)	Y	Y			Y		Y							
Breaker Handling Trolley	Y				Y	Y			Y	Y				
HT Switchgear Panel IEC-62271-200)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

**Notes:**

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought Out Items will be subject to BHEL/End customer approval.
3. Temperature rise test reports for diode plates with actual heat sink will be verified.

\* CRCA Galvanized steel with metal coating composed of Al (55%), Zn (43.4%) & Si (1.6%).

<b>Medium Voltage BUS DUCT</b>											
<div> <div>ATTRIBUTES / CHARACTERISTICS</div> <div>ITEMS/COMPONENTS SUB SYSTEMS</div> </div>	Visual & Dimensional Checks	Electrical / Mechanical / Chemical Properties	WPS & PQR	NDT (RT / DP / MPI / UT)	Painting Quality & Adhesion Test	Galvanizing Test as per IS: 2629 / 2633 6745	Electrical clearance & Creepage distance	Functional/Operational check	Make / Type Rating / Model / TC / Embossing/Printing of make & batch /General Physical Inspection	Trial Assembly at works.	Routine Test as per relevant standard / END CUSTOMER
Enclosure / Cubicle	Y	Y		Y	Y		Y				Y
Bus bar Conductor / Flexible	Y	Y		Y							





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Connector & Dis-connector Link											
Galvanized Steel Structure & Plate (Steel as per IS:2062)	Y					Y					
Epoxy / Seal-off Bushing & Epoxy / Porcelain Post / Support Insulator	Y	Y					Y		Y		Y
Welding of enclosure & conductor	Y		Y	Y							
Gasket, Silica gel Breather, Elastomer Spring Head		Y						Y	Y		
Complete Bus Duct & Cubicles IS:8084	Y				Y		Y			Y	Y

Note:

- 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
- 2) All major Bought Out Items will be subject to End customer approval.

**MV (3.3 KV / 6.6. KV / 11 KV / 33 KV) CABLES**

ATTRIBUTES / CHARACTERISTICS	Make, Type & T.C as per relevant standard	Dimension / surface finish	Mechanical properties	Chemical Composition	Spark Test (as applicable)	Electrical properties	Hot Set Test/ Eccentricity & Ovality	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal stability on outer sheath	Metallic (Cu) Screening If applicable	Anti-termite coating on wooden drums	Constructional requirements feature as per specification	Routine & Acceptance Test as per FRLS Test
<b>ITEMS/COMPONENTS, SUB SYSTEM ASSEMBLY</b>																
Aluminum (IEC 60228)	Y	Y	Y	Y		Y										
Semiconducting Compound	Y		Y			Y										
XLPE Compound (IEC 60502-2 (2005))	Y		Y			Y					Y					
FRLS PVC Compound (IEC-60754 Part-1)	Y		Y								Y	Y				Y



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Triple Extrusion & curing /Manufacturing of Core		Y			Y		Y										
Copper Tape	Y	Y	Y			Y											
Polyester tape	Y	Y															
Core Laying								Y									
Armor wire/strip	Y	Y	Y														
Copper tapping	Y	Y										Y					
Inner sheath	Y	Y															
Armoring		Y						Y									
Outer Sheathing		Y							Y								
<b>Power Cable (Finished)</b>								Y	Y	Y	Y	Y			Y	Y	Y
Wooden drum (relevant standard) /Steel Drum		Y											Y	Y			

**Notes:**

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought out items will be subject to Owner's approval.

ROUTINE TESTS	Following routine tests shall be carried out on each drum of finished cables for all types & sizes.	
1)	Conductor Resistance test	
2)	High voltage test	
3)	Partial discharge test (for Screened cables only)	
ACCEPTANCE TESTS	Following Acceptance tests shall be carried out on each size of each type (voltage rating) of cables, in the offered lot.	
A) For Conductor (as per sampling plan mentioned in IEC 60502-2 (2005))		
	1)	Annealing test (Copper)
	2)	Tensile Test (Aluminum)
	3)	Wrapping Test (Aluminum)
	4)	Resistance test
B) For copper tape / Wires (as per sampling plan mentioned in IEC 60502-2 (2005))		
	1)	Measurement of Dimensions
	2)	Conductivity check



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**B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IEC 60502-2 (2005))**

1.	Measurement of Dimensions
2.	Tensile Tests
3.	Elongation Test
4.	Torsion Test for Round wires only
5.	Wrapping Test
6.	Resistance Test
7.	Mass of Zinc coating test For G S wires / Formed wires only
8.	Uniformity of Zinc coating For G S wires / Formed wires only
9.	Adhesion test For G S wires / Formed wires only
10.	Freedom from surface defects

**C) For XLPE insulation & PVC Sheath (as per sampling plan mentioned in IEC 60502-2 (2005))**

1)	Test for thickness
2)	Tensile strength & Elongation before ageing (for tests after ageing see "D")
3)	Hot set test (For XLPE insulation)

**D) Ageing test:**

If the compound manufacturer is carrying out Ageing test, test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch)

(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre: - Routine Test of manufacturer internal test reports are to be verified by owner and Main Bidder at the time of final inspection. Owner and Main Bidder will also witness routine tests on cables on 10% sample basis.

(b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre: - Routine Test of manufacturer internal test reports are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Bidder will witness routine tests on cables for the first order on 100% basis.

1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.



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<b>E) Following tests will be carried out on completed cables as per relevant standard on each size of each type</b>		
1)	Insulation resistance test (Volume resistivity method)	
2)	High voltage test	
3)	Partial discharge test (for Screened cables only)	
<b>F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes &amp; types)</b>		
1)	Thermal stability test on outer sheath	
2)	Oxygen index test on outer sheath	
3)	Smoke density rating test on outer sheath	
4)	Acid gas generation test on outer sheath	
5)	Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable	
<b>G) Following tests shall be carried on one length of each size of each type of offered lot:</b>		
1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, marking of drum no. / Batch number of outer sheath extrusion	
2)	Measurement of Eccentricity & Ovality	

GENERAL NOTE:	
<p>(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre: - Routine Test of manufacturer internal test reports are to be verified by owner and Main Bidder at the time of final inspection. Owner and Main Bidder will also witness routine tests on cables on 10% sample basis.</p> <p>(b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre: - Routine Test of manufacturer internal test reports are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Bidder will witness routine tests on cables for the first order on 100% basis.</p> <p>1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.</p> <p>2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.</p> <p>3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.</p> <p>4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.</p>	



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LT SWITCHGEAR (MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)															
ATTRIBUTES / CHARACTERISTICS →	ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLY ↓	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per END	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per END	All Routine tests as per END CUSTOM IS
	Sheet Steel (IS: 513)	Y	Y		Y	Y		Y							
	Aluminum Bus bar Material (IS: 5082)	Y	Y	Y	Y	Y		Y							
	Copper Bus bar Material (IS: 613)	Y	Y	Y	Y	Y		Y							
	Support Insulator	Y	Y	Y	Y			Y							
	Air Circuit Breaker (IS: 13947)	Y	Y				Y	Y			Y	Y			Y
	Energy Meters (IS: 13010, 13779)	Y	Y				Y	Y			Y				Y
	Power & Aux. Contactors (IS : 13947 )	Y	Y				Y	Y			Y				
	Protection & Aux. Relays (IS : 3231) (IEC 60255 / IEC 61850)	Y	Y				Y	Y			Y				Y
	Control & Selector Switches (IS: 13947)	Y	Y				Y	Y			Y				



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CT's & PT's (IS 2705 / 3156)	Y	Y					Y						Y
MCCB (IS: 13947)	Y	Y					Y			Y			
Indicating Meters (IS: 1248)	Y	Y				Y	Y			Y			Y
Indicating Lamps (IS: 13947)	Y	Y				Y	Y			Y			
Air Break Switches (IS: 13947)	Y	Y				Y	Y			Y			
Control Terminal Blocks	Y	Y				Y	Y						

LT SWITCHGEAR (MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)															
ATTRIBUTES / CHARACTERISTICS →	ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLY ↓	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per END	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per END	All Routine tests as per END CUSTOM IS
	Fuse (IS 13703)	Y	Y				Y	Y							
	Control Transformer (IS: 12021)	Y	Y				Y	Y			Y				Y
	Push Buttons (IS: 4794)	Y	Y				Y	Y			Y				
	Transducer (IEC: 60688)	Y	Y				Y	Y			Y				Y
	MCB (IS: 8828)	Y	Y				Y	Y			Y				





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Support Insulator (BS: 2782, IEC: 660, IS: 10912)	Y	Y	Y	Y											
Galvanized Structure & GI Earthing Flat (IS: 2629 / 2633 / 4749)	Y	Y				Y						Y			
Space Heater & Thermostat		Y	Y										Y		
LT Busduct (IS: 8623 PART 2)	Y	Y				Y	Y	Y	Y	Y	Y		Y	Y	Y

**Notes:**

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to BHEL/End customer approval.

**LT POWER CABLES & CONTROL CABLES**

<b>CHARACTERISTICS ATTRIBUTES /</b>	<b>Make, Type &amp; T.C as per relevant standard</b>	<b>Dimension/surface finish</b>	<b>Mechanical properties</b>	<b>Chemical Composition</b>	<b>Spark Test (as applicable)</b>	<b>Electrical properties Hot Set Test/ Eccentricity &amp; Ovality</b>	<b>Lay length &amp; Sequence Armour coverage, cross over, looseness, gap between two wires</b>	<b>Sequential marking/ Batch marking/ surface finish/ cable length</b>	<b>T.S &amp; elongation before &amp; after ageing on outer sheath &amp; insulation</b>	<b>Thermal stability Anti-termite coating on wooden drums</b>	<b>Constructional requirements feature as per specification Routine &amp; Acceptance Tests as per relevant standard &amp; specification</b>	<b>FRLS Tests</b>
Aluminum (IEC 60228)	Y	Y	Y	Y		Y						
Copper (IEC 60228)	Y	Y	Y	Y		Y						
XLPE Compound (IEC 60502-2 (2005))	Y		Y			Y			Y			
PVC insulation Compound (IEC 60502)	Y		Y			Y			Y	Y		
FRLS PVC Compound (IEC-60754 Part-1)	Y		Y						Y	Y		Y
Extrusion & curing /Manufacturing of Core (PVC / XLPE)		Y			Y	Y				Y		
Core Laying							Y					





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Armour wire/strip	Y	Y	Y													
Inner sheath	Y	Y														
Armoring		Y						Y								
Outer Sheathing		Y							Y							
Finished Cable (IEC-60754 Part-1, IEC 60332-part III cat B/relevant standard)								Y	Y	Y	Y	Y		Y	Y	Y
Wooden drum (relevant standard) /Steel Drum		Y											Y	Y		

**Notes:**

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought out items will be subject to Owner's approval.

**QUALITY ASSURANCE**

**ROUTINE TESTS**

Following routine tests shall be carried out on each drum of finished cables for all types (PVC / XLPE insulated) & sizes.

- |    |                           |
|----|---------------------------|
| 1) | Conductor Resistance test |
| 2) | High voltage test         |

**ACCEPTANCE TESTS**

Following Acceptance tests shall be carried out on each size of each type (PVC / XLPE insulated) of cables, in the offered lot.

**A) For Conductor (as per sampling plan mentioned in IEC Pub 502 (1983)/ BS 6346:1969/ IEC 60502-2 (2005))**

- |    |                          |
|----|--------------------------|
| 1) | Annealing test (Copper)  |
| 2) | Tensile Test (Aluminum)  |
| 3) | Wrapping Test (Aluminum) |
| 4) | Resistance test          |

**B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IEC Pub 502 (1983)/ BS 6346:1969/ IEC 60502-2 (2005))**

- |    |                                   |
|----|-----------------------------------|
| 1. | Measurement of Dimensions         |
| 2. | Tensile Tests                     |
| 3. | Elongation Test                   |
| 4. | Torsion Test For Round wires only |
| 5. | Wrapping Test                     |
| 6. | Resistance Test                   |



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7.	Mass of Zinc coating test	For G S wires / Formed wires only
8.	Uniformity of Zinc coating	For G S wires / Formed wires only
9.	Adhesion test	For G S wires / Formed wires only
10.	Freedom from surface defects	

**C ) For PVC / XLPE insulation & PVC Sheath (as per sampling plan mentioned in IEC Pub 502 (1983)/ BS 6346:1969/ IEC 60502-2 (2005))**

1)	Test for thickness
2)	Tensile strength & Elongation before ageing (for tests after ageing see "D")
3)	Hot set test (For XLPE insulation)

**D) Ageing test:**

If the compound manufacturer is carrying out Ageing test, test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch)

**E) Following tests will be carried out on completed cables as per relevant standard on each size of each type (PVC / XLPE insulated)**

Insulation resistance test (Volume resistivity method)

High voltage test

**F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes & types)**

Thermal stability test on PVC insulation and outer sheath

Oxygen index test on outer sheath

Smoke density rating test on outer sheath

Acid gas generation test on outer sheath

**G) Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cables as per following sampling plan:**

This test will be carried out using composite sampling i.e., irrespective of size; cables of one particular type (i.e., armoured PVC insulated, unarmoured PVC insulated, armoured XLPE insulated, unarmoured XLPE insulated) will be bunched together, as per calculations in line with the IEC. All sizes of PVC & XLPE insulated, armoured & unarmoured cables shall be covered.

For one particular type, cables with OD less than or equal to 30 mm shall be clubbed together in touching formation while cables with OD greater than 30 mm shall be clubbed together leaving a gap equal to OD of cable having least diameter. Cable OD shall be taken as nominal overall diameter as per approved datasheet.

**H) Following tests shall be carried on one length of each size of each type (PVC / XLPE insulated) of offered lot:**

Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, drum / Batch (outer sheath extrusion batch) number marking on sheath

Measurement of Eccentricity & Ovality



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- (a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre: - Routine Test of manufacturer internal test reports are to be verified by owner and Main Bidder at the time of final inspection. Owner and Main Bidder will also witness routine tests on cables on 10% sample basis.
- (b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre: - Routine Test of manufacturer internal test reports are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Bidder will witness routine tests on cables for the first order on 100% basis.

1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.
2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.
3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.

In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.







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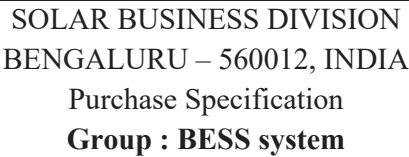
Switch Box/ Junction Box/Receptacles/ Local Push Button Station / Lighting Panel (IS-513, 2629, 2633, 4759, 6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cable Gland (BS-6121)	Y	Y									Y		
Cable Lug (IS-8309)	Y	Y									Y		
Flexible Conduit	Y										Y		
Lighting Transformer (IS11171)	Y									Y	Y		
Epoxy & Galvanized Conduit (IS-9537, 2629, 2633, 4759, 6745)	Y	Y									Y		Y

**LED Luminaire quality requirements:**

- 1) LED modules to conform to IS: 16103 part 2. Manufacturer to issue a certificate of compliance for the same.
- 2) Control gear to conform to IS 15885-part 2 section 13. Manufacturer to issue a certificate of compliance for the same.
- 3) LED luminaire to conform to IS 16107-part 2 section 1. Manufacturer to issue a certificate of compliance for the same.
- 4) LED luminaire marking to be as per IS 16107-part 2 section 1. Manufacturer to issue a certificate of compliance for the same.
- 5) Acceptance tests as per IS 16107-part 2 section 1 to be carried out on LED luminaire except long duration tests i.e., a) Chromaticity coordinates & correlated color temperature (CCT);  
b) Color rendering index (CRI). Manufacturer will submit a COC for above tests i.e., CCT & CRI
- 6) LED drivers make, model, type & rating may be as per recommendations of LED module manufacturer.

**Notes:**

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought Out Items will be subject to BHEL/End customer approval.



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Castings, stator frame, terminal box and bearing housing etc.	Y	Y	Y	Y	Y			Y												
Fabrication & machining of stator, rotor, terminal box	Y	Y			Y			Y	Y											
Wound stator	Y	Y					Y	Y												
Wound Exciter	Y	Y					Y	Y												
Rotor complete	Y	Y					Y						Y	Y						
Exciter, Stator, Rotor, Terminal Box assembly	Y	Y					Y													
Accessories, RTD, BT, CT, Space heater, antifriction bearing, gaskets etc.	Y	Y	Y																	
Complete Motor	Y	Y	Y												Y	Y	Y	Y1	Y	







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**INSTRUMENTATION CABLE**

ITEMS	TESTS															
	Conductor Resistance ® & (A)	High Voltage ® & (A)	Insulation Resistance ® & (A)	Constructional detail, dimensions (A)		Outer-Sheathe/core marking, end sealing (A)	Thermal Stability (A) +	Visual, Surface finish (A) +	Electrical Parameters ** (A) +	Persulphate Test (A) +	Overall/Coverage/Continuity (A)	Swidesh chimney Test (SS-4241475) (A) ++	FRLS Test * (A) ++	Tensile & Elongation before & after aging (A) ++	Vol. Resistivity. at room & Elevated Temp. (A) ++	Spark test report review ®
1. Instrument cable twisted and shielded																
Conductor(IS-8130)	Y			Y			Y									
Insulation(VDE-207)				Y	Y	Y	Y							Y		Y
Pairing/Twisting				Y	Y		Y									
Shielding				Y			Y			Y						
Drain wire	Y			Y			Y		Y	Y						
Inner Sheath				Y	Y	Y	Y						Y	Y		
Outer Sheath				Y	Y	Y	Y						Y	Y		
Over all cable	Y	Y	Y	Y	Y		Y	Y				Y			Y	
Cable Drums(IS-10418)				Y			Y									

**Note :** High Temp. cables shall be subjected to tests as per VDE-207(Part-6) Compensating cables shall be checked for Thermal EMF/Endurance test as per IS 8784.

**Note :** This is an indicative list of tests/checks. The manufacture is to furnish a detailed Quality Plan indicating his practice & Procedure along with relevant supporting documents during QP finalization for all items.

**Note :** ® - Routine Test      A - Acceptance Test      Y - Test Applicable

**Note :** Sampling Plan for Acceptance test shall be as per IS 8784 (As applicable)

• \* FRLS Tests: Oxygen / Temp Index ( ASTM D-2863), Smoke Density Rating ( ASTM – D 2843), HCL Emission ( IEC-754-1)

• \*\* Characteristic Impedance, Attenuation, Mutual Capacitance, Cross Talk ( As applicable)

+ Sample size will be One No. of each size/type per lot.

++ Sample size will be One No. sample for complete lot offered irrespective of size/type.



