



## **SECTION VI (A) - TECHNICAL SPECIFICATION (GROUP A)**

**EPC PACKAGE FOR DESIGN, ENGINEERING, SUPPLY, CONSTRUCTION, TESTING & COMMISSIONING OF POOLING SUBSTATION AND ASSOCIATED POWER EVACUATION SYSTEM FOR 300 MW (220kV ISTS) SOLAR PROJECT IN THE VICINITY OF MORENA PS, DISTRICT SHEOPUR, MADHYA PRADESH, INCLUDING 5 YEARS OF COMPREHENSIVE OPERATION AND MAINTENANCE**

**RFP NO.: TeCL/CC/PSS/2026-27/03**


Issued by

Terra Clean Limited

(Procurement & Contracts Section)

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New Delhi - 110 023


Bid No:	TeCL/CC/PSS/2026-27/03
 <b>TERRA</b> <i>Clean</i> Ltd. <small>A Wholly Owned Subsidiary of IOC</small>	REQUEST FOR PROPOSAL FOR EPC PACKAGE FOR DESIGN, ENGINEERING, SUPPLY, CONSTRUCTION, TESTING & COMMISSIONING OF POOLING SUBSTATIONS AND ASSOCIATED POWER EVACUATION SYSTEMS, INCLUDING 5 YEARS OF COMPREHENSIVE O&M

## 1 Project details and Scope


SN	Description	Details
a)	Location	In vicinity of Morena PS, Sheopur District, Madhya Pradesh
b)	Location classification	Corrosive category: Min C3
c)	Maximum ambient temperature	up to 45°C, however all equipment's shall be designed for 50°C ambient temperature
d)	Humidity	up to 100 RH%.
e)	Rainfall	As per data from nearby IMD Station
f)	Seismic data and design criteria	As per IS 1893 (Part I): 2002 and amended time to time
g)	Wind data and design criteria	As per IS 875 and amended time to time

### 1.1 Scope of Work


- 1.1.1 The scope of work shall include design, engineering, manufacturing, shop testing, inspection, packing, dispatching, loading, unloading and storage at site, transit/storage and construction, insurance, assembly, erection, civil structural, architectural work, complete pre-commissioning checks, testing & commissioning at site, obtaining statutory clearance & certification from Electrical Inspector, Fire Officer, other applicable government authority etc. and handing over to the Owner after satisfactory commissioning of complete 33kV/220kV Pooling substation (PSS).
- 1.1.2 The scope includes all material, equipment and works required for the construction of the Substation complete with all items considered essential for safe and trouble-free continuous commercial operation of the system in a manner acceptable to the Owner and complying with latest revision of national and international standards Codes & Practices, Indian Electricity Rules, CEA and Indian Electricity Act.
- 1.1.3 The Contractor shall also be responsible for overall co-ordination with internal and external agencies, Owner, Owner appointed project management consultancy (PMC), training of Owner's manpower, etc.
- 1.1.4 The substation equipment shall be supplied, installed and commissioned with all accessories to make the substation complete in all respects. The substation consists of but not limited to the following:
- 1.1.4.1 220 kV circuit breakers, isolators, current transformers and CVT's
- 1.1.4.2 198 kV lightning arrestors.

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- 1.1.4.3 Busbar material & accessories, insulator, assemblies, clamps & connectors.
- 1.1.4.4 Switchyard structures and equipment supports.
- 1.1.4.5 Earthing and lightning protection system.
- 1.1.4.6 Switchyard relay & control panels and Substation automation system.
- 1.1.4.7 All required power, control, communication cables & its termination kits complete in all respect.
- 1.1.4.8 Carrier communication & associated equipment (procurement, installation as per Utility / PGCIL requirements)
- 1.1.4.9 LT switchgear for auxiliary supply at Pooling substation
- 1.1.4.10 33kV Outdoor switchgears with required incomer and outgoing feeders. Number of feeders will be decided based on approved SLD after detailed engineering.
- 1.1.4.11 33kV line coming gantry for connection of incoming line coming from solar plant area with required LA, Isolator, cables, termination kits, etc.
- 1.1.4.12 Substation civil work like Site levelling, equipment foundations, Transformer foundation, Fire wall, soak pit, Burnt oil pit, cable trenches, structure foundations, switchgear and control room, fencing, gate, road, rain & storm water drain, Anti weed treatment, land scaping, security room, foundation for lighting poles, lightning protection mask, etc.
- 1.1.4.13 Plant illumination system
- 1.1.4.14 Auxiliary power supply system including DG set
- 1.1.4.15 Battery and Battery charger
- 1.1.4.16 Metering and Telemetry system
- 1.1.4.17 Firefighting system
- 1.1.4.18 Supply Installation testing and commissioning of NIFPS associated with Power Transformers.
- 1.1.4.19 Supply Installation testing and commissioning of FOTE/Communication equipment with accessories and necessary integration with ISTS substation as per CTU/RLDC requirement.
- 1.1.4.20 Any items not listed above but required to make system complete.
- 1.1.5 Terminal points
  - 1.1.5.1 The terminal points under the scope of work shall be termination and Integration of power transmission system at 220kV Morena PS (ISTS/CTU Substation).
- 1.2 **Scope of Service**
  - 1.2.1 Scope of services and engineering activities to be performed by contractor under this contract shall consist of but not limited to following: -
    - 1.2.1.1 Overall single line diagram with relay and metering protection system along with General arrangement (GA) drawings.