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Surveillance & Communication System, PLC, Fire ,LVS & Control Desk								
Item Components Sub System Assembly	Attributes Characteristics							
	Make, Model, Type, Rating, BOM®	GA/ Dimension / Paint Shade & Thickness®	Functional / operational check®	Switching capability and sequence®	HV/ IR Test®	SPL level and Sweep test response®	PAN Range / Tilt Speed/Zoom	FAT / Integrated Function Test along with Other System
<b>IP Based PA System</b>								
<b>Components-</b> Call Stations, Amplifier, Loud Speaker, Master Control Unit, Acoustic Hood, Enclosure , Power Supply, LAN Switch, Server, Work Station, Storage, Software	Y	Y	Y	Y		Y		
<b>IP PA -Complete System</b>	Y	Y			Y			Y
<b>IP Based CCTV</b>								
<b>Component-</b> Camera, Keyboard, Joystick, Housing, Pan-Tilt Unit , LAN Switch, Server, Work Station, Storage, Software	Y	Y	Y	Y			Y	
<b>IP CCTV-Complete System</b>	Y	Y			Y		Y	Y
<b>Large Video Screen</b>	Y	Y	Y					Y
<b>Modular Control Desk with draw-out console</b>	Y	Y	Y		Y			Y
<b>PLC ( IEC-1131)</b>	Y	Y	Y		Y			Y
<b>Fire Detection System(EN-54 Pt-2/Pt5/Pt-7, UL 268,UL 521, UL-864)</b>	Y	Y	Y					Y

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### QA CIVIL CHAPTER

**SAMPLING AND TESTING OF CONSTRUCTION MATERIALS** Before execution of any civil work, the Bidder shall conduct full-scale suitability tests on various construction and building materials such as soil, fine & coarse aggregates, cement, construction chemicals, supplementary cementitious materials, construction water etc. to ascertain their suitability for use. Testing of civil construction materials shall be conducted from labs mentioned in Annexure I. Further following arrangement with respect to testing and evaluation of civil construction materials and validation of test results of third-party labs can also be adopted with prior information and approval from EIC Owner/BHEL/End customer :

- i) The Bidder can carry out tests at any third-party laboratory complying with ISO/ IEC – 17025 accredited by NABL or such accredited agency.
- ii) In case the test is conducted as mentioned at point no. (i) above, the test shall be witnessed by Owner/BHEL/End customer representative including the verification of calibration status, however, for long duration test(s) the responsibility may be delegated to the laboratories.

However, if tests are carried out at laboratories mentioned in Annexure I, random witnessing of tests by Owner/BHEL/End customer representative may be carried out at the discretion of Owner/BHEL/End customer .

The test samples for full-scale testing including concrete design mix shall be jointly sampled and sealed by the Owner/BHEL/End customer and Bidder, thereafter these shall be sent to the concerned laboratory through the covering letter signed by Field Quality Assurance department (FQA) representative of the Owner/BHEL/End customer .

Format for sampling and testing of cement, coarse aggregate, fine aggregate, chemical admixture, fly ash, water, concrete design mix is enclosed at **Annexure-**


#### **II.**

Design mix shall be carried out at the start of the work and in case of change of source of concrete ingredients with all tests as per **Annexure II**. Alkali aggregate reactivity and petrographic examination for coarse & fine aggregates shall be carried out at an interval of 12 months till the completion of civil works.

- The Bidder shall identify the source of concrete ingredients including aggregates immediately after the issuance of LOI/ LOA/ NOA. Timely sampling of ingredients shall be carried out and the same shall be sent to laboratory for preconstruction/ source qualification testing. The entire exercise including availability of concrete mix design shall be completed by Bidder preferably within 2 months from the date of LOI/ LOA/ NOA so as not to hamper the start of concrete work at site. The test reports and recommendations for suitability of the materials including concrete mix design shall be promptly submitted by the Bidder to the Engineer-in-charge (EIC)/Head of Field Quality Assurance (FQA) Department of Owner/BHEL/End customer .

### **LABORATORY AND FIELD TESTING**

- The field laboratory for QA and QC activities shall be established and installed with adequate facilities to meet the requirement of envisaged day to day tests during execution of the work.

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Temperature and humidity controls shall be available wherever necessary during testing of samples. The Bidder shall furnish a comprehensive list of testing equipment/ instrument required to meet the planned/scheduled tests for the execution of works for EIC acceptance/ approval. The Bidder shall establish the requisite laboratory equipment/set up and skilled QA&QC manpower within 30 days from the mobilization at site.

- The tests which cannot be carried out/do not have facilities for testing in the field laboratory shall be done at Owner/BHEL/End customer acceptable third- party testing laboratory.
- All equipment and instruments in the field shall be calibrated before the commencement of tests and then at regular intervals, as per the manufacturer's recommendation and as directed by the BHEL/End customer EIC. The calibration certificates shall specify the fitness of the equipment and instruments within the limit of tolerance for use. The Bidder shall arrange for calibration of equipment and instruments by NABL or such accrediting agency complying with ISO/IEC-17025 accreditation and the calibration reports shall be submitted to BHEL/End customer EIC for their review and acceptance.
- The QA and QC activities (include all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirements) in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / relevant standard codes / contract documents shall be carried out at no extra cost to the Owner/BHEL/End customer .
- The Bidder shall carry out testing in accordance with the relevant IS Codes/ Standards and in line with the requirements of the technical specifications / quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and as per the directions of the BHEL/End customer EIC.

#### **FIELD QUALITY PLAN**

Well before the start of the work, the Bidder shall prepare and submit the Field Quality Plan (FQP) for review and approval by the Owner/BHEL/End customer . The FQP shall comprehensively outline the procedures, quality practices, equipment, services, and activities to be followed at site, in accordance with the technical specifications. It shall cover all aspects of the contract/schedule of items, from material procurement through to the completion of work at site. For reference, an indicative Field Quality Plan for Civil Works is provided and enclosed as Annexure

#### **PURCHASE AND SERVICE**

To facilitate advance planning of material testing/approval of Bought Out Items (BOI), well before the start of activity as per L-2 network, representative samples shall be procured by the Bidder from



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approved sub-vendors and submitted to the EIC for his approval before bulk procurement. In case of manufacturers test certificate (MTC) is submitted for acceptance, it shall be clearly traceable and correlated with the consignment received at site. MTC of all bought out items (BOI) shall essentially contain all the test parameters / characteristics specified in the technical specifications / standards / codes. In case the manufacturer's test certificate does not mention these details, sample from each lot shall be tested at the Owner/BHEL/End customer acceptable third-party lab. Approval of material / sample by the Owner/BHEL/End customer shall not relieve the Bidder of his responsibility, for their conformance to the specification, as well as the requisite performance and quality of material.

Structural steel (plates and rolled sections i.e. channels, beams & angles) conforming to IS 2062 and Reinforcement steel conforming to IS 1786 (supply if in the scope of the Bidder) shall be procured from the Steel Producers (Refer NOTE below). Currently, following steel producers are acceptable:


Reinforcement Steel	Structural Steel
SAIL	SAIL
Tata Steel Ltd.	Tata Steel Ltd.
JSW Steel Ltd.	JSW Steel Ltd.
Jindal Steel & Power Ltd. (JSPL)	Jindal Steel & Power Ltd. (JSPL)
Rashtriya Ispat Nigam Limited (RINL)	Rashtriya Ispat Nigam Limited (RINL) (for long products/Rolled sections)
ESL Steel Ltd.	Arcelormittal Nippon Steel India Ltd. (for Flat products/ Steel Plates)
JSW Ispat Special Products Ltd.	JSW Ispat Special Products Ltd.(for long products/Rolled sections)
*Jai Balaji Industries Ltd., Unit IV, Durgapur	*Evonith Value Steel Limited, Wardha
*Rungta Mines Ltd., Chaliyama Steel Plant, Jharkhand	
*Rashmi Metaliks Ltd., Kharagpur	

\*Accepted with conditions and inspection category II.

- Details regarding inspection category please refer Indicative sub-vendor List for Civil BOI

Subsequently, if any new Steel Producer/s are proposed by the main Bidder during execution of contract, the same may be considered for acceptance subject to meeting the following qualifying requirements:

- The proposed supplier should be a Steel Producer, having a minimum production capacity of one million tons per annum (MTPA).

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- ii) The proposed supplier should be a regular manufacturer of Steel Plates and / or Rolled Sections and / or Reinforcement Steel for the last two years as on date of submission of proposal.
- iii) The proposed supplier should also be a registered licensee with Bureau of Indian Standards for BIS: 1786/2062 at the time of submission of proposal.

**NOTE:** “The “Steel Producer” shall mean steel producer of any capacity, irrespective of process route, starting their operations from iron making using iron ore, virgin or processed, with necessary refining facilities and rolling/processing facilities, at a single location or else in multiple locations provided that the entire gamut of iron & steel production, from iron making to finished steel production, is owned by the same company or its subsidiary company(ies). Provided that the iron making capacity is sufficiently matching the steelmaking capacity. Further, downstream units should use material from the upstream units of the same company or its subsidiaries.”

**A) Approval conditions for procurement of structural steel sections through SAIL Conversion/Wet Leasing agent:**


In case of non-availability of certain steel sections such as angle 100X100X10 mm or smaller size, MS flats, rounds bars, square bars and chequered plate from BHEL/End customer acceptable steel producers (non-availability to be established by supporting documents), an option is given to the Main Bidder to source these sections directly from SAIL approved Conversion/Wet Leasing agent subject to the conditions given below:

1. The validity of BIS License of the finished sections shall be ensured by the Main Bidder.
2. Billets shall be procured from Owner acceptable Steel Producers. Proper records for traceability from raw material to final product shall be maintained.
3. Testing of one sample per 40 MT for each type of section/size or part thereof shall be carried out as per IS:2062 on finished product for physical and chemical properties. The sampling and testing for physical and chemical tests on finished product at Conversion/Wet Leasing agent shall be mandatorily witnessed by Main Bidder with prior consent of Owner.
4. Each lot of delivery of finished product shall be accompanied with corelatable Manufacturer’s Test Certificate (MTC). MTC of finished sections shall be correlated with original MTC for Billets received from BHEL/End customer acceptable Steel Producers.
5. Owner will have access to carry out the surveillance checks for inprocess stage.
6. In case any defects are seen in the material, Main Bidder will replace the material without any cost implication to the Owner.

**B) Approval conditions for procurement of Steel tubes conforming to IS: 1161 and Hollow (square and rectangular) steel sections conforming to IS: 4923 from BIS approved sources:**

Steel tubes conforming to IS:1161 and Hollow (square and rectangular) steel sections conforming to IS:4923 shall be sourced from BIS approved sources

having valid BIS license subject to complying and ensuring the following conditions by Main Bidder:

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1. The validity of BIS License of the finished sections shall be ensured by the Main Bidder.
2. Raw materials shall be procured from Owner acceptable Steel Producers.
3. Testing of samples of steel tubes and hollow sections from each lot shall be carried out as per IS:1161 & IS:4923 respectively on finished product.
4. Each lot of delivery of finished product shall be accompanied with corelatable Manufacturer's Test Certificate (MTC).
5. Owner will have access to carry out the surveillance checks for inprocess stage.
6. In case any defects are seen in the material, Main Bidder will replace the material without any cost implication to the Owner.

The specific methodology to be followed for Procurement of Structural Steel and Reinforcement Steel through Conversion route/BIS approved sources shall be subject to approval by BHEL/End customer in advance.

**LIST OF THIRD-PARTY LABORATORIES ACCEPTABLE FOR TESTING AND EVALUATION OF BUILDING MATERIALS**

Sl.	Name of Laboratory/ Test Centre	Contact Details (Address, Phone, Fax, E-mail)	Tests	Remarks
1	Indian Institute of Technology Bombay, Powai, Mumbai -400076	Head, Deptt of Civil Engg, Phone: 022 25722545	Mix Design and Material Properties on Selective Basis	In Situ Non-Destructive Testing (UPV) of Concrete Structures, Design of Mass Concrete, Temperature Studies, Distress Assessment
2	Indian Institute of Technology Madras, Chennai-600 036	Head, Deptt of Civil Engg. Phone: 044 22574266/5255	Selective Specialised Studies such as Design of Fly Ash Concrete and Special Concrete, Non-Destructive Testing (UPV) Of Structures	
3	Indian Institute of Technology Guwahati - 781039	Head, Deptt of Civil Engineering, Phone: 0361 2582401, 2582442, 258 2440	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Steel	In Situ Non-Destructive Testing (UPV) of Concrete Structures (Selective Basis), Design of Mass





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			Reinforcement, Petrography, Alkali Aggregate Reactivity, Mix Design	Concrete, Studies on Properties of Fly Ash Concrete
4	Indian Institute of Technology Kanpur (Up) - 208016	Head, Deptt of Civil Engineering, Phone: 0512 2597346	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design	Non-Destructive Testing (UPV) on Concrete Structures, Structural Health Assessment
5	Indian Institute of Technology Kharagpur (Wb) -721302	Head, Deptt of Civil Engineering, Phone: 03222 283421	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design, Petrography	
6	Indian Institute of Technology Delhi, Hauz Khas, New Delhi -1100 016	Head, Deptt of Civil Engineering, Phone:01126591191	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design	In Situ Non-Destructive Testing (UPV) of Concrete Structures (Selective Basis)
7	Indian Institute of Technology, Roorkee - 247667	Head, Deptt of Civil Engineering, Phone: 01332 285439, 273560	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical), Fly Ash (Physical and Chemical), Admixtures, Water, Steel Reinforcement, Mix Design, Petrography, Alkali Aggregate Reactivity	Various Tests on Other Building Materials Such as Silica Fume, Mass Concrete, Steel, Bricks, Tiles, Doors, Ferrocement Covers, Pipes, Bridge Bearings, PVC Water Tanks, etc.

Sl.	Name of Laboratory/ Test Centre	Contact Details (Address, Phone, Fax, E-mail)	Tests	Remarks
8	Indian Institute of Science Bangalore 560012	Head, Deptt of Civil Engineering, IISc Bangalore	Design of Roller Compacted Concrete, Radiation Shield Concrete, High Volume Fly Ash Concrete, Fire Behaviour of Concrete, Micro Cracking of Concrete, Non- Destructive	IISc basically involved in R&D activities related to civil engineering and may only be contacted in case of specific studies / consultancy.



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			Testing (Research & Development) Activities, Behaviour of Concrete Under Shrinkage and Creep, Assessment of Fire Damaged Concrete	
9	Institute Of Technology, Banaras Hindu University (Bhu) Varanasi (Up) - 221005	Head, Deptt of Civil Engineering, Phone: 0542-2307016	Testing and Evaluation of Cement Physical Properties), Aggregates (Mechanical Properties), Admixtures, Water, Mix Design, Petrography	
10	Central Building Research Institute (CBRI), Roorkee - 247667	Head, Structural Engineering Division, Phone: 01332 283382	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design, Alkali Aggregate Reactivity	Fire rating of doors, non-destructive testing of structures, various tests on other building materials such as bricks, steel, tiles etc.
11	Central Soil and Materials Research Station (CSMRS), Near IIT Delhi, Olof Palme Marg, New Delhi -110016	Joint Director Phone: 011 26962608, 011 2656 3140	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Petrography, Alkali Aggregate Reactivity, Mix Design	Various tests on other building materials such as steel, geotextiles, geomembrane, soil, instrumentation, monitoring, etc.
12	National Council for Cement and Building Materials (NCB), 34 Km Stone, Delhi Mathura Road Ballabgarh (Haryana)	Head, Centre for Construction Development & Research Phone: 0129-2246173	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Petrography, Alkali Aggregate Reactivity, Temperature Cycle Test, XRD, Steel Reinforcement, Mix Design	In Situ Non-Destructive Testing (UPV) Of Concrete Structures and Special Studies, Testing of Bricks, Paving Blocks, Steel Bars, Silica Fume, etc.
13	National Council for Cement and Building Materials (NCB), NCB	General Manager, Phone 040-23000344, 4023000343	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water,	In Situ Non-Destructive Testing (UPV) Of Concrete Structures (Selective Basis)



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Bhawan, Old Bombay Road Hyderabad 500008		Petrography, Alkali Aggregate Reactivity, Steel Reinforcement, Mix Design	
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Sl.	Name of Laboratory/ Test Centre	Contact Details (Address, Phone, Fax, E-mail)	Tests	Remarks
14	National Test House, Taramani Chennai 600 113	S.O.(Civil) Phone:04422432374, Fax:04422433158	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Steel Reinforcement, Water, Mix Design	Various Tests on Other Building Materials Such as Paving Blocks, Gi Pipes, Wires, Steel Plate, Flush Doors, Salt Spray Test, etc.
15	National Test House, Block Cp Sector V, Salt Lake City Kolkata-700 091	S.O. (Civil), Phone:033 2367 3870	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Steel Reinforcement, Mix Design	Various Tests on Other Building Materials Such as Paving Blocks, GI Pipes, Wires, Steel Plate, Flush Doors, etc.
16	National Test House (Nth), Kamla Nehru Nagar, Ghaziabad (Up)	S.O. (Civil), NTH Ghaziabad	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Steel Reinforcement	Timber, Clay Products, Water Proofing Compound, Flush Doors, Laminated Sheets, Plywood, etc.
17	Structural Engineering Research Centre (Serc), Taramani, Chennai 600113	Head, Department of Material Testing, Phone: 044 22549152, 22541735	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Steel Reinforcement Water, Mix Design	In Situ Non- Destructive Testing (UPV) of Concrete Structures (Selective Basis) and Special Studies Such as Cement Admixture Compatibility, Design of Special Concrete, Evaluation of Structures



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18	Vishveswaraiya National Institute of Technology (VNIT), Nagpur (MH) - 440010	Director, VNIT Nagpur, Phone:0712 2223710, 2222828	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design, Petrography	In Situ Non-Destructive Testing (UPV) of Concrete Structures and Soil Tests
19	Anna University, Department of Structural Engineering, Chennai 600025	Head, Deptt of Civil Engineering	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design	
20	Shriram Institute for Industrial Research, 19 University Road, Delhi 110007	Dr (Mrs) Laxmi Rawat, Asstt. Director & Chief Phone:011 27667267	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water, Mix Design	Various Tests on Other Building Materials Such as Steel, Geotextiles, Geomembrane, Soil, Bricks, Tiles, etc.

Sl.	Name of Laboratory/ Test Centre	Contact Details (Address, Phone, Fax, E-mail)	Tests	Remarks
21	Spectro Analytical Lab, E-41, Okhla Industrial Area, Ph II, New Delhi 110021	Phone: 011 26383048-49 Fax: 40503150, 40503151	Testing of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Water	Chemical And Physical Tests on Steel Reinforcement
22	Motilal Nehru National Institute of Technology (MNIT), Allahabad 211004	Director, MNIT Allahabad, Phone: 0532-2271305, Fax: 0532-2545341	Testing and Evaluation of Cement (Physical and Chemical), Aggregates (Mechanical Properties), Fly Ash (Physical and Chemical), Admixtures, Steel Reinforcement Water, Mix Design	In Situ Non-Destructive Testing (UPV) Of Concrete Structures.
23	Govt Engineering College, Jalpaiguri (WB) -735102	Head Deptt of Civil Engg, Fax: 3561256143	Testing and Evaluation of Cement (Physical), Aggregates (Mechanical Properties), Water, Mix Design	



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24	College Of Engineering Pune -411005	Head Deptt of Civil Engg, Phone No: 02025507067, Fax: 2025507299	Testing and Evaluation of Cement (Physical & Chemical Properties), Fly Ash (Physical & Chemical Properties), Aggregates (Mechanical Properties Except Alkali Aggregate Reactivity & Petrography), Water, Admixtures, And Mix Design	
25	Maulana Azad National Institute of Technology, Bhopal (MP)	Head Deptt of Civil Engg, Phone No: 7554051390	Testing and Evaluation of Cement (Physical), Aggregates (Mechanical Properties), Water, Mix Design	In Situ Non-Destructive Testing (UPV) Of Concrete Structures and Soil Tests.
26	National Institute of Technology, Rourkela (Odisha)	Head Deptt of Civil Engg, Phone No: 06612462300	Testing and Evaluation of Cement (Physical), Aggregates (Mechanical Properties), Mix Design,	In Situ Non-Destructive Testing (UPV) of Concrete Structures and Soil Tests. Test on Steel Reinforcement, Bricks and Bitumen
27	Indian Institute of Technology (ISM), Dhanbad, Jharkhand	Department of Civil Eng., Dhanbad – 826004 Dr. Sarat Kumar Panda, Associate Professor, Ph- 03262235091, M-9570151300, Email Id: sarat@iitism.ac.in	Testing of Soil, Building Materials & Road Materials, Concrete Design Mix	



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**LIST OF THIRD-PARTY LABORATORIES ACCEPTABLE FOR TESTING AND EVALUATION OF BUILDING MATERIALS**

Sl.	Name of Laboratory/ Test Centre	Contact Details (Address, Phone, Fax, E-mail)	Tests	Remarks
28	National Institute of Technology (NIT), Jamshedpur, Jharkhand	Department Of Civil Engg., Dr. Virendra Kumar, Associate Professor M- 9431330642, 8340607039, Email Id: kumarvirendra57@gmail.com  Department of Mechanical Engg., Dr. Anil Kumar Prasad, Associate Professor & Principal Investigator, Ph- 0657-2374056, M9835314761, Email Id: akpradas.me@nitjsr.ac.in, anilnitj@yahoo.com	Testing of Soil, Building Materials & Road Materials, Concrete Design Mix, NDT of Old Structures, Rebound Hammer, Core Test of Concrete, UPV, Mini Structure Scanner etc. Reinforcement Rod Testing, Weld Strength Test etc.	

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Format of Request Letter for Evaluation of Materials and Concrete Mix Design

Ref: \_\_\_\_\_

Date: \_\_\_\_\_

To,

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Subject: Evaluation of Materials and Concrete Mix Design**

Dear Sir,

We have awarded the work of \_\_\_\_\_ on M/s \_\_\_\_\_ vide our WO No. \_\_\_\_\_ dated \_\_\_\_\_ for execution of Civil Works. Based on provisions of contract, M/s \_\_\_\_\_ are expected to get the following tests/ evaluation done through your laboratory and accordingly the tests have been described below.

M/s \_\_\_\_\_ have been advised to deposit the requisite evaluation/ testing charges and to deliver the test samples of quantities, specified below.

**1. Evaluation of Cement:**


- a) To carry out different physical tests on cement samples i.e. Blaine's fineness, initial and final setting time, soundness and compressive strength at 3, 7 and 28 days as per IS: 4031 and drying shrinkage and specific gravity in case of PPC.
- b) To carry out chemical analysis of the cement samples as per IS: 4032, including the total alkali content of the cement ( $\text{Na}_2\text{O}$  equivalent).
- c) To advise the suitability of cement based on the test results of a) and b) above.

**2. Evaluation of Aggregates:**

- a) To carry out different tests on coarse aggregate sample i.e. specific gravity, water absorption, sieve analysis, deleterious material content (coal & lignite, clay lumps, material finer than 75-micron sieve, soft fragment, shale, Total of % of all deleterious materials), soundness, crushing value, impact value, abrasion value, elongation index and flakiness index, as per IS: 383 & IS: 2386.
- b) To carry out different tests on fine aggregate sample i.e. specific gravity, water absorption, sieve analysis, soundness, deleterious material content (coal & lignite, clay lumps, material finer than 75-micron sieve, soft fragment, shale, Total of % of all deleterious materials), silt content, organic impurities and mica content as per IS: 383 & IS: 2386.

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To prepare evaluation report based on test results of a) and b) above and to advise regarding suitability of fine and coarse aggregates to be used with the cement of 1) above.

**3. Evaluation of Aggregates for Potential Alkali-Aggregate Reactivity:**

- a) To carry out petrographic analysis and Alkali-Aggregate Reactivity as per IS 2386 (Part VIII & VII).
- b) If rock type is limestone, X-Ray diffraction test (XRD) shall be carried out to determine clay mineral in the rock for preliminary conclusions and to carry out repeated temperature cycle test to determine residual expansion of aggregate for concrete to be used in dynamic foundations like TG, Fans, mills, crushers etc. Additionally, Alkali carbonate reactivity test may be carried out wherein the parameters shall be reported in conjunction with the petrographic analysis.
- c) To prepare a report based on test results of a) and b) above and to advise regarding suitability of aggregates to be used with the cement of 1) above and further testing required if any.

**4. Evaluation of Fly ash Sample (if applicable):**

- a) To carry out various physical and chemical tests on fly ash sample i.e. Blaine's fineness, lime reactivity, specific gravity, loss on ignition and other chemical tests as per IS: 3812, conforming to grade-I.
- b) To advise the suitability of fly ash sample based on the test results of a) above.

**5. Evaluation of water:** To carry out various physical and chemical tests as per IS: 456 and IS:3025.

**6. Evaluation of admixtures:** To carry out various physical and chemical tests as per IS: 9103.

**Note:** Test certificate shall be obtained from the supplier to compare the values given in Table 2 of IS: 9103 i.e. uniformity tests and requirements.

**7. Concrete Mix Design:** Based on the provisions of technical specification, the following may be specified by site Construction department/Quality department \*\*

- a) For RCC Work
  - i. Grade of concrete: ii. Slump required, mm: iii. Cement- type and grade: iv. Max. size of Aggregates, mm:
  - v. Exposure conditions:
  - vi. Maximum water-cement ratio: vii. Minimum cement content:
  - viii. Concrete admixture to be used or not (If yes, specify the brand/type/batch no. of admixture): ix. Fly ash to be used or not (If yes, indicate % of fly ash to be used):
- b) For PCC work : same as i) to ix) of a) above
- c) For piling work (if required) : same as i) to ix) of a) above

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8. **Details of material sampled:** In order to facilitate the above-mentioned tests, specified quantities of samples have been collected and sealed jointly (by Owner- Quality department, Execution department and Bidders' representative) is being sent for testing. The impression of seal has also been punched below.

a) **Quantity of material required for each mix-design:**

Sl. No.	Material Description	Quantity Required
i)	Cement	2 bags (sealed in double polythene bags)
ii)	Coarse Aggregates	100 Kg of each fraction as explained below: e.g.; If Maximum size of aggregates (MSA) is 20mm, then 100 Kg each of 20-10mm and 10mm down are required. If MSA is 40mm then 100Kg each of 40-20mm, 20-10mm and 10mm down are required.
iii)	Fine Aggregates	200Kg
iv)	Chemical Admixtures	2 Litres
v)	Water	100 Litres
vi)	Fly ash (If decided to be used)	100Kg


b) **Quantity of material required for Alkali-Aggregate reactivity**

Sl. No.	Material Description	Quantity Required
i)	Coarse aggregate	
a)	80-40mm	60Kg
b)	40-20mm	60Kg
c)	20-10mm	60Kg
d)	<10mm	60Kg
ii)	Fine aggregates	60Kg
iii)	Cement	2 samples (1 bag each), contemplated for use in construction

c) **Impression/ Punch Mark of seal:**

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You are requested to kindly forward us the test reports along with the recommendations regarding the suitability of materials to us at the earliest.

Thanking you,

Yours faithfully,

Name:

Designation:

Contact Number:

Email ID:

**Note:**

1. Based on provisions of technical specification, the testing charges for all the abovementioned tests shall be borne by the Bidder.
  2. The content of the letter is for guidance only, and if required may be suitably modified to suit the specific requirements of the package in consultation with Construction and quality department.
- \*\* This line may be deleted in the letter sent to the institute.**

**Indicative civil and other field quality plan is attached in Annex**


**Disclaimer for Indicative Vendor List**

1.1 Reasonable efforts have been made to collate the sub-vendors proposed by the various main Bidders from time to time against different Projects/Packages and accepted by BHEL/End customer for various items. However, in case of error/omission, if any, and represented by the successful bidder this will be addressed during the execution of the contract based on the material evidence available with BHEL/End customer / Main Bidder.

1.2 The approved sub-vendor list drawn is not based on BHEL/End customer driven enlistment process but based on the sub-vendors proposed by various Main Bidders. As such, it is possible that some of the Suppliers/Manufacturers who may be involved in similar work/process may not be appearing in the list as such sub-vendors may not have been proposed by Main Bidders against BHEL/End customer Contracts.

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1.3 In case the successful bidder chooses to propose additional sub-vendors with relevant experience after the award of the contract such sub-vendors will be considered as per specification, provided the proposals are received sufficiently in time: 90 days prior to ordering date of a Bought Out Items/Start of Manufacturing so as not to impede the progress of the contract.

1.4 Sub-vendors have been grouped under different categories of items. It is possible that an item characterized by certain specific features such as range and type required as per Main Bidder's design requirements may not be in the range of the listed sub-vendor's manufacturing process/capability. As such the main Bidder to ascertain the vendor's capability to meet his specific requirements before considering a sub-vendor.


1.5 It is to be noted by the bidders that any shortfall in contract performance attributable to the sub-vendor listed will not absolve the Bidder from his contractual obligations in any manner.

1.6 The approval was granted based on the evaluation of relevant capabilities and facilities possessed by the sub-vendor at the time of evaluation. Also, some of the sub-vendors may not be active. As such, the successful bidder is to carry out his own due diligence before considering the listed sub-vendor for subletting: the current status of the sub-vendor, the continued availability of productive resources including Human Resources.

1.7 The list of sub-vendors is periodically revised to include new sub-vendors. Such a revision may also see a deletion of certain sub-vendors who may have been disqualified on grounds of inadequate performance or banned in line with BHEL/End customer 's banning policy. The then current list will be shared with the successful bidder immediately on award.

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## 34. GENERAL TECHNICAL REQUIREMENTS (GTR)

**End customer technical requirements is attached in annex – same need to be complied.**

### INTRODUCTION

This part covers technical requirements which will form an integral part of the Contract. The following provisions shall supplement all the detailed technical specifications and requirements brought out in Section-VI, the Technical Specification and the Technical Data Sheets.

### BRAND NAME

Whenever a material or article is specified or described by the name of a particular brand, manufacturer or vendor, the specific item mentioned shall be understood to be indicative of the function and quality desired, and not restrictive; other manufacturer's products may be considered provided sufficient information is furnished to enable the Employer to determine that the products proposed are equivalent to those named.

### BASE OFFER & ALTERNATE PROPOSALS

The Bidder's proposal shall be based upon the use of equipment and material complying fully with the requirements specified herein. It is recognized that the Bidder may have standardized on the use of certain components, materials, processes or procedures different than those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice may also be considered, provided the base offer is in line with technical specifications and such proposals meet the specified design standards and performance requirement and are acceptable to the Employer. Sufficient amount of information for justifying such proposals shall be furnished to Employer along with the bid to enable the Employer to determine the acceptability of these proposals

### COMPLETENESS OF FACILITIES


Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant shall be engineered and designed in accordance with the specification requirement. All engineering and associated services are required to ensure that a completely engineered plant is provided.

All equipment furnished by the Bidder shall be complete in every respect, with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or those needed for erection, completion and safe operation & maintenance of the equipment and for the safety of the operating personnel, as required by applicable codes, though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.

All similar standard components/ parts of similar standard equipment provided, shall be interchangeable with one another.

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## CODES & STANDARDS


In addition to the codes and standards specifically mentioned in the relevant technical specifications for the equipment / plant / system, all equipment parts, systems and works covered under this specification shall comply with all currently applicable statutory regulations and safety codes of the Republic of India as well as of the locality where they will be installed, including the following:

- a) Indian Electricity Act
- b) Indian Electricity Rules
- c) Indian Explosives Act
- d) Indian Factories Act and State Factories Act
- e) Indian Boiler Regulations (IBR)
- f) Regulations of the Central Pollution Control Board, India
- g) Regulations of the Ministry of Environment & Forest (MoEF), Government of India
- h) Pollution Control Regulations of Department of Environment, Government of India
- i) State Pollution Control Board.
- j) Rules for Electrical installation by Tariff Advisory Committee (TAC).
- k) Building and other construction workers (Regulation of Employment and Conditions of services) Act, 1996
- l) Building and other construction workers (Regulation of Employment and Conditions of services) Central Rules, 1998
- m) Explosive Rules, 1983
- n) Petroleum Act, 1984
- o) Petroleum Rules, 1976,
- p) Gas Cylinder Rules, 1981
- q) Static and Mobile Pressure Vessels (Unified) Rules, 1981
- r) Workmen's Compensation Act, 1923
- s) Workmen's Compensation Rules, 1924
- t) End customer Safety Rules for Construction and Erection
- u) End customer Safety Policy
- v) CERC (Indian Electricity Grid Code) Regulations, 2023
- w) CEA (Flexible Operation of Coal Based Thermal Power Generating Units) Regulations, 2023
- x) Any other statutory codes / standards / regulations, as may be applicable.

The Bidder shall be responsible for facilitating statutory compliance for their part when applying for overall compliance up to Point of Interconnection (POI). Bidder shall comply with all provisions and its amendment(s)/Clarification(s) thereof of the following:

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- a. Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022.
- b. CERC 'Detailed Procedure for Connectivity and GNA' under the Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter - State Transmission System) Regulations, 2022".
- c. CERC (Grant of Connectivity, Long Term Access and Medium-term Access in Interstate Transmission and related matters) Regulation 2009 (if applicable as per extant connectivity regulations/procedures).
- d. CERC's revised procedure for "Grant of Connectivity to Projects based on renewable sources to inter-state transmission system" (if applicable as per extant connectivity regulations/procedures).
- e. CEA (Technical Standards for Connectivity to Grid) Regulation,2007.
- f. CEA (Technical Standards for construction of Electrical Plants and Electrical Lines) Regulation,2010.
- g. CEA (Grid Standard) Regulation,2010.
- h. CEA (safety requirements for construction, operation and maintenance of Electrical Plants and Electrical Lines) Regulations,2011.
- i. CEA (Measures relating to Safety and Electrical Supply) Regulations,2010.
- j. CEA (Installation and Operation of Meters) Regulations 2006.
- k. Indian Electricity Grid Code Regulation,2023.
- l. CEA (Technical standards for communication system in Power system operations) Regulation 2020
- m. CERC (Communication System for Inter State Transmission of Electricity) Regulations 2017
- n. MOP Order dated 02.07.2020 stating measures to protect the security, integrity and reliability of the strategically important and critical Power Supply System and Network in the Country.
- o. CEA (Cyber Security in Power Sector) Guidelines, 2021.
- p. Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022.
- q. MNRE/CEA/MOP guidelines/OM/Advisory/Clarifications.
- r. And any other applicable standards/regulations/Guidelines /clarifications /Oms /Advisories.
- s. Indian Electricity Grid Code (IEGC) 2023.
- t. Any other specific guidelines/Regulation/Advisory issued for BESS.


Bidder shall facilitate Employer by arranging required documents for submission of connectivity application (connectivity application shall be submitted by Employer) as per CERC/SERC guidelines. Employer shall bear the statutory charges to be paid for connectivity application (if applicable).

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications, the latest editions (as applicable as on date of bid opening), of the codes and standards given below shall also apply:

- a) Bureau of Indian standards (BIS)

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- b) Japanese Industrial Standards (JIS)
- c) American National Standards Institute (ANSI)
- d) American Society of Testing and Materials (ASTM)

- e) American Society of Mechanical Engineers (ASME)
- f) American Petroleum Institute (API)
- g) Standards of the Hydraulic Institute, U.S.A.
- h) International Organization for Standardization (ISO)
- i) Tubular Exchanger Manufacturer's Association (TEMA)
- j) American Welding Society (AWS)
- k) National Electrical Manufacturers Association (NEMA)
- l) National Fire Protection Association (NFPA)
- m) International Electro-Technical Commission (IEC)/ European Norm (EN)
- n) Expansion Joint Manufacturers Association (EJMA)
- o) Heat Exchange Institute (HEI)
- p) IEEE standard
- q) JEC standard

Other International/ National standards such as DIN, VDI, BS, GOST etc. shall also be accepted for only material codes and manufacturing standards, subject to the Employer's approval, for which the Bidder shall furnish, along with the offer, adequate information to justify that these standards are equivalent or superior to the standards mentioned above. In all such cases the Bidder shall furnish specifically the variations and deviations from the standards mentioned elsewhere in the specification together with the complete word to word translation of the standard that is normally not published in English.

As regards highly standardized equipment National /International standards such as JIS, DIN, VDI, ISO, SEL, SEW, VDE, IEC & VGB shall also be considered as far as applicable for Design, Manufacturing and Testing of the respective equipment. In addition, these standards shall be referred for the design of machine foundations, wherever specifically mentioned in the specifications. However, for those of the above equipment not covered by these National / International standards, established and proven standards of manufacturers shall also be considered.


In the event of any conflict between the codes and standards referred to in the above parts and the requirement of this specification, the requirement of Technical Specification shall govern.

Two (2) English language copies of all-national and international codes and/or standards which are not available with BHEL/End customer and same is used in the design of the plant, equipment, civil and structural works shall be provided by the Bidder to the Employer within two calendar months from the date of the Notification of Award.

In case of any change in codes, standards & regulations between the date of bid opening and the date when vendors proceed with fabrication, the Employer shall have the option to incorporate the

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changed requirements or to retain the original standard. It shall be the responsibility of the Bidder to bring to the notice of the Employer such changes and advise Employer of the resulting effect.

#### **EQUIPMENT FUNCTIONAL GUARANTEE**

The functional guarantees of the equipment under the scope of the Contract is given in of Technical Specifications. These guarantees shall supplement the general functional guarantee provisions covered under Defect liabilities ,General Conditions of Contract. .

Liquidated damages for shortfall in meeting functional guarantee(s) during the performance guarantee tests shall be assessed and recovered from the Bidder as specified elsewhere in this specification.