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- 1.2.1.2 Switchyard related engineering calculations.
- 1.2.1.3 Necessary software and hardware, including laying of Communication cable/ Fibre Optic cable up to load dispatch center (as applicable) for communication of plant data from Solar plant SCADA/SAS to RLDC/NLDC is included in the contractor scope.
- 1.2.1.4 Sizing of various electrical equipment and confirmation of the rating of the various equipment.
- 1.2.1.5 Substation layout drawings (plan, section and clearance diagram).
- 1.2.1.6 Complete civil, structure and electrical system related engineering (drawings/ documents) for the substation including switchyard.
- 1.2.1.7 Design calculation for substation civil foundation / structure.
- 1.2.1.8 Lighting system design calculation and layouts for complete substation area including control room.
- 1.2.1.9 Earthing system design calculation including the measurement of earth resistivity of 220kV substation as per IEC Pub 60364 (and Parts) electrical installations in buildings and IEEE 80 for complete substation area including control room.
- 1.2.1.10 Lightning protection design calculation and Direct stroke lightning protection (DSLPP) layout as per IEC 62205-3: 2010 for complete substation area including control room.
- 1.2.1.11 Various electrical layouts such as electrical equipment's layouts, lighting layouts, cabling layouts, earthing layouts, lightning protection layout etc. for complete substation area.
- 1.2.1.12 Control, metering, protection and signaling scheme of each piece of equipment.
- 1.2.1.13 Construction of roads in substation area including access to all major equipment, buildings and connecting to the substation approach road.
- 1.2.1.14 Construction of road in substation area including access to all major equipment, buildings and connecting to the Pooling Substation approach road.
- 1.2.1.15 Preparation of bill of material for cabling, lighting, earthing, lightning protection and miscellaneous items for substation area.
- 1.2.1.16 Preparation of bill of material for SAS hardware and software, Preparation of SAS HMI screens, preparation of operation philosophy for SAS, preparation of alarm schedule for SAS, preparation of operation and maintenance manual for SAS if required to PGCIL / UTILITY / Local Statutory Authority.
- 1.2.1.17 Cable schedule and interconnection and termination drawings.
- 1.2.1.18 Protections relay co-ordination and relay setting calculation for complete substation equipment.
- 1.2.1.19 Construction of Pooling Substation Control Building. Water supply for toilet and office in the buildings and connecting to water supply line and/ or bore well with pumping facility for providing water supply.

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- 1.2.1.20 Construction of all Equipment Supporting Foundation and Structures, Earthing Mat in PSS
- 1.2.1.21 Cable trenches/Trestles laying including cable tray supporting arrangements in PSS
- 1.2.1.22 Construction of soak pits, burnt oil pits, etc.
- 1.2.1.23 Fencing for pooling substation.
- 1.2.1.24 Overall drainage system layout including storm water drainage and cable trench drainage in substation area.
- 1.2.1.25 Construction of drainage system for complete substation area and suitable outfalls.
- 1.2.1.26 Factory inspection and testing procedure for all electrical equipment based on the relevant latest BIS/IEC/IEEE standard.
- 1.2.1.27 Field testing and commissioning procedure for all electrical equipment.
- 1.2.1.28 Preparation of operation and maintenance manuals for all electrical equipment.
- 1.2.1.29 Preparation of testing and commissioning schedules for various equipment in contractor's scope of supply.
- 1.2.1.30 Preparations of all final as built drawings on completion of project and submit the final as built with 1 set of soft copy in USB pen drive along with 4 sets of hard copy.
- 1.2.1.31 Training of Owner's Operation and maintenance (O&M) personnel (both classroom and onsite job training).
- 1.2.1.32 Testing & Inspection of all major items will be carried out by the contractor.
- 1.2.1.33 Integration of SAS system with Solar plant SCADA including various Cable lying and terminations.
- 1.2.1.34 The communication system shall be with PLCC as per existing PGCIL/ Regional Load dispatch Centre (RLDC) of India / Local Statutory Authority requirement. The equipment shall be supplied by contractor (PLCC panel, EPAX, OFC/Communication Cable etc.) as per the rating similar to utility end communication equipment. The same shall also comply with PGCIL/RLDC/ Local Statutory Authority standards & requirements.
- 1.2.1.35 Installation of all the protection relays as detailed out in technical specification section of the tender.
- 1.2.1.36 Any other work / activity which is not listed above, however is necessary for completeness of total substation package.
- 1.2.2 The scope also covers completion of the PSS in its entirety up to the satisfaction of Owner within stipulated period of time, including co-ordination with all agencies/authorities, and getting requisite drawings approval from Owner / PGCIL/ RLDC / Local Statutory Authority etc. On completion of the job the contractor shall arrange for testing and successful commissioning of the PSS.

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1.2.3 Obligations of Owner and Contractors provided here are indicative. Any other activities not listed here but required to make system complete is deemed included in the Contractor/contractor scope.

## **2 Project Warranties**

2.1.1 Overall project warranties shall essentially include but not be limited to the following:

### **2.2 Defects Warranty**

2.2.1 The contractor shall provide warranty as per the terms of the Contract for the entire 33/220kV substation. The contractor shall warrant that the project shall be free from any and all defects including unseen and latent in all project components and workmanship.

2.2.2 In case of any manufacturing defect or underperformance of any project component, the contractor shall guarantee supply, installation, testing and commissioning of replacement of defective project component/s at no cost to the Owner.

2.2.3 In case of defects due to improper handling of project components by contractor's team, contractor shall be responsible for repairing any / all defects. Owner may claim additional monetary compensation for loss of energy generation caused due to substation unavailability.

2.2.4 Expected pooling substation and power evacuation system availability should be minimum 99%, in case of non-maintaining of the required availability, Owners may claim any loss in revenue due to such non availability during the O&M period as per relevant clauses mentioned elsewhere in tender.

2.2.5 Any replacement made or component repaired by the contractor shall continue to be in warranty for balance warranty period along with an additional extended warranty for 12 months with no charge to the Owner. The extended warranty shall come into effect upon completion of original warranty period.

### **2.3 Project Components Warranty**


2.3.1 Project components warranty can essentially be construed as guarantees / warranties provided by the project component manufacturers beyond the defect liability period, performance warranty period and extended warranties.

2.3.2 Warranties and conditions thereof for key project components are separately specified in general technical specification of key project components mentioned in this document.

2.3.3 Any and all such warranty for any of the project components shall be transferred to the Owner after completion of O&M period.

2.3.4 Owner shall reserve the right to call for extended warranties from the manufacturers; same shall be agreed by the contractor and product manufacturer.

## **3 Project Start-up and Functional Requirements**

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The start-up and functional requirements shall essentially meet all the supply, installation, testing and commissioning by contractors as required to complete the substation and the required infrastructure within the premises. Functional requirements presented here are non-exhaustive, these are required to conform the latest International standards, wherever not applicable then best industry engineering practices shall be followed with prior approval from Owner / Owner appointed PMC.

### 3.1 Site Facilities

- 3.1.1 Contractor shall provide all the required site facilities essentially including utilities and adequate temporary sanitation facilities for its employees and labours in order to maintain hygiene onsite in line with applicable Indian/international laws. Contractor shall arrange electricity with required backup and water for executing the works as per scope of work without any additional charge to the Owner.
- 3.1.2 Storage and security for Substation/switchyard equipment / inventory shall be in the contractor's scope. Respective supplier standards, recommendations and practices shall be followed for open storage and covered storage for all the equipment.
- 3.1.3 Appropriate housekeeping and security shall be provided by the contractor to timely replenish the material breakage / theft/ repair including transport without additional cost to the Owner.

### 3.2 Illumination

#### 3.2.1 Standards and Codes


LED luminaires shall be tested at independent laboratory as per the following test standards.

Standard/Code	Description
LM79-08	Electrical and Photometric Measurements of Solid-State Lighting Products
LM 80-15	Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

#### 3.2.2 General Specifications:

- 3.2.2.1 Internal roads, periphery area, equipment area shall be provided with LED based external lighting system strategizing yard security and maintenance requirements.
- 3.2.2.2 Entire substation area shall be provided with external lighting with LED-based lights. Complete external lighting system shall be powered by the auxiliary power supply system of the plant with average illumination level as mentioned below. Additionally, substation lighting system shall be as per IS 3646-1 standard and other applicable standards/guidelines.



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Location	Average Illumination Level (Lux)
Control Room and equipment room	300
Office	300
Battery and other rooms	150
Internal and access roads	10
Switch Yard/ Substation etc.	20(general) & 50 (on strategic equipment)

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

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


3.2.3 LED Luminaire for Outdoor Applications:

3.2.3.1 LED luminaires shall meet the following parameters.

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

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




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- 3.2.3.3 The LED luminaire (outdoor) housing should be made of non-corrosive, high pressure, die-cast aluminium and the housing should be power coated grey, so as to ensure good weatherability. Each individual LED source should be provided with an asymmetrical distribution high reflectance aluminized reflector, which should ensure that the light distribution of the luminaire is suitable for road lighting applications (wide beam distribution) and should ensure high pole to pole spacing.
- 3.2.3.4 The luminaire should be provided with in-built power unit and electronic driver.
- 3.2.3.5 The luminaire should be suitable for standard street light poles and should be suitable for side entry and bottom entry (post top).
- 3.2.3.6 GI Lighting pole of suitable diameter capable of withstanding system and wind load, shall be provided with average Zn coating thickness of 80micron. The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.
- 3.2.3.7 All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.
- 3.2.3.8 Lighting panels shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, etc. shall be earthed by means of separate earth continuity conductor. Cable armour shall be connected to earthing system at both the ends. Proper earthing of street light poles shall be ensured.
- 3.2.3.9 Junction box for lighting shall be made of fire-retardant material. The degree of protection shall be IP 55 for outdoor JB.
- 3.2.3.10 Lighting cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.
- 3.2.4 LED Luminaire/Lamps for Indoor Applications
- All indoor LED luminaire/lamps shall be supplied with proper diffuser to avoid direct visibility of LED and suitable heat sink for longer life.

### **3.3 Fire Fighting and Detection System**

- 3.3.1 The substation shall be equipped with suitable fire protection and fighting systems for protection of entire equipment, switchyard & control room as per the International safety standards, local fire authority requirements and as per CEIG requirement. Firefighting of transformers and other electrical equipment as required shall be in accordance with NFPA 70, NFPA 15 and latest CEA safety guidelines. Wherever required, latest fire safety codes / standards shall be followed for building fire protection and prevention.