#### **DESIGN OF FACILITIES/ MAINTENANCE & AVAILABILITY CONSIDERATIONS**

##### **DESIGN OF FACILITIES**

All the design procedures, systems and components proposed shall have already been adequately developed and shall have demonstrated good reliability under similar conditions elsewhere.

The Bidder shall be responsible for the selection and design of appropriate equipment to provide the best co-ordinated performance of the entire system. The basic requirements are detailed out in various parts of the Technical Specifications. The design of various components, assemblies and subassemblies shall be done so that it facilitates easy field assembly and dismantling. All the rotating components shall be so selected that the natural frequency of the complete unit is not critical or close to the operating range of the unit.

##### **MAINTENANCE AND AVAILABILITY CONSIDERATIONS**

Equipment/facilities offered shall be designed for high availability, low maintenance and ease of maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability/ availability and ease of maintenance. The Bidder shall also furnish details of availability records in the reference plants stated in his experience list.

Bidder shall state in his offer the various maintenance intervals, spare parts and man- hour requirement during such operation. The intervals for each type of maintenance namely the minor and major overhauls shall be specified in terms of fired hours, clearly defining the spare parts and man-hour requirement for each stage.

Lifting devices i.e. hoists and chain pulley jacks, etc. shall be provided by the Bidder for handling of any equipment or any of its part having weight in excess of 500 kgs during erection and maintenance activities.

Lifting devices like lifting tackles, slings, etc. to be connected to hook of the hoist / crane shall be provided by the Bidder for lifting the equipment and accessories covered under the specification.

#### **DOCUMENTS, DATA AND DRAWINGS TO BE FURNISHED BY BIDDER**

Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant and equipment shall be fully integrated, engineered and designed

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to perform in accordance with the technical specification. All engineering and technical services required ensuring a completely engineered plant shall be provided in respect of mechanical, electrical, control & instrumentation, civil & structural works as per the scope.

Each main and auxiliary equipment/item of the plant including instruments shall be assigned a unique tag number. The assignment of tag numbers shall be in accordance with KKS system. In all drawings/documents/data sheet etc. KKS tag number of the equipment/item/instrument etc. shall be indicated.

A comprehensive engineering and quality coordination procedure shall be finalized with the successful bidder covering salient features as described in this section of specifications.

The Bidder shall furnish engineering data/drgs. for entire equipment covered under this specification in accordance with the schedule of information as specified in Technical Specification and Data sheets.

The documentation that shall be provided by the Bidder is indicated in the various sections of specification. This documentation shall include but not be limited to the following:

**A) BASIC ENGINEERING DOCUMENTATION**

Prior to commencement of the detailed engineering work, the Bidder shall furnish a Plant Definition Manual within 12 weeks from the date of the Notification of Award. This manual shall contain the following documents (as applicable) as a minimum:

- i) System description of all the mechanical, electrical, control & instrumentation & civil systems.
- ii) Technology scan for each system / sub-system & equipment.
- iii) Selection of appropriate technology / schemes for various systems/ subsystems including techno-economic studies between various options.
- iv) Optimization studies.
- v) Sizing criteria of all the systems, sub-systems/ equipments/ structures/ equipment foundations along with all calculations justifying and identifying the sizing and the design margins.
- vi) Schemes and Process & Instrumentation diagrams for the various systems/ sub-system with functional write-ups.
- vii) Not used.
- viii) Operation Philosophy and the control philosophy.
- ix) General Layout plan of the System incorporating all facilities in Bidder's as well as those in the Employer's scope.


Basic layouts and cross sections of the building, transformer yard, switchyard and other areas included in the scope of the bidder.

- xi) Documentation in respect of Quality Assurance System as listed out elsewhere in this specification.

The successful bidder shall furnish within three (3) weeks from the date of Notification of Award, a list of contents of the Plant Definition Manual (PDMs) including techno-economic studies, which shall then be mutually discussed & finalised with the Employer.

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**B) DETAILED ENGINEERING DOCUMENTS**


- i) General layout plan of the station.
- ii) Layouts, general arrangements, elevations and cross-sections drawings for all the equipment and facilities of the plant.
- iii) Flow diagram, Process and Instrumentation diagrams along with write up and system description.
- iv) Not Used.
- v) Not Used. vi) Not Used.
- vii) Technical data sheets for all bought out and manufactured items. Bidder shall use the (PSOR\HUV specifications as a base for placement of orders on their sub vendors.
- viii) Detailed design calculations for components, system, piping etc., wherever applicable including sizing calculations for all auxiliaries.
- ix) Not Used.
- x) Not Used. xi) Not Used xii) Not Used.
- xiii) Comprehensive list of all Terminal Points which interface with Employer's facilities, giving all the required details.
- xiv) Power supply single line diagram, block logics, control schematics, electrical schematics, etc.
- xv) Protection system diagrams and relay settings.
- xvi) Cables schedules and interconnection diagrams. xvii) Cable routing plan.
- xviii) Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, installation drawings for field mounted instruments, logic diagrams, control schematics, wiring of panels and enclosures etc.

Alarm and annunciation/ Sequence of Event (SOE) list and alarms & trip set points.

- xx) Sequence and protection interlock schemes. xxi) Type test reports. xxii) Control system configuration diagrams and maintenance details. xxiii) Detailed EMS/SCADA system manuals. xxiv) Not Used. xv) Mimic diagram layout, Assignment for other application engg.
- xxvi) Civil and Structural works drawings and documents for all structures, facilities, architectural works, foundations underground and overground works and super-structural works as included in the scope of the bidder civil calculation sheets including structural analysis and design alongwith output results.
- xxvii) Underground facilities, levelling, sanitary, land scaping drawings.
- xxviii) Geotechnical investigation and site survey reports (if and as applicable).

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- xxix) Not Used. xxx) Functional & guarantee test procedures and test reports.
- xxxi) Documentation in respect of Quality Assurance System, and Documentation in respect of Commissioning, as listed out elsewhere in this specification.
- xxxii) Documents such as P&IDs, Sizing calculations for various associated HTXLSPHQW\ datasheet etc. shall be as per MDL.
- xxxiii) Bidder shall submit all tabulated design calculations/ data, in both EXCEL format as well as in PDF format to enable BHEL/End customer for fast review /approval.

### INSTRUCTION MANUALS

The Bidder shall submit to the Employer, draft Instruction Manuals for all the equipment covered under the Contract by the end of one year from the date of his acceptance of the Letter of Award. The Instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. After finalization and approval of the Employer the Instruction Manuals shall be submitted. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals have been supplied to the Employer. The Instruction Manuals shall comprise of the following.


#### (a) Erection & Commissioning Manuals/Checklists

The erection & Commissioning Manuals/Checklists shall be submitted at least three (3) months prior to the commencement of erection activities of particular equipment/system. The erection manual should contain the following as a minimum.

- a) Erection strategy.
- b) Sequence of erection.
- c) Erection instructions.
- d) Critical checks and permissible deviation/tolerances.
- e) List of tool, tackles, heavy equipment like cranes, dozers, etc. f) Bill of Materials
- g) Procedure for erection.
- h) General safety procedures to followed during erection/installation.
- i) Procedure for initial checking after erection.
- j) Procedure for testing and acceptance norms.
- k) Procedure / Check list for pre-commissioning activities.
- l) Procedure / Check list for commissioning of the system.
- m) Safety precautions to be followed in electrical supply distribution during erection

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#### **(b) Operation & Maintenance Manuals**

- i. The operating and maintenance instructions together with drawings (other than shop drawings) of the equipment, as completed, shall be in sufficient detail to enable the Employer to operate, maintain, dismantle, reassemble and adjust all parts of the equipment. They shall give a step-by-step procedure for all operations likely to be carried out during the life of the plant / equipment including, operation, maintenance, dismantling and repair including periodical activities such as chemical cleaning of the generator. Each manual shall also include a complete set of drawings together with performance/rating curves of the equipment and test certificates wherever applicable. The contract shall not be considered to be completed for purposes for taking over until these manuals have been supplied to the Employer.
- ii. If after the commissioning and initial operation of the plant, the manuals require any modification / additions / changes, the same shall be incorporated and the updated final instruction manuals shall be submitted to the Employer for records.
- iii. A separate section of the manual shall be for each size/ type of equipment and shall contain a detailed description of construction and operation, together with all relevant pamphlets and drawings.
- iv. The manuals shall include the following:
  - a. List of spare parts along with their drawing and catalogues and procedure for ordering spares.
  - b. Lubrication Schedule including charts showing lubrication checking, testing and replacement procedure to be carried daily, weekly, monthly & at longer intervals to ensure trouble free operation.
  - c. Where applicable, fault location charts shall be included to facilitate finding the cause of mal-operation or break down.
- v. Detailed specifications for all the consumables including lubricant oils, greases, chemicals etc. system/equipment/assembly/sub-assembly - wise required for the complete plant.
- vi. On completion of erection, a complete list of bearings / equipment giving their location, and identification marks etc. shall also be furnished to the Employer indicating lubrication method for each type/category of bearing.

#### **Project Completion Report**


The Bidder shall submit a Project Completion Report at the time of handing over the plant. After final acceptance of individual equipment /system by the Employer, the Bidder will update all original drawings and documents for the equipment/ system to "as built" conditions and submit.

#### **ENGINEERING INFORMATION SUBMISSION SCHEDULE**

Prior to the award of Contract, a Detailed Engineering Information Submission Schedule shall be tied up with the Employer. For this, the bidder shall furnish a detailed list of engineering information along with the proposed submission schedule. This list would be a comprehensive one including

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all engineering data / drawings / information for all bought out items and manufactured items. The information shall be categorized into the following parts.

- a) Information that shall be submitted for the approval of the Employer before proceeding further, and
- b) Information that would be submitted for (PSOR\HUV information only.

The Engineering Information Schedule shall be updated month-wise.

The schedule should allow adequate time for proper review and incorporation of changes/modifications, if any, to meet the contract without affecting the equipment delivery schedule and overall project schedule. The early submission of drawings and data is as important as the manufacture and delivery of equipment and hardware and this shall be duly considered while determining the overall performance and progress.

#### **ENGINEERING PROGRESS AND EXCEPTION REPORT**

Report giving the status of each engineering information including

- (a) A list of drawings/engineering information which remains unapproved for more than four (4) weeks after the date of first submission

Drawings which were not submitted as per agreed schedule.

The draft format for this report shall be furnished to the Employer within four

- (4) weeks of the award of the contract, which shall then be discussed and finalized with the Employer.

#### **TECHNICAL CO-ORDINATION MEETING**

- x The Bidder shall organize and attend at least one monthly progress Meetings with the Employer/Employer's representatives during the period of Contract at mutually agreed venues for review of progress & resolving technical clarifications, if any. The Bidder shall attend such meetings at his own cost and fully co-operate with such persons and agencies involved during the discussions.
- x The Bidder shall ensure availability of the concerned experts / consultants/ personnel who are empowered to take necessary decisions during these meetings. The Bidder shall be equipped with necessary tools and facilities so that, if required, the drawings/documents can be resubmitted after incorporating necessary changes and approved during the meeting itself.
- x The Bidder shall furnish monthly progress report to the Employer detailing out the progress achieved on all erection activities as compared to the schedules. The report shall also indicate the reasons for the variance between the scheduled and actual progress and the action proposed for corrective measures, wherever necessary.

#### **DESIGN IMPROVEMENTS**

The Employer or the Bidder may propose changes in the specification of the equipment or quality thereof and if the parties agree upon any such changes the specification shall be modified accordingly.

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If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any changing the price and/or schedule of completion before the Bidder proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

#### **EQUIPMENT BASES**

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer. Each base plate which support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

#### **PROTECTIVE GUARDS**

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards shall be designed for easy installation and removal for maintenance purpose.

#### **LUBRICANTS, SERVO FLUIDS AND CHEMICALS**

7KH%LGGHU¶VVFRLSHLQFOXGHVDOOWKHILUVWILOODQGRQH\HDU¶VWRSSLQJUHTXLUHPHQWV of consumables such as oils, lubricants including grease, servo fluids, gases and essential chemicals etc. Consumption of all these consumables during the initial operation and final filling after the initial operation shall also be included in the scope of the Bidder.

As far as possible lubricants marketed by reputed companies shall be used. The variety of lubricants shall be kept to a minimum possible.

Detailed specifications for the lubricating oil, grease, gases, servo fluids, control fluids, chemicals etc. required for the complete plant covered herein shall be furnished. On completion of erection, a complete list of bearings/ equipment giving their location and identification marks shall be furnished to the Employer along with lubrication requirements. **Lubrication**

Equipment shall be lubricated by systems designed for continuous operation. Lubricant level indicators shall be furnished and marked to indicate proper levels under both standstill and operating conditions.

#### **Material of Construction**


All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilized for various components shall be those which have established themselves for use in such applications.

#### **RATING PLATES, NAME PLATES & LABELS**

Each main and auxiliary item of plant including instruments shall have permanently attached to it in a conspicuous position, a rating plate of non- corrosive material upon which shall be engraved PDQXIDFWXUHU¶V name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Employer.

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Such nameplates or labels shall be of white non-hygroscopic material with engraved black lettering or alternately, in the case of indoor circuit breakers, starters, etc. of transparent plastic material with suitably coloured lettering engraved on the back. The name plates shall be suitably fixed on both front and rear sides.

Hanger/ support numbers shall be marked on all pipe supports, anchors, hangers, snubbers and restraint assemblies. Each constant and variable spring support shall also have stamped upon it the designed hot and cold load which it is intended to support. Suitable scale shall also be provided to indicate load on support/hanger.

Nameplates shall be as per best practices of the industry

All such plates, instruction plates, etc. shall be bilingual with Hindi inscription first, followed by English. Alternatively, two separate plates one with Hindi and the other with English inscriptions may be provided.

All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system

#### **TOOLS AND TACKLES**

The Bidder shall supply with the equipment one complete set of all special tools and tackles and other instruments required for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software). These special tools will also include special material handling equipment, jigs and fixtures for maintenance and calibration / readjustment, checking and measurement aids etc. A list of such tools and tackles shall be submitted by the Bidder along with the offer.

The price of each tool / tackle shall be deemed to have been included in the total bid price. These tools and tackles shall be separately packed and sent to site. The Bidder shall also ensure that these tools and tackles are not used by him during erection, commissioning and initial operation. For this period the Bidder should bring his own tools and tackles. All the tools and tackles shall be of reputed make acceptable to the Employer.

#### **Welding**

If the manufacturer has special requirements relating to the welding procedures for welds at the terminals of the equipment to be performed by others the requirements shall be submitted to the Employer in advance of commencement of erection work.

#### **COLOUR CODE FOR ALL EQUIPMENTS/ PIPINGS/ PIPE SERVICES**

All equipment/ piping/ pipe services are to be painted by the Bidder in accordance with (PSOR\HUV standard colour coding scheme, which will be furnished to the Bidder during detailed engineering stage.

#### **PROTECTION AND PRESERVATIVE SHOP COATING**


##### **Protection**

All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either metallic or a nonmetallic protection device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage. The parts

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which are likely to get rusted, due to exposure to weather, should also be properly treated and protected in a suitable manner. All primers/paints/coatings shall take into account the hot humid, corrosive & alkaline, subsoil or overground environment as the case may be.

#### **Preservative Shop Coating**

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. All surfaces which will not be easily accessible after the shop assembly, shall be treated beforehand and protected for the life of the equipment. All surfaces shall be thoroughly cleaned of all mill scales, oxides and other coatings and prepared in the shop. The surfaces that are to be finish- painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer.

Transformers and other electrical equipment if included shall be shop finished with one or more coats of primer and two coats of high-grade resistance enamel. The ILQLVKHG FRORUV VKDOO EH DV SHU PDQXIDFWXUHU¶V VWDQGDUGV WR EH VHOHFWHG DQG specified by the Employer at a later date.

Shop primer for all steel surfaces which will be exposed to operating temperature below 95 degrees Celsius shall be selected by the Bidder after obtaining specific approval of the Employer regarding the quality of primer proposed to be applied. Special high temperature primer shall be used on surfaces exposed to temperature higher than 95 degrees Celsius and such primer shall also be subject to the approval of the Employer.

All other steel surfaces which are not to be painted shall be coated with suitable rust preventive compound subject to the approval of the Employer.

All piping shall be cleaned after shop assembly by shot blasting or other means approved by the Employer. Lube oil piping or carbon steel shall be pickled.

Painting for Civil structures shall be done as per relevant part of technical specification

#### **Provision for Fail Safe operation of vital Equipments**

All the Plant and equipment / Systems supplied under the contract shall be designed IROORZLQJ³DLO6DIH´FRQFHSW In case of failure of Power supply, the system should be designed in such a way that the equipment/systems etc. shall always remain in the safest position as per system requirement to ensure safety of Man and Equipment.

#### **Engineering Co-ordination Procedure**

The following principal coordinators will be identified by respective organizations after award of contract:

End customer Engineering Coordinator (End customer EC):

Name :

Designation :

Address :


a) Postal :

b) Telegraphic / e-Mail :

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c) FAX : TELEPHONE :

Name :

Designation :

Address :

a) Postal :

b) Telegraphic / e-Mail :

c) FAX : TELEPHONE :

All engineering correspondence shall be in the name of above coordinators on behalf of the respective organizations.

All data/information furnished by Vendor in the form of drawings

- Bidder shall furnish this format to his sub-vendor along with his purchase order
- The Bidder shall make a visit to site to see the existing facilities and understand the layout completely and collect all necessary data / drawings at site which are needed as an input to the engineering. The Bidder shall do the complete engineering including interfacing and integration of all his equipment, systems & facilities within his scope of work as well as interface engineering & integration of systems, facilities, equipment & works under (PSOR\HUIV VFRSH DQG VXEPLW DOO QHFHVVDU\ GUDZLQJs/ documents for the same.
- **Drawings must be checked by the Bidder in terms of its completeness, data adequacy and relevance with respect to engineering schedule prior to submission to the Employer. In case drawings are found to be submitted without proper endorsement for checking by the Bidder, the same shall not be reviewed and returned to the Bidder for re-submission.**
- drawings submitted by the Bidder/vendor shall be reviewed by End customer and their comments shall be forwarded within three (3) weeks of receipt of drawings. Upon review of each drawing, depending on the correctness and completeness of the drawing, the same will be categorized and approval accorded in one of the following categories:

CATEGORY- I : Approved


CATEGORY- II Approved, subject to incorporation of comments/ modification as noted. Resubmit revised drawing incorporating the comments.

CATEGORY ±III Not approved. Resubmit revised drawings for approval after incorporating comments/ modification as noted.

CATEGORY -IV For information and records.