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### 3.3.2 Fire Extinguishers and Sand Buckets

3.3.2.1 Portable type fire extinguishers conforming IS 3034:1993, IS 2190:2010 or other relevant national standard shall be provided as means of dealing effectively and immediately with fire caused from oils, solvents, gases, paints, varnishes, electrical wiring and all flammable liquids and gases. Systems shall comply with required insurance norms.


### 3.3.3 Fire alarm panel

3.3.3.1 Contractor to provide microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions in each loop. Fire alarm system shall include but not limited to the following items:

- i) Fire Alarm control Panel
- ii) Multi Sensor smoke detector
- iii) Heat Detectors
- iv) Hooter cum strobe
- v) Manual call Point
- vi) Hooter
- vii) Fault isolation modules
- viii) Control Modules
- ix) Cables from Sensors to Fire panels
- x) Digital output from the fire detection system shall be integrated with SCADA
- xi) Network Control Module
- xii) Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA
- xiii) Multi sensor type smoke detectors and heat detectors shall be provided for false ceiling areas of control room. No of sensors and modules to be approved by Owner during detail engineering.

### 3.3.3.2 Fire Alarm Control Panel Indication

- i) Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.
- ii) During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.

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iii) If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.

3.3.3.3 All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset. There shall be weatherproof Hooter cum strobe outside and strobe inside each control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Control room shall also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

3.3.3.4 Contractor shall submit document to Owner for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report.

3.3.3.5 Contractor shall submit Site Acceptance Test (SAT) reports for approval by Owner. Complete fire alarm system shall be checked at site for verification of faithful performance and completeness of the system. Contractor shall carry out necessary modification and supply hardware/accessories if required free of cost at site.

### 3.4 Safety Clearances

3.4.1 The minimum safety clearances for 220kV substation shall be as per PGCIL / Local Statutory Authority recommendation / CBIP Pub No. 299 manual on substation layout

3.4.1.1 Phase to Phase - 2100mm

3.4.1.2 Phase to Earth - 2100mm

3.4.1.3 Safety working clearances (Sectional Clearance) - 5000mm

3.4.1.4 Ground Clearance (elevation of live conductor above plinth level) - 5500mm

3.4.1.5 Height of insulator’s bottom from ground - 2400mm


3.4.2 “Safety working clearance” is the minimum clearance to be maintained in air between the live part of the equipment on one hand and earth or another piece of equipment or conductor on which it is necessary to carry out work.

### 3.5 Auxiliary Power Supply System

3.5.1 Main control room shall however be provided with independent auxiliary transformer. Auxiliary power supply arrangement shall be in line with load requirements. Auxiliary transformer shall be designed with 100% of Substation load including Owner’s requirement. Following consideration shall be taken while arriving kVA capacity of auxiliary transformer,

i) 20 % future load margin.

ii) The minimum kVA capacity of auxiliary transformer requirement shall be 250kVA.

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3.5.2 All non-critical auxiliary loads shall be fed directly from ACDB. However, emergency, and important load shall be fed from Battery system. Input AC supply for Battery Charger shall be fed from ACDB.

### **3.6 Communication System**

3.6.1 Communication equipment's shall be strictly as per Utility / PGCIL requirement. Any items required in line with Utility /PGCIL requirement but not listed in the specification is deemed included in the contractor's scope.

### **3.7 Flood Drainage System**

3.7.1 The substation shall be provided with Storm Water Management (SWM) with RCC type main drain and sub-drains shall be supported with stone pitching. The drain design shall be based on Hydrology study reports. If any or full area are falling in low laying area, contractor will raise switchyard level in manner to avoid flood in worst weather condition. If required contractor shall provide retaining wall also to prevent substation from flood based on Hydrology study report.

### **3.8 Site restoration**

3.8.1 Contractor shall reinstate all areas which have been disturbed during the work with landscaping in conformance to the contractor's best practices and in acceptance to the Owner / Owner appointed PMC.

## **4 Codes and Standards**

4.1.1 All equipment and materials shall be design, manufacture and tested in accordance with the latest applicable International Electro-technical Commission (IEC), Bureau of Indian Standards (BIS), Grid code defined by Central Electrical Authority (CEA) and Power Grid Corporation of India Limited (PGCIL) except where modified and/or supplemented by this specification.


4.1.2 Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted. 220kV/ 33kV substation layout and Grounding shall be confirming to Indian Standard (IS), Institute of Electrical and Electronics Engineers (IEEE) in addition to relevant IEC.

4.1.3 All electrical installation work shall comply with the provisions of the Central Electricity Regulation Commission (CERC), 2003 with its latest amendment, the Indian Electricity Act latest / as amended up-to-date, relevant IS/IEC/BIS, Codes of practice and National Fire protection association (NFPA) etc. In addition, other rules and regulations applicable to the work shall be followed.


4.1.4 In addition, other rules and regulations applicable to the work shall be followed. In case of any discrepancy, the more stringent rules shall be binding.

4.1.5 Nothing in this specification or in the accompanying specifications shall be construed to relieve the contractor of his responsibility.


4.1.6 Following table indicates the list of standards to which substation equipment should confirm.

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IEEE 80	Earth-mat sizing calculations
IS: 3043	Code of practice for earthing
IS: 2209	Protection of Buildings and Allied Structures against Lighting- Code of Practice (Second Revision)
IEC: 62205-3: 2010	Code of practice for the protection of Building and an allied structure against lightning
IEEE 998-1996	Lightning protection design and calculation
NFPA-72E/EN54	Fire insurance regulations
AS 1603.2 - 1997	Type approval for smoke detector
IEC: 1107	Protocol data exchange for meter reading tariff and load control
IEC: 62056	Electricity metering data exchange
IEC: 60870-5-104	Systems used for tele control (supervisory control and data acquisition) in electrical engineering and power system automation applications
IEC: 207, 208, 209	High-voltage switchgear and control gear
IEC: 307	High-voltage switchgear and control gear
IS: 2026 (Part-1)	Specification for power transformer part - 1 general
IS: 2026 (Part-2)	Specification for power transformer temperature rise.
IS: 2026 (Part-3)	Specification for power transformer's part - 3 insulation level and dielectric tests.
IS: 2026 (Part-4)	Specification for power transformer's part - 4 terminal marking, tapping's & connections.
IS: 2026 (Part-5)	Power transformer part - 5 bushings -minimum external clearance in air -specification.
IS: 3639	Specification for fittings and accessories for power transformers.
IS: 8478	Application guide for on load tap changers.
IS:10561	Application guide for power transformers.


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IS: 335	Specification for new insulating oil (Fourth Revision).
IS: 2099	Specification for bushings for alternating voltages above 1000 Volts (second revision)
IS: 3716	Application guide for insulation co-ordination
IS: 209	Specification for Zinc.
IS: 432 (Part-I & II)	Specification for mild steel & medium tensile steel bars and hard drawn steel wires for concrete reinforcement.
IS: 335	Specification for New Insulating Oil (Fourth Revision).
IS: 9921-4	Specification for Alternating Current (Isolators) and Earthing Switches for Voltages above 1000V.
IS: 2516	Specifications for Outdoor Circuit Breaker
IS: 2705 (Part-I to IV)	Specification for Current Transformer.
IS: 3156	Specification for Potential Transformer.
IS: 8130	Specification for conductors for insulated electric cables and flexible cords.
IS: 5831	Specification for PVC insulation & sheath of electric cables.
IS: 7098 (Part-I)	Specification for cross linked polyethylene insulated PVC sheathed cables.
IS: 1554 (Part-I)	Specification for PVC insulated (heavy duty) electric cables.
IS: 3975	Specification for mild steel wires, strips and tapes for armouring of cables.
IS: 10810	Method of test for cables.
IS: 10418	Specification for drums for electric cables.
IS: 6474 & IS-694	Fire Insurance Authority Regulations.
IS: 2016	Specification for plain washer.

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IS: 2551	Specification for danger notice plate.
IS: 2629	Recommended practice for hot-dip galvanizing of iron & steel.
IS: 2633	Method of testing uniformity of coating on zinc coated articles.
IS: 3063	Single coil rectangular section spring washers for bolts, nuts & screws.
IS: 3757	High strength structural bolts.
IS: 4091	Code of Practice for Design & Construction of Foundations for Transmission Line Towers & Poles.
IS: 4759	Hot-dip zinc coatings on structural steel & other allied products.
IS: 5358	Hot-dip galvanizing coatings on fasteners.
IS: 5613	Part-II /Sec-I & Sec-II: Code of practice for design, installation & maintenance of overhead lines above 11 kV and up to & including 220kV
IS: 5624	Specification for foundation bolts.
IS: 6610	Specification for heavy washers for steel structures.
IS: 6623	Specification for high strength structural nuts.
IS: 6639	Specification for hexagonal bolts for steel structures.
IS: 6649	Specification for hardened & tempered washers for high strength structural bolts & nuts.
IS: 6745	Methods of determination of weight of zinc coating of zinc coated iron & steel articles.
IS: 8500	Specification for structural steel - micro alloyed (medium & high strength qualities).
IS: 10238	Specification for step bolts for steel structures.
IS:12427	Specification for transmission tower bolts.
	Indian electricity rules 1956.




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	CBIP manual on Transformer
	CBIP manual on Substation
ISO: 1459	Metallic coatings - Protection against Corrosion by Hot Dip Galvanising - Guiding Principles
ISO: 1460	Metallic coatings - Hot dip galvanized coatings on ferrous materials. Gravimetric determination of the mass per unit area
ISO: 2178	Non-magnetic coatings on magnetic substrates - Measurements of coating thickness - Magnetic method
ISO: 9000	Quality management and quality assurance standards - Guidelines for selection and use
D 202	Methods of sampling and testing untreated paper used for electrical insulation

## 5 System Parameter and Design requirements

5.1.1 The following Table lists all system parameters available for 220kV and 33kV. Tabulated values given below for various parameters are as per CEA guidelines, however same shall be finalized during detailed engineering phase as per system requirement.