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- h) After Rev 0 comments, the drawing will be locked in the system. Bidder will review the Rev 0 comments within 7 days & furnish the Comment Reply Sheet (CRS) to BHEL/End customer as an agenda point for TCM. TCM shall be conducted with Bidder on non-agreed comments of CRS. System will not allow Bidder to submit approval category drawings before the scheduled submission date. However, documents may be unlocked on case to case basis. Based on resolution of all comments and agreements, the document will be approved in TCM itself. The Bidder will revise the document based on the resolutions and certify that all the resolutions has been taken care of. Based on this certification, the document will be opened and submitted by Bidder in the system for approval as Rev 01 within 10 days of TCM.
- i) In case, the Bidder/ Vendor does not agree with any specific comment, he shall furnish the explanation for the same to BHEL/End customer for consideration. In all such cases the Bidder shall necessarily enclose explanations along with the revised drawing (taking care of balance comments) to avoid any delay and/or duplication in review work.
- j) It is responsibility of the Bidder/ Vendor to get all the drawings approved in the Category I & IV (as the case may be) and complete engineering activities within the agreed schedule. Any delay arising out of submission and modification of drawings shall not alter the contract completion schedule.
- k) If Bidder/ Vendor fails to resubmit the drawings as per the schedule, construction work at site will not be held up and work will be carried out on the basis of comments furnished on previous issues of the drawing.
- l) These comments will be taken care by the Bidder while submitting the revised drawing.

The Bidder shall use a single transmittal for drawings. Submission. This shall include transmittal numbers and date, number of copies being sent, names of the agencies to whom copies being sent, drawing number and titles, remarks or special notes if any etc.

## **QUALITY ASSURANCE PROGRAMME**


**NOTE: RESPECTIVE QA PORTION OF THE GTR SHALL BE APPLICABLE AS PER SCOPE OF THE SUBJECT PACKAGE.**

To ensure that the equipment and services under the scope of contract whether PDQXIDFWXUHGRUSHUIRUPHGZLWKLQWKH&RQWUDFWRU¶VZRUNVRUDWKLVVXE-FRQWUDFWRU¶V SUHPLVHVRUDWWKH(PSOR\HU¶VVLWHRUDWDQ\RWKHUSODFHRIZRUNDUHLQDFFRUGDQFH with the specifications, the Bidder shall adopt suitable quality assurance programme to control such activities at all points, as necessary. Such programmes shall be outlined by the Bidder and shall be shall be finalized during detailed engineering with employer / authorized representative after discussion. The QA programme shall be generally in line with ISO-9001/IS-14001. A quality assurance programme of the Bidder shall generally cover the following:

- His organisation structure for the management and implementation of the proposed quality assurance programme
- Quality System Manual
- Design Control System

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- d) Documentation Control System
- e) 4XDOLILFDWLRQGWDWDIRU%LGGHU¶VNH\3HUVRQQHO
- f) The procedure for purchase of materials, parts, components and selection of sub-FRQWUDFWRU¶V¶VHUYLFHVLQFOXGLQJYHQGRUDQDO\VLVVRXUFHLQVSHFWLRQ incoming raw-material inspection, verification of materials purchased etc.
- g) System for shop manufacturing and site erection control including process controls and fabrication and assembly controls.
- h) Control of non-conforming items and system for corrective actions.
- i) Inspection and test procedure both for manufacture and field activities.
- j) Control of calibration and testing of measuring testing equipment's.
- k) System for Quality Audits.
- l) System for indication and appraisal of inspection status.
- m) System for authorising release of manufactured product to the Employer.
- n) System for handling storage and delivery.
- o) System for maintenance of records, and


Furnishing of quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality.

#### **GENERAL REQUIREMENTS - QUALITY ASSURANCE**

- All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme.
- Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted on electronic media through C-folders, a webbased system of End customer ERP, for review and approval.
- Field Quality Plans will detail out for all the equipment, the quality practices ,during various stages of site activities starting from receipt of materials/equipment at site.
- All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Employer along with technical justification for approval and dispositioning.

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- The field welding schedule shall be submitted to the Employer along with all supporting documents. like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site.
- The Bidder shall have suitable Field Quality Organization with adequate manpower at Employer's site, to effectively implement the Field Quality Plan (FQP) and Field Quality Management System for site activities. The Bidder shall submit the details of proposed FQA setup (organizational structure and manpower) for employer's approval. The FQA setup shall be in place at least one month before the start of site activities.
- No material shall be dispatched from the manufacturer's works before the same is accepted by Employer's Project Manager/Authorized representative and duly authorized for dispatch by issuance of Material Dispatch Clearance Certificate (MDCC / CHP Clearance).
- All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details
- All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Employer.
- All welding/brazing procedures shall be submitted to the Employer or its authorized representative prior to carrying out the welding/brazing.
- Procedures to be qualified at site will be submitted to BHEL/End customer .
- For all IBR pressure parts and high pressure piping welding, the latest applicable requirements of the IBR (Indian Boiler Regulations) shall also be essentially complied with. However, other piping shall be as per relevant code. Similarly, any other statutory requirements for the equipment/systems shall also be complied with. On all back-gauged welds MPI/LPI shall be carried before seal welding
- All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.
- No welding shall be carried out on cast iron components for repair.
- Unless otherwise proven and specifically agreed with the Employer, welding of dissimilar materials and high alloy materials shall be carried out at shop only.

All non-destructive examination shall be performed in accordance with written procedures as per International Standards, The NDT operator shall be qualified as per SNT-TC-IA/ISO:9712 (of the American Society of non-destructive examination). NDT shall be recorded in a report, which

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includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.

In general all plates of thickness greater than 40mm & for pressure parts plates of thickness equal to or greater than 25mm shall be ultrasonically tested otherwise as specified in respective equipment specification. All bar stock/Forging of diameter equal to or greater than 40 mm shall be Ultrasonically tested.

The Bidder shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-Bidders (BOI).

All the sub-vendors proposed by the Main Bidder for procurement of major bought out items including castings, forgings, semi-finished and finished components/equipment etc., list of which shall be drawn up by the Bidder and finalised with the Employer, shall be subject to Employer's approval on enclosed format as Annexure-III.

List of End customer approved sub vendors against similar Pkg/items refer End customer site.

7KHFRQWUDFWRU¶VSURSRVDOIRUDQ\QHZVXEYHQGRUIRUDQ\RIWKHLWHPVLGHQWLILHGLQ indicative sub-vendor list shall necessarily be furnished in the sub vendor questionnaire & main Bidder Evaluation report format attached as Annexure- VII with all relevant documents and main Bidder's own physical assessment report(physical for domestic manufacturers and physical/document review as applicable for foreign manufacturer) assessed as per their quality management system for End customer review and acceptance.


New sub vendor proposal will only be considered for End customer review, provided the proposal is received sufficiently in time: 90 days prior to ordering date of a BoughtOut Items/Start of Manufacturing so as not to impede the progress of the contract. Main Bidder shall submit the documentation as mentioned below:

- Duly Filled Main supplier Evaluation Report.
- Duly Filled Sub-Supplier Questionnaire.
- Factory Registration/License Certificate(as applicable).
- Overall Organization Chart with Manpower details (Design, Manufacturing, Quality etc.)
- Supply reference list of the Sub-Supplier indicating similar product supply order reference no., customer name, rating of product, date /year of supply, date / year of commissioning.
- vi. List of Manufacturing Equipment available with sub vendor.
- vii. List of Testing Equipment available with sub vendor.
- Manufacturing process execution plan with flow chart indicating various stages of manufacturing from raw material to finished product including outsourced process, if any.
- ix. Details of Outsourced Manufacturing Processes, if any.
  - Quality control exercised during receipt, in-process & final inspection.
- Compliance of Statutory requirements (As applicable)

After first submission of proposal to BHEL/End customer , in absence of relevant documents/ Incompleteness of the proposal, The main Bidder will be given a period of maximum 07 days to submit the compliance of the BHEL/End customer comments. In case of noncompliance, it will

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be presumed that main Bidder is not serious about pursuing the proposal & the proposal will be foreclosed.

Major checks and quality requirements as mentioned below shall necessarily be assessed by main Bidder and complied with documentary support in case the same is not the part of their Quality management system

The proposed Sub vendor will be assessed broadly on following mandatory criteria

i) Quality Management System Compliance including raw material/BOI control, traceability & control over outsources process ii) Design Capabilities (As applicable) iii) Manufacturing, Testing & Storage Facility iv) Processing Capabilities

v) Supply Experience indicating similar product supply order reference no., customer name, rating of product, date /year of supply, date / year of commissioning

vi) Safety Aspect

In case of major observations or non-compliance observed during sub vendor works visit (Jointly with the main Bidder) with respect to the submitted documents, proposed sub vendor will not be considered for acceptance and Main Bidder will be solely responsible in such cases.

Monthly progress reports on sub-vendor detail. Submission / approval shall be furnished preferably on enclosed format at Annexure-IV. Such vendor approval shall not relieve the Bidder from any obligation, duty or responsibility under the contract.

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

Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Employer/ authorised representative.

#### **Environmental Stress Screening**

Environmental stress screening test process / procedure for eliminating infant mortile components for DDCMIS / PLC based system & for other systems having substantial electronics components (as determined by employer) like Electronic transmitter, CCTV components, PA systems etc. shall be furnished for BHEL/End customer acceptance


The Bidder / Sub-Bidder shall carry out routine test on 100% item at Bidder / sub-Bidder's works. The quantum of check / test for routine & acceptance test by employer shall be generally as per criteria / sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check / test for routine / acceptance test shall be as agreed during detailed engineering stage.

#### **Software Reliability / Quality Certification**

PLC, CCTV, PA, Pyrometer, CEMS, AAQMS, EQMS, BHMS etc. declaring that the all the offered software(s) had gone through the established software quality test and offered version and offered software is also free from all known bugs as on date of approval of systems documents by

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BHEL/End customer as a part of quality documentation review and approval process during detail engineering.

## QUALITY ASSURANCE DOCUMENTS

The Bidder shall be required to submit the QA Documentation in soft copies, as identified in respective quality plan with tick (✓) mark.

Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The final quality document will be compiled and issued at the final assembly place of equipment before despatch. However, **soft copies will be furnished** not later than two (2) weeks.

Typical contents of QA Documentation is as below:-

- (a.) Quality Plan
- (b.) Material mill test reports on components as specified by the specification and approved Quality Plans.
- (c.) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- (d.) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
- (e.) Heat Treatment Certificate/Record (Time- temperature Chart)
- (f.) All the accepted Non-conformance Reports (Major/Minor)/deviation, including complete technical details / repair procedure).
- (g.) CHP / Inspection reports duly signed by the Inspector of the Employer and Bidder for the agreed Customer Hold Points.
- (h.) Certificate of Conformance (COC) wherever applicable.
- (i.) MDCC

Similarly, the Bidder shall be required to submit soft copies containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.


Before dispatch / commissioning of any equipment, the Supplier shall make sure that the corresponding quality document or in the case of protracted phased deliveries, the applicable section of the quality document file is completed. The supplier will then notify the Inspector regarding the readiness of the quality document (or applicable section) for review.

If the result of the review carried out by the Inspector is satisfactory, the Inspector shall stamp the quality document (or applicable section) for release.

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If the quality document is unsatisfactory, the Supplier shall endeavor to correct the incompleteness, thus allowing to finalize the quality document (or applicable section) by time compatible with the requirements as per contract documents. When it is done, the quality document (or applicable section) is stamped by the Inspector.

If a decision is made for dispatch, whereas all outstanding actions cannot be readily cleared for the release of the quality document by that time, the supplier shall immediately, upon shipment of the equipment, send a copy of the quality document Review Status signed by the Supplier Representative to the Inspector and notify of the committed date for the completion of all outstanding actions & submission. The Inspector shall stamp the quality document for applicable section when it is effectively completed. The submission of QA documentation package shall not be later than two (2) weeks after the dispatch of equipment.

#### **TRANSMISSION OF QA DOCUMENTATION**

On release of QA Documentation by Inspector, one set of quality document shall be forwarded to Corporate Quality Assurance Department and other set to respective Project Site of Employer.

For the particular case of phased deliveries, the complete quality document to the Employer shall be issued not later than two (2) weeks after the date of the last delivery of equipment.

The work shall be performed under the supervision of the Project Manager.

The scope of the duties of the Project Manager pursuant to the Contract, will include but not be limited to the following:

The Project Manager or Inspector shall within 15 days from the date of inspection as defined herein give notice in writing to the Bidder, or any objection to any drawings and all or any equipment and workmanship which is in his opinion not in accordance with the contract. The Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Project Manager/Inspector giving reasons therein, that no modifications are necessary to comply with the contract.

In all cases where the contract provides for tests whether at the premises or works of the Bidder or any sub-Bidder, the Bidder, except where otherwise specified shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Project Manager /Inspector or his authorized representatives to carry out effectively such tests on the equipment in accordance with the Bidder and shall give facilities to the Project Manager/Inspector or to his authorized representative to accomplish testing.

The inspection by Project Manager / Inspector and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the agreed Quality Assurance Programme forming a part of the contract.

The Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be

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made for each three consecutive months and shall be furnished before beginning of each calendar month.

All inspection, measuring and test equipment used by Bidder shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Bidder shall maintain all the relevant records of periodic calibration and instrument identification and shall produce the same for inspection by BHEL/End customer. Wherever asked specifically, the Bidder shall re-calibrate the measuring/test equipment in the presence of Project Manager / Inspector.

#### **PRE-COMMISSIONING AND COMMISSIONING FACILITIES**

The Bidder upon completion of installation of equipments and systems, shall conduct pre-commissioning and commissioning activities, to make the equipment/systems ready for safe, reliable and efficient operation on sustained basis. During commissioning the Bidder shall carry out system checking and reliability trials on various parts of the facilities. All pre-commissioning/commissioning activities considered essential for such readiness of the equipment/systems including those mutually agreed.

#### **SAFETY ASPECTS DURING CONSTRUCTION AND ERECTION**

In addition to the requirements given in Erection Conditions of Contract (ECC) the following shall also cover:

- (a) Working platforms should be fenced and shall have means of access.
- (b) Safety officer and supervisor need to be deployed and standard wages as per state/central acts to be provided.

#### **PACKAGING AND TRANSPORTATION**

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Bidder shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

#### **ELECTRICAL ENCLOSURE**

All electrical equipment and devices, including insulation, heating and ventilation devices shall be designed for ambient temperature and a maximum relative humidity as specified elsewhere in the specification.

#### **Instrumentation and Control**

All instrumentation and control systems/ equipment/ devices/ components, furnished under this contract shall be in accordance with the requirements stated herein, unless otherwise specified in the detailed specifications.

All instrument scales and charts shall be calibrated and printed in metric units and shall have linear graduation. The ranges shall be selected to have the normal reading at 75% of full scale.

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All scales and charts shall be calibrated and printed in Metric Units

All instruments and control devices provided on panels shall be of miniaturized design, suitable for modular flush mounting on panels with front draw out facility and flexible plug-in connection at rear.

All electronic modules shall have gold plated connector fingers and further all input and output modules shall be short circuit proof. These shall also be tropicalised & components shall be of industrial grade or better.

#### **ELECTRICAL NOISE CONTROL**

The equipment furnished by the Bidder shall incorporate necessary techniques to eliminate measurement and control problems caused by electrical noise. Areas LQ & RQWUDFWRUHTXLSPHQW ZKLFK DUH YXOQHUDEOH WR HOHFWULFDO QRLVH VKDOO EH hardened to eliminate possible problems. Any additional equipment, services required for effectively eliminating the noise problems shall be included in the proposal. The equipment shall be protected against ESD as per IEC-801-2. Radio Frequency interference (RFI) and Electro Magnetic Interference (EMI) protection against hardware damage and control system mal-operations/errors shall be provided for all systems.

#### **ELECTRONIC MODULE/COMPONENT DETAILS**

The Bidder shall have to furnish all technical details including circuit diagrams, specifications of components, etc., in respect of each and every electronic card/module as employed on the various solid state as well as microprocessorbased systems and equipment including conventional instruments, peripherals etc.

It is mandatory for the Bidder to identify clearly the custom-built ICs used in the package. The Bidder shall also furnish the details of any equivalents of the same.

#### **TRAINING OF EMPLOYER'S PERSONNEL**

The Bidder shall provide training (free of cost) to the personnel of BHEL/End customer (for the operators, engineers, technicians and maintenance personnel) for 15 man-days at respective site for erection, testing, commissioning and O&M. Expenses towards travel, lodging, and boarding etc. for BHEL/End customer personnel shall be borne by BHEL/End customer .

#### **MAKE IN INDIA REQUIREMENTS**


The bidder shall follow Indian laws, regulations and standards. There shall not be any restriction in terms of compliance to codes & standards of foreign origin only. The compliance to equivalent/better Indian as well as other codes & standards, wherever available, shall also be acceptable.

The technologies/ products offered shall be environmentally friendly, consuming less energy, and safe, energy efficient, durable and long lasting under the prescribed operational conditions.

The bidder/its sub vendor/supplier shall ensure supply of spares, materials and technological support for the entire life of the project.

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- The bidder shall list out the products and components producing Toxic Ewaste and other waste as specified. It shall have an Extended Producers Responsibility (EPR) so that after the completion of the lifecycle, the materials are safely recycled/ disposed of by the Bidder and for this, the bidder has to establish recycling/disposal unit as specified. Bidder shall also comply with Plastic Waste Management Rules, 2016, as amended from time to time, and facilitate EPR (Extended Producer Responsibility) registration of Employer before import of plastic packaging product or products with plastic packaging or carry bags or multi-layered packaging or plastic sheets or like.
- The equipment/ material sourced from foreign companies will be tested in accredited labs in India before acceptance wherever such facilities are available. The testing shall be carried out in accordance with MOP extant order/guidelines.
- The bidder shall have to furnish a certificate regarding cyber security/safety of the equipment/process to be supplied/services to be rendered as safe to connect.
- All applicable safety requirements shall be met. Regular safety audit shall be carried out by the manufacturer/ supplier.
- Wherever required, the foreign supplier shall establish fully functional service centers in India and shall keep spares/material locally for future needs of Employer.


To protect the security, integrity and reliability of equipment in this package, it is essential to remove vulnerabilities arising out of the possibility of cyberattack through malware/ Trojans etc. embedded in imported equipments. This requirement shall apply to any item imported for end use or to be used as a component, or as a part in manufacturing, assembling of any equipment or to be used in this package. Bidder shall comply all the requirements of Order No 25-11/6/2018-PG, dated 02/07/2020 (attached as Appendix-I), issued by Ministry of Power, Government of India and its subsequent amendments/revisions. Bidder shall furnish declaration of compliance of MOP order dated 02/07/2020 requirements with dispatch of equipment/ item. Further, Bidder shall furnish back up testing certificates, whenever Employer asks the same.

All equipment/materials/parts/items required in this package which are domestically manufactured with sufficient domestic capacity as identified in Annexure-I of MOP order dated 16/11/2021 including its subsequent revisions

Any violation w.r.t Make in India and minimum local content (MLC) requirements as specified shall be sole responsibility of the Bidder.