SN	Parameter	Unit	220kV	33kV
a)	Nominal system voltage between phases	kV	220	33
b)	System frequency	Hz	50	50
c)	Rated voltage between phases / System Highest voltage	kV	245	36
d)	Lightning impulse withstand	kV	1050	170
e)	50 Hz withstand 1 minute	kV	460	70
f)	Symmetrical short-circuit current	kA	50	31.5
g)	Minimum Substation Clearances			
(i)	Minimum clearance between phase to earth	mm	2100	320

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SN	Parameter	Unit	220kV	33kV
(ii)	Minimum clearance between phases	mm	2100	320
(iii)	Minimum safety clearance between ground and the nearest point not at earth potential of an insulator	mm	4600	2800
(iv)	Minimum safety clearance between ground and the nearest live unscreened conductor)	mm	4600	2800
(v)	Minimum clearances between equipment	mm	4500	3000
(vi)	Minimum insulator creepage distance (at rated voltage between phases)	mm/kV	25	25

## 5.2 Substation Designing

5.2.1 The substation shall be configured with double busbar system Main 1 and Main 2 configuration as per relevant IS/IEC standards, CBIP manual and Utility requirement.


5.2.2 The various line and transformer feeders shall have following minimum protection requirements. Same shall be finalized during detailed engineering with the approval of Owner.

5.2.3 The protection relay on 33kV side incomers shall be as under;


- i) Numerical Relay - 1: 50, 50N, 51, 51N CT (Core 1: Class: 5P20)
- ii) Electromechanical Relay - 2: 86 (Master Trip Relay) (Equivalent to VAJM23)
- iii) Electromechanical Relay - 3: 95 (Trip Circuit Supervision Relay) (Equi. to VAX 31)
- iv) Electromechanical Relay - 4: 94 (VCB Anti-pumping Relay)
- v) CT core 2 - Class: 0.2 TVM metering

5.2.4 The Power Transformer protection relay on 33kV side shall be as under;


- i) Numerical Relay - 1: 67, 67N, 50, 50N, 51, 51N CT (Core 1: Class: 5P20)
- ii) Electromechanical Relay - 2: 86 (Master Trip Relay) (Equi. to VAJM23)
- iii) Electromechanical Relay - 3: 95 (Trip Circuit Supervision Relay 1 and 2) (Equi. to VAJX 31)
- iv) Electromechanical Relay - 4: 94 (VCB Anti-pumping Relay)
- v) CT core 2 - Class: 0.2 TVM metering
- vi) CT core 3 - Differential and REF HV connection Class: PS class.
- vii) CT Core 4- Class PS: Spare

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- 5.2.5 The Power Transformer protection relay on 220kV side shall be as under;
- Numerical Relay - 1: 87T, 64RHV, 64RLV, 51S, 50BF, 24, (CT core 1 - PS class)
  - Numerical Relay - 2: 67, 67N, 50, 50N, 51, 51N, 25, 27, 81U, 81O, 59 (CT core 2 - Class PS)
  - Electromechanical Relay - 3: 51SHV, 51SLV (Sensitive Earth Fault Relay 1 and 2) (Equi. to CDG11)
  - Electromechanical Relay - 4: 186, 286 (Master Trip Relay 1 and 2) (Equi. to VAJM23)
  - Electromechanical Relay - 5: 195, 295 (Trip Circuit Supervision Relay 1 and 2) (Equi. to VAJX 31)
  - Electromechanical Relay - 6: 63A, 63B, 63C, 63D (3 Element - Buccholz Alarm / Trip, OTI Alarm / Trip, HV WTI Alarm / Trip, LV WTI Alarm / Trip, MOG alarm, PRV Trip) (Equi. to VAA33)
  - Electromechanical Relay - 7: 94 (SF6 CB Anti-pumping Relay)
  - CT core 3 - Class: 0.2S Tariff metering, TVM metering, BCU.
  - CT core 4 - Class: PS, Bus basr protection.
  - CT core 5 - PS class: Spare
- 5.2.6 The Line protection relay on 220kV side shall be as under;
- Numerical Relay - 1: 87<sub>L1</sub> cum 21<sub>1</sub>, 79, 68/78, 27, 59, 81O, 81U, 97, 98 SOTF, DR, 50, 50N, 67, 67N, 51, 51N (CT core 1 - PS class)
  - Numerical Relay - 2: 87<sub>L2</sub> cum 21<sub>2</sub>, 79, 68/78, 27, 59, 81O, 81U, 97, 98 SOTF, DR, 50, 50N, 67, 67N, 51, 51N (CT core 2 - PS class)
  - Electromechanical Relay - 4: 186, 286 (Master Trip Relay 1 and 2) (Equi. to VAJM23)
  - Electromechanical Relay - 5: 195, 295 (Trip Circuit Supervision Relay 1 and 2) (Equi. to VAJX 31)
  - Electromechanical Relay - 6: 78 (Vector Surge Relay) (Equi. to MRG2)
  - Electromechanical Relay - 7: 94 (SF6 CB Anti-pumping Relay)
  - CT core 3 - Class: 0.2S TVM metering
  - CT core 4 - PS class: Busbar Protection
  - CT Core 5 - Spare
- 5.2.7 The Bus coupler protection relay on 220kV side shall be as under;
- Numerical Relay - 1: 67, 67N, 50, 50N, 51, 51N (CT core 1 - Class PS)
  - Electromechanical Relay - 2: 186, 286 (Master Trip Relay 1 and 2) (Equi. to VAJM23)

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- iii) Electromechanical Relay - 3: 195, 295 (Trip Circuit Supervision Relay 1 and 2) (Equi. to VAJX 31)
- iv) Electromechanical Relay - 4: 78 (Vector Surge Relay) (Equi. to MRG2)
- v) Electromechanical Relay - 5: 94 (SF6 CB Anti-pumping Relay)
- vi) CT core 2 - Class: 0.2S TVM metering
- vii) CT core 3 - PS class: Busbar Protection
- viii) CT core 4 - PS class: Spare
- ix) CT core 5 - PS class: spare
- 5.2.7.1 The tariff metering arrangement shall be done as per Utility / SLDC requirement and as per PPA. (This shall include CT Ratio (Single or Dual), CT/PT Class of accuracy, CT/PT VA burden, CT/PT Make, Tariff meter make, Tariff meter type (ABT), Accessories with Tariff meter (Communication Port, software, MRI etc.) Structure arrangement, material make & type etc.
- 5.2.8 The Busbar protection relay on 220kV Bus side shall be as under;
  - i) Numerical Relay - 1: 87<sub>B1</sub> (CT core 1 - PS class)
  - ii) Numerical Relay - 2: 87<sub>B2</sub> (CT core 2 - PS class)
- 5.2.8.1 The reactor or capacitor compensation requirement as per Load flow study and Utility requirement deemed to be considered in the scope of contractor. This section though does not cover Technical specification for this requirement, it is deemed that the same shall be done as per Utility requirement and Best Industrial Technical practices.
- 6 Quality assurance plan and Type Test requirement**
- 6.1 The contractor shall submit a Quality Assurance Plan (QAP) covering all stages of design, manufacture, inspection, testing, packing, and dispatch of equipment for the Employer's review and approval prior to commencement of manufacture. The QAP shall be prepared in accordance with the "Guidelines for Model Quality Assurance Plan (MQAP) for Major Equipment of Power Sector" issued by the Central Electricity Authority in Jan'2026, including amendments issued from time to time.
- 6.2 All major equipment shall conform to the "Guidelines for Type Tests for Major Equipment of Power Sector" issued by the Central Electricity Authority in Jan'2026, including amendments issued from time to time.
- 7 Submittals**
- 7.1 General Requirements**
- 7.1.1 The Contractor shall be responsible for the preparation, submission, and obtaining approval of all design, engineering, and construction documents

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required for execution of the Works. All submittals shall be complete in all respects and submitted in a phased manner in line with the approved project schedule.

7.1.2 Approval of any document by the Owner shall not relieve the Contractor of its responsibility for the correctness, adequacy, and completeness of the design and engineering.

7.1.3 Documents to be submitted for approval


7.1.3.1 The Contractor shall submit the following documents for all major equipment and systems to the Owner for review and approval upon completion of detailed design and engineering:

- i) General Arrangement (GA) drawings along with guaranteed technical parameters (GTP)
- ii) Bill of Materials (BoM)
- iii) Foundation plans along with loading details, wherever applicable
- iv) Details of clamps and connectors, wherever applicable
- v) Control schematics and wiring diagrams, wherever applicable
- vi) Instruction manuals covering installation procedures, pre-commissioning checks, and tests to be carried out prior to commissioning of the equipment.
- vii) Any other drawings, documents, or data required for satisfactory installation, operation, and maintenance.
- viii) List of specific requirements during installation, if any
- ix) Test reports (type/routine, as applicable)
- x) Quality Assurance Plan (QAP)

7.1.4 Final / As-Built Submittals

7.1.4.1 The Contractor shall submit and hand over the following documents upon completion of supply, erection, testing, and commissioning of the Works:

- i) Final General Arrangement (GA) drawings
- ii) Final foundation drawings, wherever applicable.
- iii) Final control schematics and wiring diagrams, wherever applicable.
- iv) Data sheets, Results of all routine, type, special tests conducted
- v) Complete set of test reports and inspection certificates
- vi) Final Operation and Maintenance (O & M) manuals

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vii) Recommended spare parts list

viii) Guarantee/Warranty certificates

## **8 EHV Switchgear Equipment's**

### **8.1 220 kV Circuit Breaker**

8.1.1 This Specification describes the requirements governing engineering, design, manufacture, inspection/ testing at works, packing, and delivery at site of Extra high voltage outdoor 220kV SF6 EHV Circuit Breakers and of class C2-M2 as per IEC. The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.


8.1.2 The circuit breaker shall be complete with operating mechanism, common marshalling box, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanized support structure, platform with ladder for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.

8.1.3 All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.

#### **8.1.4 Codes and Standards**

8.1.4.1 The circuit breaker assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below:

IEC 62271 - 100	High-voltage switchgear and control gear - Part 100: Alternating-current circuit-breakers
IEC 60376	Specification of technical grade Sulphur hexafluoride (SF6) and complementary gases to be used in its mixtures for use in electrical equipment
IEC 62271-1	High-voltage switch gear and control gear - Part 1: Common specifications
IEC TR 62271-300	High-voltage switchgear and control gear - Part 300: Seismic qualification of alternating current circuit-breakers
IEC 60529	Degrees of protection provided by enclosures
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel

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IEC 60480	Guidelines for reuse and handling of SF <sub>6</sub> gas
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8.1.4.2 The Contractor shall be responsible to be, or to become, knowledgeable of the requirements of these Standards and Codes. Any alternations or changes to the equipment to make it meet Standards and Codes requirements shall be at his expense only.