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## 35. SITE ESTABLISHMENT FOR BHEL

### General

The Bidder shall be fully responsible for establishing, provisioning, maintaining, and operating the complete site infrastructure and amenities required to support BHEL's project execution , Trial run and CAMC activities at the site. The entire scope of site establishment shall remain active and in working condition for the entire duration of the construction phase as well as the Trial run, CAMC or until specifically released by the BHEL Site In-Charge. The Bidder shall ensure that all infrastructure, utilities, food , manpower, equipment, and services provided are in compliance with applicable safety, statutory, and environmental norms, and are maintained in safe, clean, and efficient condition throughout the contractual duration.

### Site Infrastructure and Utilities

The Bidder shall provide a minimum of two , maximum three (will be decided during site works) air-conditioned Porta Cabins for each projects, having a combined area of not less than 400 sq. ft. The office units shall be equipped with desks, chairs, fans, lighting, fire extinguishers, and electrical plug points. IT infrastructure including laptops or desktops with licensed software, a multifunction A4 printer ,A3 printer and high-speed document scanner, LED television, and unlimited internet dongles shall be provided for BHEL's use. All office units shall remain functional and accessible for the full duration of the project execution and CAMC phase

A separate mobile or environmentally friendly toilet container with water tank shall also be installed nearby. All necessary electrical and civil works including water pipeline and plumbing shall be executed by the Bidder. The Porta Cabins shall be powered by the main green solar system or individual microgrids.

Provision of water supply through Sintex-type water tanks, including necessary plumbing, refilling arrangements, and sanitation support shall be ensured. Hygienic prefabricated western-style toilets with ventilation, septic tanks, and plumbing connections shall be installed and maintained. Outdoor and indoor LED lighting shall be installed for safe working conditions during low light hours.


### Security and Surveillance

The Bidder shall install a complete CCTV system covering all strategic points, including entry, storage, and work areas, consisting of PTZ and fixed cameras, NVR/DVR systems with display and storage, and power backup. Site fencing using metallic posts and GI chain-link mesh, guard cabins, and secure storage containers shall also be provided and maintained to ensure security of personnel and materials.

### Storage and Material Handling

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The Bidder shall provide covered storage sheds with GI roofing and raised flooring for safe storage of materials. Equipment such as forklifts, hydra cranes, and weighing machines (10 kg and 100 kg) shall be made available along with trained manpower for material unloading, shifting, and verification.

#### **Site Preparation and Access**

Clearing, Grading , levelling, and preparation of internal WBM roads shall be carried out for the smooth and safe movement of men and materials. Wooden fencing shall be installed around key areas to prevent unauthorized access and entry of animals.

#### **Pantry, Housekeeping, and Daily Services**

A pantry with gas stove, hot plate, LPG cylinder, utensils, and provision of basic hospitality with refreshments shall be ensured for BHEL personnel and site visitors. Daily housekeeping and drinking water supply shall be arranged. Required PPE (helmets, shoes, gloves, jackets) and first-aid kits shall be stocked and made accessible.

#### **Manpower Support**

Trained manpower including helpers, operators, security personnel, storekeepers, and housekeeping staff shall be deployed as per requirement. All statutory requirements including PF, ESI, safety training, and PPE compliance shall be ensured by the Bidder.

#### **Accommodation and Transport**

The Bidder shall provide a well-furnished air conditioned 3 nos (minimum) of 2 BHK house with cook, lighting, furniture, TV, water, electricity, LPG gas refills, and utensils for BHEL officials' accommodation or minimum four double bed AC rooms with TV , Fridge in hotel in the nearest city. Additionally, two numbers air-conditioned 4-wheeler SUV vehicle-7seater, in excellent roadworthy condition with a professional driver, shall be made available for official use of BHEL personnel for commuting and site visits, throughout the project execution , Trial run and CAMC duration. Minimum movement of vehicle shall be from nearest city to BESS plant and inside the plant on daily basis and need to go out of the city occasionally during the contract period.

During Trial runs and critical fault durations required transportation including extra vehicle , extra accommodation shall be arranged by bidder.

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**Food:**

“The bidder shall provide healthy vegetarian and non-vegetarian food to BHEL executives/nominated personnel for a minimum of ten (10) members on a daily basis. During Trial run and critical fault durations, food for a minimum of fifteen (15) members shall be arranged daily. The menu shall be mutually decided. The bidder shall ensure that all food is freshly prepared using good-quality vegetables, fish, meat, and other ingredients. Snacks and refreshments shall be maintained and provided as required. One room boy shall be available in the BHEL accommodation on a 24×7 basis. The accommodation shall also be equipped with a refrigerator, television, and washing machine in good working condition.”

**Notes**

The Bidder shall ensure availability and operational readiness of all above-mentioned infrastructure, manpower, and equipment throughout the construction Trial run period, till completion of CAMC/O&M- as per BHEL’s instructions. Any required consumables, maintenance, or repairs shall be done at the Bidder’s cost. The infrastructure shall remain the property of the Bidder and may be removed after commissioning of the full project.

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### **36.DELIVERY SCHEDULE**

The following shall be the schedule for completion of work for Each Project

S. N	Activities/Milestone	Period from LOA/PO (Months)	
		Start	Finish
General Works			
1	Site Mobilization, Site office opening and Preparatory works	0	1
2	Topographical Survey and Geo-Technical investigation	0	1
3	Site clearance, Grading work, etc.	1	3
4	Grid study studies, Interconnection studies and Reactive Power Compensation studies and its approval	2	7
5	Basic Engineering, SLD, Site Layout & approvals	0	1
Detail Engineering, BOI and Execution			
6	Ordering of BOIs	1	2
7	Detailed Engineering and Approvals	2	4
8	Supply of BESS and associated systems	5	10
9	civil works for BESS and associated systems till 33kV switchyard end	4	8
10	Erection of BESS and associated systems till 33kV switchyard end	6	11
11	Supply of AC cables, Inverters, Switchgears, IDT & other electrical equipment till 33kV switchyard end , Meters , PMUs , CCTV	4	8
12	Fencing, Road and Drainage works	2	8
17	Interconnecting line/cable from BESS to Switchyard, Interfacing EMS with SAS , Meters , LDC , AGC , System studies completion , All approvals completion	8	11
18	Testing & Readiness of Equipment and communication system	8	12

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Commissioning, Trial Run and Completion of Facilities

19	Commissioning, Stabilization & Trial Run	12	14
20	Completion of facilities	13	14
O&M cum AMC completion			
21	O&M cum CAMC	5 years from Taking over certificate issue	
	<b>Note : Taking over certificate will be issued after successful completion of trial run and successful completion of facilities and acceptance of Discoms/STUs/ End customer</b>		

Until issuance of the Taking-Over Certificate, the bidder shall be responsible for maintaining the BESS plant up to 33 kV level. Upon issuance of the Taking-Over Certificate, O&M shall commence. The O&M-cum-CAMC period shall be 15 years from the date of issuance of the Taking-Over Certificate, covering the BESS plant up to 33 kV level, including all bidder-supplied equipment.

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## 35. ERECTION CONDITIONS AND WORK EXECUTION

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## GENERAL

The following provisions shall supplement the conditions already contained in the other parts of these specifications and documents and shall govern that portion of the work of this contract which is to be performed at site. The erection requirements and procedures not specified in these documents shall be in accordance with the recommendations of the equipment manufacturer, or as mutually agreed to between the Employer and the Contractor prior to commencement of erection work.

The Contractor upon signing of the Contract shall, in addition to a Project Coordinator, nominate another responsible officer as his representative at Site suitably designated for the purpose of overall responsibility and co-ordination of the Works to be performed at Site. Such a person shall function from the Site office of the Contractor during the pendency of Contract.

## CODE REQUIREMENTS

The erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Government of India Rules & Codes, accepted good practices in the industry and shall fulfill all statutory requirements.

## ELECTRICAL SAFETY REGULATIONS

The contractor shall ensure that entire electrical installation work is executed by adopting applicable statutory safety regulations and best practices in the industry. The Contractor shall employ the necessary number of qualified, full time electricians to maintain his temporary electrical installation.

## INSPECTION AND TESTING INSPECTION CERTIFICATES

The provisions of the clause entitled Inspection and Testing in the Technical Specification, shall also be applicable to the erection portion of the Works. The Employer shall have the right to re-inspect any equipment though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site. If by the above inspection, the Employer rejects any equipment, the Contractor shall make good for such rejections either by replacement or modification/ repairs as may be necessary to the satisfaction of the Employer. Such replacements will also include the replacements or re-execution of such of those works of other Contractors and/or agencies, which might have got damaged or affected by the replacements or re-work done to the Contractor's work.

## CONTRACTOR'S SITE OFFICE ESTABLISHMENT

The Contractor shall establish an Office at the Site and keep posted an authorized representative for the purpose of the Contract. Any written order or

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instruction of the Employer or his duly authorized representative shall be communicated to the said authorized resident representative of the Contractor and the same shall be deemed to have been communicated to the Contractor at his legal address.

### **CONTRACTOR'S FIELD OPERATION**

The Contractor shall keep the Employer informed in advance regarding his field activity plans and schedules for carrying out each part of the works. Any review of such plan or schedule or method of work by the Employer shall not relieve the Contractor of any of his responsibilities towards the field activities. Such reviews shall also not be considered as an assumption of any risk or liability by the Employer or any of his representatives and no claim of the Contractor will be entertained because of the failure or inefficiency of any such plan or schedule or method of work reviewed. The Contractor shall be solely responsible for the safety, adequacy and efficiency of plant and equipment and his erection methods.

The Contractor shall have the complete responsibility for the conditions of the Work-Site including the safety of all persons employed by him or his Sub-Contractor and all the properties under his custody during the performance of the work. This requirement shall apply continuously till the completion of the Contract and shall not be limited to normal working hours. The construction review by the Employer is not intended to include review of Contractor's safety measures in, on or near the Work-Site, and their adequacy or otherwise.

### **PROTECTION OF WORK**

The Contractor shall have total responsibility for protecting his works till it is finally taken over by the Employer. No claim will be entertained by the Employer or the representative of the Employer for any damage or loss to the Contractor's works and the Contractor shall be responsible for complete restoration of the damaged works to original conditions to comply with the specification and drawings. Should any such damage to the Contractor's Works occur because of any other agency/individual not being under his supervision or control, the Contractor shall make his claim directly with the party concerned. The Contractor shall not cause any delay in the repair of such damaged Works because of any delay in the resolution of such disputes. The Contractor shall proceed to repair the Work immediately and no cause thereof will be assigned pending resolution of such disputes.

### **FACILITIES TO BE PROVIDED BY THE CONTRACTOR**

#### **Contractor's site office Establishment**

The Contractor shall establish a site office at the site and keep posted an authorized representative for the purpose of the contract, pursuant to GCC.

#### **Tools, tackles, and scaffoldings**

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The Contractor shall provide all the construction equipment, tools, tackles, and scaffoldings required for pre-assembly, installation, testing, commissioning and conducting Guarantee tests of the equipment covered under the Contract. The Contractor shall arrange machinery & equipment such as Dozer, Hydra, Cranes, Trailer, etc. wherever required for the purpose of fabrication, erection, and commissioning.

#### **Testing Equipment and Facilities:**

The contractor shall provide the necessary testing equipment and facilities.

#### **Testing of construction material at the site:**

Contractor shall make arrangements for the testing of construction material at the site wherever required, under the scope of services of the contract.

#### **First-aid**

The Contractor shall provide necessary first-aid facilities for all his employees, representatives and workmen working at the Site. Enough number of Contractor's personnel shall be trained in administering first-aid.

#### **Water**

Contractor shall make all arrangements himself for the supply of construction water as well as potable water for labour and other personnel at the worksite/colony.

#### **FIRE PROTECTION**

The work procedures that are to be used during the erection shall be those which minimize fire hazards to the extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the Site regularly. Fuels, oils and volatile or flammable materials shall be stored away from the construction and equipment and materials storage areas in safe containers. Untreated canvas, paper, plastic or other flammable flexible materials shall not at all be used at Site for any other purpose unless otherwise specified. If any such materials are received with the equipment at the Site, the same shall be removed and replaced with acceptable material before moving into the construction or storage area.

All materials used for storage or for handling of materials shall be of water proof and flame resistant type. All the other materials such as working drawings, plans etc. which are combustible but are essential for the works to be executed shall be protected against combustion resulting from welding sparks, cutting flames and other similar fire sources.

All the Contractor's supervisory personnel and sufficient number of workers shall be trained for fire-fighting and shall be assigned specific fire protection duties. Enough of such trained personnel must be available at the Site during the entire period of the Contract.

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The Contractor shall provide suitable quantity & type fire protection equipment for the warehouses, office, temporary structures etc.

## SECURITY

The Contractor shall have total responsibility for all equipment and materials in his custody stores, loose, semi-assembled and/or erected by him at Site. The Contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

## PACKAGING AND TRANSPORTATION

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling, and storage due to improper packing. The Contractor shall ascertain the availability of Railway wagon sizes from the Indian Railways or any other agency concerned in India well before effecting dispatch of equipment. Before dispatch it shall be ensured that complete processing and manufacturing of the components is carried out at shop, only restricted by transport limitation, in order to ensure that site works like grinding, welding, cutting & preassembly to bare minimum. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

## CRATING

All equipment and materials shall be suitably coated, wrapped, or covered and boxed or crated for moist humid tropical shipment and to prevent damage or deterioration during handling and storage at the site.

Equipment shall be packed with suitable desiccants, sealed in water proof vapour-proof wrapping and packed in lumber of plywood enclosures, suitably braced, tied and skidded. Lumber enclosures shall be solid, not slatted.

Desiccants shall be either silica gel or calcium sulphate, sufficiently ground to provide the required surface area and activated prior to placing in the packaging. Calcium sulphate desiccants shall be of a chemical nature to absorb moisture. In any case, the desiccant shall not be of a type that will absorb enough moisture to go into solution. Desiccants shall be packed in porous containers, strong enough to withstand handling encountered during normal shipment. Enough desiccant shall be used for the volumes enclosed in wrapping.

Packaging or shipping units shall be designed within the limitations of unloading facilities and the equipment which will be used for transport. Complications involved with ocean shipment and the limitations of ports, railways and roads shall be considered. It shall be the Contractor's responsibility to investigate these

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limitations and to provide suitable packaging to permit safe handling during transit and at the job site.

Electrical equipment, control and instrumentation shall be protected against moisture and water damage. All external gasket surfaces and flange faces, couplings, motor pump shafts, bearing and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection.

Equipment having antifriction or sleeve bearings shall be protected by weather tight enclosures.

Coated surfaces shall be protected against impact, abrasion, discolouration and other damage. Surfaces which are damaged shall be repaired.

All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors. All female threaded openings shall be closed with forged steel plugs. All pipings, tubing, and conduit equipment and other equipment openings shall be sealed with metallic or other rough usage covers and tapped to seal the interior of the equipment piping, tubing, or conduit.

Provisions shall be made to ensure that water does not enter any equipment during shipment or in storage at the plant site.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Contractor's expense.

While packaging the material, care shall be taken for the limitation from the point of view of availability of railway wagon sizes in India.

## **MATERIALS HANDLING AND STORAGE**

All the equipment furnished under the Contract and arriving at Site shall be promptly received, unloaded and transported and stored in the storage spaces by the Contractor.

Contractor shall be solely responsible for any shortages or damage in transit, handling and / or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

The equipment stored shall be properly protected to prevent damage either to the equipment or to the floor where they are stored. The equipment from the store shall be moved to the actual location at the appropriate time to avoid damage of such equipment at Site.

All electrical panels, controls gear, motors and such other devices shall be properly dried by heating before they are installed and energised. Motor bearings, slip rings, commutators and other exposed parts shall be protected against moisture ingress and corrosion during storage and periodically inspected. Heavy

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rotating parts in assembled conditions shall be periodically rotated to prevent corrosion due to prolonged storage.

All the electrical equipment such as motors, etc. shall be periodically tested for insulation resistance from the date of receipt till the date of commissioning and a record of such measured insulation values maintained by the Contractor. Such records shall be open for inspection by the Employer.

The Contractor shall ensure that all the packing materials and protection devices used for the various equipment during transit and storage are removed before the equipment are installed.

The consumables and other supplies likely to deteriorate due to storage must be thoroughly protected and stored in a suitable manner to prevent damage or deterioration in quality by storage.

All the materials stored in the open or dusty location must be covered with suitable weatherproof and flameproof covering material wherever applicable.

#### CONSTRUCTION MANAGEMENT

Contractor shall be responsible for performance of his works in accordance with the specified construction schedule. If at any time, the Contractor is falling behind the schedule, he shall take necessary action to make good for such delays by increasing his work force or by working overtime or otherwise accelerate the progress of the work to comply with the schedule and shall communicate such actions in writing to the Employer, satisfying that his action will compensate for the delay. The Contractor shall not be allowed any extra compensation for such action.

The Employer shall however not be responsible for provision of additional labour and/or materials or supply or any other services to the Contractor.

#### FIELD OFFICE RECORDS

The Contractor shall maintain at his Site Office up-to- date copies of all drawings, specifications and other Contract Documents and any other supplementary data complete with all the latest revisions thereto. The Contractor shall also maintain in addition the continuous record of all changes to the above Contract Documents, drawings, specifications, supplementary data, etc. effected at the field and on completion of his total assignment under the Contract shall incorporate all such changes on the drawings and other Engineering data to indicate as installed conditions of the equipment furnished and erected under the Contract. Such drawings and Engineering data shall be available for inspection & review to the Employer.

#### PROTECTION OF PROPERTY AND CONTRACTOR'S LIABILITY

The Contractor shall be responsible for any damage resulting from his operations. He shall also be responsible for protection of all persons including

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members of public and employees of the Employer and his own employees and all public and private property including structures, building, other plants and equipment and utilities either above or below the ground.

The Contractor will ensure provision of necessary safety equipment such as barriers, sign - boards, warning lights and alarms, etc. to provide adequate protection to persons and property.

### **PAINTING**

All exposed metal parts of the equipment including pipings, structure railings, etc. wherever applicable, after installation unless otherwise surface protected, shall be first painted in accordance with relevant codes & standards, after thoroughly cleaning all such parts of all dirt, rust, scales, greases, oils and other foreign materials by wire brushing, scraping or sand blasting.

### **UNFAVOURABLE WORKING CONDITIONS**

The Contractor shall confine all his field operations to those works which can be performed without subjecting the equipment and materials to adverse effects during inclement weather conditions, like monsoon, storms, etc. and during other unfavourable construction conditions. No field activities shall be performed by the Contractor under conditions which might adversely affect the quality and efficiency thereof, unless special precautions or measures are taken by the Contractor in a proper and satisfactory manner in the performance of such Works and with the concurrence of the Employer. Such unfavourable construction conditions will in no way relieve the Contractor of his responsibility to perform the Works as per the schedule.

### **PROTECTION OF MONUMENTS AND REFERENCE POINTS**

The Contractor shall ensure that any finds such as relic, antiquity, coins, fossils, etc. which he may come across during the course of performance of his Works either during excavation or elsewhere, are properly protected and handed over to the Employer.

### **FOUNDATION DRESSING & GROUTING FOR EQUIPMENT/ EQUIPMENT BASES**

The surfaces of foundations shall be dressed to bring the top surface of the foundations to the required level, prior to placement of equipment/equipment bases on the foundations.

All the equipment/ equipment bases shall be grouted and finished as per these specifications unless otherwise recommended by the equipment manufacturer.

The concrete foundation surfaces shall be properly prepared by chipping, grinding as required to bring the top of such foundation to the required level, to provide the necessary roughness for bondage and to assure enough bearing strength.

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## GROUT

The grout shall be high strength grout having a minimum characteristic compressive strength of 60 N/mm<sup>2</sup> at 28 days. The grout shall be chloride - free, cement based, free flowing, non-metallic grout.

The Grout shall have good flowability even at very low water/ grout powder ratio.

The Grout shall have characteristics of controlled expansion to be able to occupy its original volume to fill the voids and to compensate for shrinkage. Grout shall be of pre-mix variety so that only water needs to be added before use.

The mixing of the Grout shall conform to the recommendations of the manufacturer of the Grout.

## PLACING OF GROUT

After the base has been prepared, its alignment and level has been checked and approved and before actually placing the grout, a low dam shall be set around the base at a distance that will permit pouring and manipulation of the grout. The height of such dam shall be at least 25mm above the bottom of the base. Suitable size and number of chains shall be introduced under the base before placing the grout, so that such chains can be moved back & forth to push the grout into every part of the space under the base.

The grout shall be poured either through grout holes if provided or shall be poured at one side or at two adjacent sides to make the grout move in a solid mass under the base and out in the opposite side. Pouring shall be continued until the entire space below the base is thoroughly filled and the grout stands at least 25 mm higher all around than the bottom of the base. Enough care should be taken to avoid any air or water pockets beneath the bases.

In addition to the above, recommendations of Grout manufacturer shall also be followed.

## FINISHING OF THE EDGES OF THE GROUT

The poured grout should be allowed to stand undisturbed until it is well set. Immediately thereafter, the dam shall be removed and grout which extends beyond the edges of the structural or equipment base plates shall be cut off, flushed and removed. The edges of the grout shall then be pointed and finished with 1:2 cement mortar pressed firmly to bond with the body of the grout and smoothed with a tool to present a smooth vertical surface. The work shall be done in a clean and scientific manner and the adjacent floor spaces, exposed edges of the foundations, and structural steel and equipment base plates shall be thoroughly cleaned of any spillage of the grout.

## SHAFT ALIGNMENTS

All the shafts of rotating equipment shall be properly aligned to those of the matching equipment to as perfect accuracy as practicable. The equipment shall

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be free from excessive vibration to avoid overheating of bearings or other conditions which may tend to shorten the life of the equipment. The vibration level of rotating equipment measured at bearing housing shall conform to VDI 2056. All bearings, shafts and other rotating parts shall be thoroughly cleaned and suitably lubricated before starting.

#### **DOWELLING**

All the motors and other equipment shall be suitably doweled after alignment of shafts with tapered machined dowels as per the direction of the Employer.

#### **CABLING**

All cables shall be supported by conduits or cable tray run in air or in cable channels. These shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turn made of symmetrical bends or fittings. When cables are run on cable trays, they shall be clamped at a minimum intervals of 2000mm.

Each cable, whether power or control, shall be provided with a metallic or plastic tag of an approved type, bearing a cable reference number indicated in the cable and conduit list (prepared by the Contractor), at every 5 meter run or part thereof and at both ends of the cable adjacent to the terminations. Cable routing is to be done in such a way that cables are accessible for any maintenance and for easy identification.

Sharp bending and kinking of cables shall be avoided. Installation of other cables like high voltage, coaxial, screened, compensating, mineral insulated shall be in accordance with the cable manufacturer's recommendations. Wherever cables cross roads and water, oil, sewage or gas lines, special care should be taken for the protection of the cables in designing the cable channels.

In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop fault at a later date.

Control cable terminations shall be made in accordance with wiring diagrams, using identifying codes subject to the Employer's approval. Multicore control cable jackets shall be removed as required to train and terminate the conductors. The cable jacket shall be left on the cable, as far as possible, to the point of the first conductor branch. The insulated conductors from which the jacket is removed shall be neatly twined in bundles and terminated. The bundles shall be firmly but not tightly tied utilizing plastic or nylon ties or specifically treated fungus protected cord made for this purpose. Control cable conductor insulation shall be securely and evenly cut.

The connectors for control cables shall be covered with a transparent insulating sleeve so as to prevent accidental contact with ground or adjacent terminals and shall preferably terminate in Elmex terminals and washers. The insulating sleeve

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shall be fire resistant and shall be long enough to over pass the conductor insulation. All control cables shall be fanned out and connection made to terminal blocks and test equipment for proper operation before cables are corded together.

## EQUIPMENT INSTALLATION

### GENERAL REQUIREMENTS

The Contractor shall furnish all construction materials, tools and equipment and shall perform all work required for complete installation of all control and instrument equipment furnished under this specification.

Contractor shall prepare detailed installation drawings for each equipment furnished under this specification. Installation of all equipment/systems furnished by this specification shall be as per installation drawings.

Erection procedures not specified herein shall be in accordance with the recommendations of the equipment manufacturers. The procedures shall be acceptable to the Employer.

The Contractor shall coordinate his work with other suppliers where their instruments and devices are to be installed under specifications.

### INSTALLATION MATERIALS

All materials required for installation, testing and commissioning of the equipment shall be furnished by the Contractor.

### REGULATORY REQUIREMENTS

All installation procedures shall confirm with the accepted good engineering practice and with all applicable governmental laws, regulations and codes.

### CLEANING

All equipment shall be cleaned of all sand, dirt and other foreign materials immediately after removal from storage and before the equipment is installed.

### INSTALLATION OF FIELD MOUNTED INSTRUMENTS/DEVICES AND NON-FREE

#### Standing Equipment

The installation drawings for all field mounted equipment/instrument/devices furnished under this specification shall meet the requirements of this specification, applicable codes and standards and recommendations of manufacturers of instruments/devices. In addition to above relevant Portion as specified elsewhere in technical specification may be referred.

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Field mounted instruments and accessories shall be bracket or sub panel mounted on the nearest suitable firm steel work or masonry. The brackets, stands, supports and other miscellaneous hardware required for mounting instruments and accessories such as receiver gauge, air set, valve manifold, purge-meter etc. shall be furnished and installed. No field mounted instruments shall be installed such that it depends for support or rigidity on the impulse piping or on electrical connection to it.

All free standing instrumentation cabinets and panels shall be located within the construction tolerances of +/- 3 mm of the location dimensions indicated on the plant arrangement drawings.

Non-free standing local enclosures and cabinets shall be mounted in accessible locations on columns, walls, or stands. Bracket and stands shall be fabricated as required to install the local enclosures and cabinets in a workman like manner. Rough edges and welds on all fabricated supports shall be ground smooth. The supports shall be finished with two coats of primer and two coats of paint as specified in this part.

#### DEFECTS

All defects in erection shall be corrected to the satisfaction of the Employer and the Project Manager. The dismantling and reassembly of Contractor furnished equipment to remove defective parts, replace parts, or make adjustments shall be included as a part of the work under these specifications.

The removal of control and instrument equipment in order to allow bench calibration, if required, and the re-installation of the said equipment after calibration shall also be included as a part of the work under these specifications.

#### EQUIPMENT PROTECTION

All equipment to be erected under these specifications shall be protected from damage of any kind from the time of contract award until commissioning of each unit.

The equipment shall be protected during storage as described herein.

Equipment shall be protected from weld spatter during construction.

Suitable guards shall be provided for protection of personnel on all exposed rotating or moving machine parts. All such guards with necessary spares and accessories shall be designed for easy removal and maintenance.

Equipment having glass components such as gauges, or equipment having other easily breakable components, shall be protected during the construction period with plywood enclosures or other suitable means. Broken, stolen, or lost components shall be replaced by the Contractor.

Machine finished surfaces, polished surfaces, or other bare metal surfaces which are not to be painted, such as machinery shafts and couplings shall be provided

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temporary protection during storage and constructional periods by a coating of a suitable non- drying, oily type, rust preventive compound.

#### **DEVIATIONS DISPOSITIONING:**

Any deviation to the contract and employer approved documents shall be properly recorded in the format prescribed by NTPC. All the deviations shall be brought to the knowledge of employer's representative for suitable dispositioning.

#### **STATUTORY REQUIREMENTS**

In addition to the local laws and regulations, the Contractor shall also comply with the Minimum Wages Act and the Payment of Wages Act (both of the Government of India) and the rules made there under in respect of its labour and the labour of its sub-contractors currently employed on or connected with the contract.

All registration and statutory inspection fees, if any, in respect of his work pursuant to this Contract shall be to the account of the Contractor. However, any registration, statutory inspection fees lawfully payable under the provisions of any statutory laws and its amendments from time to time during erection in respect of the plant equipment ultimately to be owned by the Employer, shall be to the account of the Employer. Should any such inspection or registration need to be re-arranged due to the fault of the Contractor or his Sub-Contractor, the additional fees for such inspection and/or registration shall be borne by the Contractor.

#### **EMPLOYMENT OF LABOUR**

In addition to all local laws and regulations pertaining to the employment of labour to be complied with by the Contractor pursuant to GCC, the Contractor will be expected to employ on the work only his regular skilled employees with experience of the particular work. No female labour shall be employed after darkness. No person below the age of eighteen years shall be employed.

All travelling expenses including provisions of all necessary transport to and from Site, lodging allowances and other payments to the Contractor's employees shall be the sole responsibility of the Contractor.

In case the Employer becomes liable to pay any wages or dues to the labour or any Government agency under any of the provisions of the Minimum Wages Act, Workmen Compensation Act, Contract Labour Regulation Abolition Act or any other law due to act of omission of the Contractor, the Employer may make such payments and shall recover the same from the Contractor's Bills.

#### **WORK & SAFETY REGULATIONS**

The Contractor shall ensure proper safety of all the workmen, materials, plant and equipment belonging to him or to Employer or to others, working at the Site. The Contractor shall also be responsible for provision of all safety notices and safety

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equipment required both by the relevant legislation and the Employer as he may deem necessary.

Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the contractor shall be responsible for carrying-out such provision and/or storage in accordance with the rules and regulations laid down in petroleum act 1934, explosives act, 1948, and petroleum and carbide of calcium manual published by the chief inspector of explosives of India. All such storage shall have prior approval of the employer. In case, any approvals are necessary from the chief inspector (explosives) or any statutory authorities, the contractor shall be responsible for obtaining the same.

Where explosives are to be used, the same shall be used under the direct control and supervision of an expert, experienced, qualified and competent person strictly in accordance with the Code of Practices/Rules framed under Indian Explosives Act pertaining to handling, storage and use of explosives.

All equipment used in construction and erection by Contractor shall meet Indian/International Standards and where such standards do not exist, the Contractor shall ensure these to be absolutely safe. All construction and erection equipment shall be strictly operated and maintained by the Contractor in accordance with statutory safety regulations. Periodical Examinations and all tests for all lifting/ hoisting equipment & tackles shall be carried-out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity Act 1910 and associated Laws/Rules in force from time to time.

The Contractor shall provide suitable safety equipment of prescribed standard to all employees and workmen according to the need, as may be directed by Employer who will also have right to examine these safety equipments to determine their suitability, reliability, acceptability and adaptability.

- (a) Working platforms should be fenced and shall have means of access.
- (b) Ladders in accordance with statutory safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

The Contractor shall provide safe working conditions to all workmen and employees at the Site including safe means of access, railings, stairs, ladders, scaffoldings etc. The scaffoldings shall be erected under the control and supervision of an experienced and competent person. For erection, good and standard quality of material only shall be used by the Contractor.

The Contractor employing workmen whether temporary, casual, probationer, regular or permanent or on contract, shall employ at least one full time officer exclusively as **Safety Steward** to supervise safety aspects of the equipment and workmen, who will co- ordinate with the Employer's Safety Officer. In case of work being carried out through sub-Contractors, the Sub-Contractor's workmen/employees will also be considered as the Contractor's employees/workmen for the above purpose

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In case any accident occurs during the construction/ erection or other associated activities undertaken by the Contractor thereby causing any minor or major or fatal injury to his employees due to any reason, whatsoever, it shall be the responsibility of the Contractor to promptly inform the same to the Employer and also to all the authorities envisaged under the applicable laws.

The Contractor shall follow and comply with relevant provisions of applicable laws pertaining to the safety of workmen, employees plant and equipment as may be prescribed from time to time without any demur, protest or contest or reservation.

If the Contractor does not take all safety precautions and/or fails to comply with the Safety Rules as prescribed by the Employer or under the applicable law for the safety of the equipment and plant and for the safety of personnel and the Contractor does not prevent hazardous conditions which cause injury to his own employees or employees of other Contractors, or the Employer's employees or any other person who are at Site or adjacent thereto, the Contractor shall be responsible for payment of compensation to Employer as per the following schedule:-

1	Fatal injury or accident. These are causing death applicable	Rs. 1,00,000/- per person
2	Major injuries or accident	Rs. 20,000/- per person for death/ causing 25% or more injury to any permanent disablement to person workmen or employees whosoever

Permanent disablement shall have same meaning as indicated in Workmen's Compensation Act. The compensation mentioned above shall be in addition to the compensation payable to the workmen/employees under the relevant provisions of the Workmen's Compensation Act and rules framed thereunder or any other applicable laws as applicable from time to time. In case the Employer is made to pay such Compensation then the Contractor is liable to reimburse the Employer such amount in addition to the compensation indicated above.

If the Contractor observes all the Safety Rules and Codes, Statutory Laws and Rules during the currency of Contract awarded by the Employer and no accident occurs then the Employer may consider the performance of the Contractor and award suitable "ACCIDENT FREE SAFETY MERITORIOUS AWARD" as per scheme as may be announced separately from time to time.


#### INSURANCE

In addition to the conditions covered under the Clause entitled "Insurance" in Section General Conditions of Contract (GCC), the following provisions will also apply to the portion of works to be done beyond the Contractor's own or his Sub-Contractor's manufacturing Works and all statutory obligations shall be fulfilled.

- (a) Bidder shall take Fire & Allied Peril insurance during O&M period in the name of NTPC. Insurance for theft to be taken by contractor.

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#### **(b) Workmen's Compensation Insurance**

This insurance shall protect the Contractor against all claims applicable under the Workmen's Compensation Act, 1948 (Government of India). This policy shall also cover the Contractor against claims for injury, disability disease or death of his or his Sub-Contractor's employees, which for any reason are not covered under the Workmen's Compensation Act, 1948. The liabilities shall not be less than the following:

Workmen's Compensation	- As per Statutory Provisions
Employee's Liability	- As per Statutory Provisions

#### **(c) Comprehensive Automobile Insurance**

This insurance shall be in such a form to protect the Contractor against all claims for injuries, disability, disease and death to members of public including the Employer's men and damage to the property of other arising from the use of motor vehicles during on or off the Site operations, irrespective of the Ownership of such vehicles. The liability covered shall be as herein indicated:

Fatal Injury	: Rs.100,000 each person
	: Rs.200,000 each occurrence
Property Damage	: Rs.100,000 each occurrence

#### **(d) Comprehensive General Liability Insurance**

The insurance shall protect the Contractor against all claims arising from injuries, disabilities, disease or death of members of public or damage to property of others, due to any act or omission on the part of the Contractor, his agents, his employees, his representatives and Sub-Contractors or from riots, strikes and civil commotion. This insurance shall also cover all the liabilities of the Contractor arising out of the Clause entitled "Defence of Suits" in Section General Conditions of Contract (GCC).

The hazards to be covered will pertain to all the Works and areas where the Contractor, his Sub-Contractors, his agents and his employees have to perform work pursuant to the Contract.

This part covers technical requirements which will form an integral part of the Contract. The following provisions shall supplement all the detailed technical requirements brought out in the Technical Specifications and the Technical Data Sheets.

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### Work Execution

#### Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Employer shall appoint and notify the Bidder in writing of the name of the Project Manager. The Employer may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Bidder without delay. The Employer shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Employer at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided. Omission by the Employer or Project Manager, as the case may be, to respond to any communication including letters of or on behalf of the Bidder to either or both of them shall not be deemed or construed as admission by the Employer or the Project Manager of the contents thereof, except as otherwise provided for in the contract.

All notices, instructions, information and other communications given by the Bidder to the Employer under the Contract shall be given to the Project Manager, except as herein otherwise provided.


The Bidder shall appoint the Bidder's Representative within fourteen (14) days of the Effective Date or before start of work whichever is earlier and shall request the Employer in writing to approve the person so appointed.

#### Bidder's Representative & Construction Manager

- The Bidder's representative shall be a regular Employee/ Partner/ Director only and the Bidder shall be required to submit a Power of Attorney in original in favour of its representative. Notarized photocopy of the Power of Attorney shall be acceptable only if the Power of Attorney has been registered by the Bidder. The Employer may verify the photocopy of the Power of Attorney with the Original and the Bidder shall be required to produce the original Power of Attorney for verification, if required by the Employer. The relation of the Bidder's representative with the Bidder such as Partner/ Employee etc. should be clearly brought out in the Power of Attorney. The Bidder would be required to submit a documentary proof of the relation of the Bidder's representative with the Bidder in the form of self-attested copy of any of the following documents:
- Previous financial year's Form 16 as available at TRACES site of Income tax department, if the Bidder's representative is an employee of Bidder or his Appointment Letter/ Salary Slip/ other documentary evidence (only in case of recent appointment or where Form 16 details are not uploaded at TRACES). Further, the Bidder shall submit the copy of Form 16 as available through TRACES site for every subsequent year also in respect of the Bidder's representative till the period of authorization.
- Article of Association/ Registered Partnership Deed if the Bidder's representative is a partner or stake holder in Company.

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- In case, the Bidder is not able to submit any of the documentary proofs as mentioned above at para (i) & (ii), he would be required to submit an affidavit stating the relationship between the Bidder's representative and the Bidder.
- In case, the Bidder's representative is also doing some other Contract(s)/ Work(s) as nominee of the same Bidder, the Bidder shall give a declaration citing list of all works where the Bidder's representative is the nominee.
- The Bidder's Representative shall represent and act for the Bidder at all times during the currency of the Contract and shall give to the Project Manager all the Bidder's notices, instructions, information and all other communications under the Contract.
- All notices, instructions, information and all other communications given by the Employer or the Project Manager to the Bidder under the Contract shall be given to the Bidder's Representative or, in its absence, its deputy, except as herein otherwise provided.
- The Bidder shall not revoke the appointment of the Bidder's Representative without the Employer's prior written consent, which shall not be unreasonably withheld.
- The Bidder's Representative may, subject to the approval of the Employer (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Bidder's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Employer and the Project Manager.
- Notwithstanding anything stated for the purpose of execution of contract, the Employer and the Bidder shall finalise and agree to a Contract Co-ordination Procedure and all the communication under the Contract shall be in accordance with such Contract Co-ordination Procedure.
- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Bidder's Representative shall appoint a suitable person as the construction manager (hereinafter referred to as "the Construction Manager"). The Construction Manager shall supervise all work done at the Site by the Bidder and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.
- The Employer may by notice to the Bidder object to any representative or person employed by the Bidder in the execution of the Contract who, in the reasonable opinion of the Employer, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations. The Employer shall provide evidence of the same, whereupon the Bidder shall remove such person from the Facilities.
- If any representative or person employed by the Bidder is removed, the Bidder shall, where required, promptly appoint a replacement.
- In case any of the information/ declaration/ undertaking provided by Bidder/Bidder's representative is found to be false and/ or the Bidder/ Bidder's representative suppresses any relevant information at any stage, the Bidder will be liable for actions in terms of Employer's Debarment policy.

#### **Work Program**

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The Bidder shall supply to the Employer and the Project Manager a chart showing the proposed organization to be established by the Bidder for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within twenty-one (21) days of the Effective Date. The Bidder shall promptly inform the Employer and the Project Manager in writing of any revision or alteration of such an organization chart

#### **Program of Performance**

Within twenty-eight (28) days after the date of notification of award of Contract, the Bidder shall prepare and submit to the Project Manager a detailed program of performance of the Contract, made in the form of PERT Network 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 Employer 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 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 Appendix 4 (Time Schedule) to the Contract Agreement 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 Project Manager.

#### **Progress Report**

The Bidder shall monitor progress of all the activities and submit a progress report to the Project Manager every month.

The progress report shall be in a form acceptable to the Project Manager and shall also 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.


#### **Progress of Performance**

If at any time the Bidder's actual progress falls behind the program or it becomes apparent that it will so fall behind, the Bidder shall, at the request of the Employer or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

#### **Work Procedures**

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The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Employer and the Bidder, the Bidder may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

#### **Maintenance of Records of Weekly Progress Review Meetings at site**

The Bidder shall be required to attend all weekly site progress review meetings organized by the 'Project Manager' or his authorized representative. The deliberations in the meetings shall inter alia include the weekly program, progress of work (including details of manpower, tools and plants deployed by the Bidder vis-a-vis agreed schedule), inputs to be provided by Employer, delays, if any, and recovery program, specific hindrances to work and work instructions by Employer. Record of Hindrances / events that lead to slow/ stoppage of smooth execution of work shall be maintained in "Hindrance Register". The minutes of the weekly meetings shall be recorded in triplicate in a numbered register available with the 'Project Manager', or his authorized representative. These recordings shall be jointly signed by the Project Manager or his authorized representative and the Bidder and one copy of the signed records shall be handed over to the Bidder.

#### **Subcontracting**

List of Approved vendor to the Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Bidder shall prepare a list of Subcontractors for such item for inclusion in such list. The Bidder may from time to time propose any addition to or deletion from any such list. The Bidder shall submit any such list or any modification thereto to the Employer for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Employer for any of the Subcontractors shall not relieve the Bidder from any of its obligations, duties or responsibilities under the Contract. The Bidder shall select and employ its Subcontractors for such major items from those listed in the lists referred.


The Bidder shall not be allowed to sub-contract works to any subcontractor/ sub-vendor from a country which shares a land border with India unless such subcontractor is registered with the competent Authority.

The Competent Authority for the purpose of registration shall be as mentioned in the relevant Annexure of SCC.

However, the said requirement of registration will not apply to subcontractors from those countries (even if sharing a land border with India) to which the Government of India has extended lines of credit or in

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which the Government of India is engaged in development projects. The Bidder may apprise itself of the updated lists of such countries available in the website of the Ministry of External Affairs.

Procurement of raw material, components, etc. for the purposes of performance of the Bidder's obligation under the Contract shall not constitute subcontracting.

#### **Sub-Bidder/Sub-vendor Management**

In the event of failure to commence work or achieve the desired work progress as per the Program of Performance because of non-payment to any Sub-Bidder/ Sub-vendor by the Bidder, Employer may issue notice as set forth herein in respect thereof to the Bidder. Even after serving two notices with notice period of 14 days & 7 days, if Bidder fails to commence the work /restore the progress of work by making the payment to such Subcontractor/ Sub-vendor, the Bidder hereby expressly consents to the Employer for making direct payment in the name and on behalf and to the account of the Bidder to such Subcontractor/ Sub-vendor from the payments due to the Bidder under the Contract or in order to commence / restore the progress of the work. No such payment by the Employer in the name and behalf and to the account of the Bidder shall constitute or be construed as any privity of contract of such Sub-Bidder/ Sub-vendor with the Employer and such Subcontractor/ Sub-vendor shall continue to be Sub-Bidder/ Sub-vendor of Bidder and the Bidder shall continue to be responsible and liable to the Employer for all the obligations including but not limited to Performance Guarantees and Warranties under the Contract and the work of such Sub-Bidder/ Sub-vendor.

#### **Specifications and Drawings**

The Bidder shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice.


The Bidder shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Bidder by or on behalf of the Employer.

The Bidder shall be entitled to disclaim responsibility for any design, data, drawing, specification or other document, or any modification thereof provided or designated by or on behalf of the Employer, by giving a notice of such disclaimer to the Project Manager.

#### **Codes and Standards**

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Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date fifteen (15) days prior to deadline set for price bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Employer.

#### **Transportation**

The Bidder shall at its own risk and expense transport all the Plant and Equipment and the Bidder's Equipment to the Site by the mode of transport that the Bidder judges most suitable under all the circumstances.

#### **Packing Material**

- The Bidder shall ensure that all the plant and equipment are suitably packed and protected to prevent damage or deterioration during its transportation to site, handling and storage at site till the time of its installation.
- In case, the Bidder decides to transport the Plant and Equipment and the Bidder's Equipment by road, then such Plant and Equipment and the Bidder's Equipment must necessarily be transported through a registered common carrier as per Carriage by Road Rules 2011 of Central Government of India.
- 
- Upon despatch of each shipment of the Plant and Equipment and the Bidder's Equipment, the Bidder shall notify the Employer of the description of the Plant and Equipment and of the Bidder's Equipment, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Bidder shall furnish the Employer with relevant shipping documents to be agreed upon between the parties.
- 
- The Bidder shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipment and the Bidder's Equipment to the Site. The Employer 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 Employer 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 and Equipment and the Bidder's Equipment to the Site.


#### **Customs Clearance**

The Bidder shall, at its own expense, handle all imported Plant and Equipments and spares and Bidder's Equipments at the point(s) of import and shall handle any formalities for customs clearance, subject to the Employer's obligations.

#### **Setting Out/Supervision/Labour**

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Bench Mark: The Bidder shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Employer.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Bidder shall forthwith notify the Project Manager of such error and, at its own expense, immediately rectify such error to the reasonable satisfaction of the Project Manager. If such error is based on incorrect data provided in writing by or on behalf of the Employer, the expense of rectifying the same shall be borne by the Employer.

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.

#### **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 shall preferably engage skilled/ semiskilled/ unskilled workers from amongst the land oustees of the Project.
- (b) Unless otherwise provided in the Contract, 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 Subcontractor'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 Employer may provide the same to such personnel and recover the cost of doing so from the Bidder.
- (e) The Bidder shall at all times during the progress of the Contract use its best endeavour to prevent any unlawful, riotous or disorderly conduct or behaviour by or amongst its employees and the labour of its Subcontractors.

The Bidder shall, in all dealings with its labour and the labour of its Subcontractors 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.

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### **Bidder's Equipment**

All Bidders' Equipment brought by the Bidder onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Bidder shall not remove the same from the Site without the Project Manager's consent that such Bidder's Equipment is no longer required for the execution of the Contract.

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.

The Employer will, if requested, use its best endeavour to assist the Bidder in obtaining any local, state or national government permission required by the Bidder for the export of the Bidder's Equipment imported by the Bidder for use in the execution of the Contract that is no longer required for the execution of the Contract.

### **Site Regulations and Safety**

The Employer 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 Employer, with a copy to the Project Manager, proposed Site regulations for the Employer'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.


The Employer has formulated Safety Rules for Construction & Erection of Power Plants . These Safety Rules lay down the safety requirements for safe execution of project activities, responsibilities of the Bidder, and all concerned involved in Construction and Erection. The Bidder, including his sub-Bidders, while executing the Works, shall strictly comply with these Safety rules and statutory requirements (including amendments thereof), as applicable, in respect of safety of personnel, equipment and materials at site area under execution of the Bidder.

In addition to other parts specified in 'End customer Safety Rules for Construction and Erection of Substation' ,Bidder shall adhere to the following provisions for payment linked to Safety Compliances as specified in Payment Terms:

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#### **Safety Personnel**

- Bidder shall adhere to the requirements of of ‘End customer Safety Rules for Construction and Erection of substation , Personal Protective Equipment & Safety Equipment
- Bidder shall adhere to the requirements of Personal Protective Equipment of ‘End customer Safety Rules for Construction and Erection of Substation’ and the provisions of the Bidding Documents with regards to number of Safety Equipment/PPEs to be provided by the Bidder.
- In case Bidder fails to comply with aforesaid requirement, Project Manager /Safety Officer shall issue a warning letter/Non-compliance Memo to the Bidder regarding the same advising him to take corrective action.
- Project Manager /End customer Safety Officer shall maintain written record of all such incidents when Warning letter/Non-compliance Memo is issued to the Bidder for not meeting the requirements Personal Protective Equipment.

#### **Safety Induction and Training**

- Bidder shall adhere to the requirements of imparting Safety training of ‘End customer Safety Rules for Construction and Erection of Substations.
- Bidder shall maintain written record of Safety trainings imparted to its Employees/ workmen for purpose of aforesaid payment. These records shall be available for review of Project Manager /End customer Safety Officer all the time.

#### **Medical and First Aid Amenities**

Bidder shall adhere to the requirements Medical and First Aid Amenities of ‘End customer Safety Rules for Construction and Erection of Substation.

#### **Compliance to Work Permit System**

Bidder shall adhere to the requirements of ‘End customer Safety Rules for Construction and Erection of Substation’.


In case Bidder fails to obtain work permit or fails to comply to any requirements of aforesaid Work permit system, he will be issued a warning letter/Noncompliance Memo by Project Manager /Safety Officer of End customer regarding the same advising him to take corrective action.

End customer Safety Officer / Project Manager shall maintain written record of all such incidents when Warning letter / Non-compliance Memo is issued to Bidder for not complying with the requirements of Work Permit System .

#### **Opportunities for Other Bidders**

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- The Bidder shall, upon written request from the Employer or the Project Manager, give all reasonable opportunities for carrying out the work to any other Bidders employed by the Employer on or near the Site.
- If the Bidder, upon written request from the Employer or the Project Manager, makes available to other Bidders any roads or ways the maintenance for which the Bidder is responsible, permits the use by such other Bidders of the Bidder's Equipment, or provides any other service of whatsoever nature for such other Bidders, the Employer shall fully compensate the Bidder for any loss or damage caused or occasioned by such other Bidders in respect of any such use or service, and shall pay to the Bidder reasonable remuneration for the use of such equipment or the provision of such services.
- The Bidder shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other Bidders. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Bidder and other Bidders and the workers of the Employer in regard to their work.

The Bidder shall notify the Project Manager promptly of any defects in the other Bidders' work that come to its notice, and that could affect the Bidder's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Bidder.

#### **Emergency Work**

- 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.
- If the Bidder is unable or unwilling to do such work immediately, the Employer may do or cause such work to be done as the Employer may determine is necessary in order to prevent damage to the Facilities. In such event the Employer shall, as soon as practicable after the occurrence of any such emergency, notify the Bidder in writing of such emergency, the work done and the reasons therefor. If the work done or caused to be done by the Employer is work that the Bidder was liable to do at its own expense under the Contract, the reasonable costs incurred by the Employer in connection therewith shall be paid by the Bidder to the Employer. Otherwise, the cost of such remedial work shall be borne by the Employer.

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### Site Clearance

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.

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.

### Disposal of Scrap

- The Bidder shall with the agreement of the Employer promptly remove from the site any 'Scrap' generated during performance of any activities at site in pursuance of the Contract. The term 'Scrap' shall refer to scrap/ waste/ remnants arising out of the fabrication of structural steel work and piping work at the project site in the course of execution of the contract and shall also include any wastage of cables during the termination process while installing the cables.
- The ownership of such Scrap shall vest with the Bidder except in cases where the items have been issued by the Employer from its stores for their installation only without any adjustment to the Contract Price. The removal of scrap shall be subject to the Bidder producing the necessary clearance from the relevant authorities (Custom, GST etc.), if required by the law, in respect of disposal of the scrap. The liability for the payment of the applicable taxes/duties shall be that of the Bidder.
- The Bidder shall also indemnify to keep the Employer harmless from any act of omission or negligence on the part of the Bidder in following the statutory requirements with regard to removal/disposal of scrap. Further, in case the laws require the Employer to take prior permission of the relevant Authorities before handing over the scrap to the Bidder, the same shall be obtained by the Bidder on behalf of the Employer.


### Watching and Lighting

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.

### Shift Work

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- To achieve the required rate of progress in order to complete the Facilities within the Time for Completion, the Bidder may carry on the work, round the clock, in multiple shifts per day, as may be necessary. The Bidder shall however be responsible to comply with all applicable laws in this regard.
- No additional payment will be made on account of round the clock working in multiple shifts.
- Wherever the work is carried out at night adequate lighting of working areas and access routes for pedestrians or vehicles shall be provided by the Bidder at his cost. Sufficient notice should be given by the Bidder to the Employer regarding the details of works in shifts so that necessary supervision could be provided.


#### **Test And Inspection**

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.

- The Employer and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/or inspection, provided that the Employer shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- Whenever the Bidder is ready to carry out any such test and/or inspection, the Bidder shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Bidder shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Employer and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- The Bidder shall provide the Project Manager with a certified report of the results of any such test and/or inspection.
- If the Employer or Project Manager (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 Project Manager with a certified report of the results thereof.
- The Project Manager may require the Bidder to carry out any test and/or inspection not required by the Contract, where the purpose of these tests/ inspection is to verify compliance with the Technical Specifications and are feasible without creating a risk of damage to the Works, provided that the

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Bidder's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impedes the progress of work on the Facilities and/or the Bidder's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.

- If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Bidder shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- The Bidder shall afford the Employer and the Project Manager, at the Employer's expense, access at any reasonable time to any place where the Plant and Equipment are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Bidder a reasonable prior notice.

#### **Completion of the Facilities**

- As soon as installation of the Facilities or any part thereof has, in the opinion of the Bidder, been completed as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Bidder shall so notify the Employer in writing.
- 
- As soon as all works in respect of Pre-commissioning are completed and, in the opinion of the Bidder, the Facilities or any part thereof is ready for Commissioning, the Bidder shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Bidder shall so notify the Project Manager in writing.

#### **Commissioning**

- Commissioning of the Facilities or any part thereof shall be completed by the Bidder as per procedures detailed in the Technical Specifications.
- The Employer shall, unless otherwise specified in Appendix 6 (Scope of Works and Supply by the Employer)/ Technical Specifications, supply the operating and maintenance personnel and all raw materials, utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning of the Facilities.

#### **Guarantee Test**

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- The Guarantee Test (and repeats thereof) shall be conducted by the Bidder as specified in the Technical Specifications or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Bidder's and Project Manager's advisory personnel shall attend the Guarantee Test. The Employer shall promptly provide the Bidder with such information as the Bidder may reasonably require in relation to the conduct and results of the Guarantee Test (and any repeats thereof).
- The number and other relevant details of key personnel required to be engaged/ employed by the Bidder in all areas shall be finalized with the successful bidder during post bid discussions (if required).
- During the entire period of Contract, the Bidder and his Sub-Bidders shall, at all times abide by the following Acts/ Statutes related to Human Resources:
  - EPF & MP Act, 1952;
  - Building & Other Construction Workers (Regulation of Employment & Conditions of Service) Act, 1996;
  - ESI Act, 1948;
  - Minimum Wages Act, 1948;
  - Payment of Wages Act, 1936;
  - Payment of Bonus Act, 1965;
  - Payment of Gratuity Act, 1972;
  - Workmen's Compensation Act, 1923;
  - ID Act, 1947;
  - Maternity Benefit Act, 1961;
  - Inter-State Migrant Workmen (Regulation of Employment & Conditions of Service) Act, 1979;
  - Factories Act, 1948; Contract Labor (Regulation & Abolition) Act, 1970;
  - Fatal Accidents Act, 1855
  - Model Welfare Code

#### **Protection of Trees**

Trees shall be protected from damage during the course of the Works and earth level within at least one (1) meter of each such tree shall not be disturbed. Where necessary, such trees shall be protected by providing temporary fencing at the cost of the Employer.

#### **Security Watch and Lighting**

The Bidder shall provide and maintain at his own expense all lights, guards, fencing and watching when and where necessary or required by the Project Manager for the protection of the Works or for the safety and convenience of those employed on the Works or the public.

#### **Prevention of Pollution**

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The Bidder shall make necessary arrangement to prevent pollution of the water in any adjacent water bodies including stream, springs, nallah, river and lakes etc. The Bidder shall be solely responsible and liable for all damage caused by any pollution that may take place during the execution of the Work.

**Royalty**

If the Bidder intends to engage itself in quarrying or mining of soil/earth, sand, stone/aggregates, metals, minerals or minor minerals required for the Civil works, as the case may be, it shall obtain necessary permits under the applicable law for such mining or quarrying from the State/Central Government authorities and pay the fee or charges applicable thereto.

The Civil works component of the Contract Price shall be inclusive of any Royalties and/or Seigniorage Fee and/or Cess and /or other charges payable on the quarried and /or mined metal, minerals, and/ or minor minerals, as the case may be, at the rate(s) prevailing as on seven (7) days prior to the deadline set for Price Bid submission.

It shall be the responsibility of the Bidder to ensure that the Royalties and /or Seigniorage Fee and/or Cess and /or other charges on the quarried and /or mined metal, minerals and /or minor minerals are paid to the statutory authorities.

The component of Royalties and/or Seigniorage Fee and/or Cess and /or other charges, if applicable in a running account bill, shall only be released by the Employer to the Bidder on submission of required credentials.

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