8.1.4.3 Compliance by the Contractor with the provisions of this specification shall not relieve the Contractor/Manufacturer of the responsibility of furnishing apparatus and accessories of proper design, electrically and mechanically suited to meet the operating requirements under the specified service conditions and be suitable for the purpose of which they are intended.

#### 8.1.5 Specific Design Requirements

##### 8.1.5.1 Type and Duty


- i) The circuit breaker shall be three-pole, gang operated sulphur hexafluoride (SF<sub>6</sub>) type, having internal isolation without any sequential interlock.
- ii) The circuit breakers shall carry rated current continuously and short-time current 50kA for 1 second. Same shall be decided during detailed engineering based on system requirement.
- iii) The breaker shall be suitable for operation even under, out of phase condition arising out of faulty synchronization. The breaker shall be capable of clearing short-line fault of same magnitude as rated short-circuit current.
- iv) The breaker shall be capable of interruption of low reactive currents (lagging/leading) without undue over voltage and also shall be capable of interruption of line charging current without causing excessive over voltage and charging current without re-strike.
- v) Breakers with multi-break interruptions shall be so designed that the voltage developed across a pole is uniformly distributed over the power breaks.

##### 8.1.5.2 Constructional Feature

- i) Each EHV circuit-breaker shall comprise of three (3) identical poles complete with individual operating mechanism for specified duty. Three poles shall be linked together electrically/pneumatically for simultaneous closing.
- ii) Where mechanically gang-operated type EHV Circuit Breaker specified, it shall be triple pole mechanically ganged with common operating mechanism.
- iii) The circuit breaker shall be single pressure type. The design and construction shall be such that there is minimum possibility of gas leakage and ingress of moisture. Further, the arrangement shall be such that condensation of SF<sub>6</sub> gas on the internal insulating surfaces of the circuit breaker must not occur under any condition.
- iv) Each pole shall form an enclosure filled with SF<sub>6</sub> gas independent of two other poles. The SF<sub>6</sub> gas density of each pole shall be monitored and regulated by individual temperature compensated gas density monitoring

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devices, which shall be mounted at a convenient and easily approachable location. The device shall provide continuous and automatic monitoring of the state of the gas as follows:

- a) Gas Refill level: This contact will be used for remote indication/ to annunciate the need for gas refilling.
- b) SF6 density Low Alarm level -1: This contact will be used for remote indication/ to annunciate the need for urgent gas refilling.
- c) SF6 density Low Alarm level -2: This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.
- d) Breaker Block level - Minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker.

Also, pressure gauge shall be mounted at a convenient height so that gas pressure can be visually observed.

- v) The circuit breaker shall have proper sealing so that leakage of gas outside is not more than 0.5% of the total quantity per annum under all conditions of operation. Further, it shall incorporate devices to absorb any moisture, which may exist/be released within breaker poles after assembly, gas charging and during operation.
- vi) All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimize distortion and make a tight seal.
- vii) SF6 breakers shall be furnished with first charge of SF6 gas, plus 15% additional quantities of SF6 gas required for complete lot.
- viii) The SF6 gas shall be supplied in properly treated steel cylinder of adequate strength. Chemical analysis of gas supplied shall be furnished for Owner's reference.
- ix) The circuit breaker units shall be complete with associated valves, piping, gauges, pressure switches, seals, lubricants and other accessories/materials to ensure their proper assembly and functioning.
- x) The circuit breaker shall be provided with terminal pads of adequate size for connection to Rigid Aluminium tube by expansion type terminal connector and shall be designed to withstand the rated terminal load, wind load/Earthquake load and short circuit forces.
- xi) Adequate transversal and vertical force shall be considered for the terminals so as to support the interconnecting tubes spanning around 10 meters during short circuit and wind force.
- xii) The circuit breaker shall be so designed that upon loss of pressure the gap between open contacts shall be adequate to withstand at least the rated voltage at atmospheric pressure of gas.
- xiii) The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanized). The maximum temperature of enclosure with CB carrying full load current shall not exceed the ambient temperature by more than 20°C.

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#### 8.1.5.3 Main Contacts and Arc Quenching Chamber


- i) The main contacts shall have adequate area and contact pressure for carrying rated continuous and short time current without excessive heating liable to cause pitting and welding.
- ii) The tips of the arcing and main contacts shall be heavily silver plated.
- iii) The contacts shall be adjustable to allow for wear, shall be easily replaceable and shall have minimum movable parts and adjustments.
- iv) Arcing contacts, if provided, shall be the first to close and the last to open and shall be easily accessible for inspection and replacement. The arcing contacts shall have tungsten alloy tipping.
- v) The arc quenching device shall be of robust construction and shall not require any critical adjustment. The devices shall be easily accessible and removable for access to the breaker contacts.
- vi) Each breaker shall be provided with six (6) normally open and six (6) normally closed electrically separate spare auxiliary contacts, in addition to those required for its own operation and indication.
- vii) The auxiliary contacts shall be convertible type so that normally open contacts can be converted into normally close contact and vice versa at site.
- viii) The auxiliary contacts shall be rated 10A at 240V AC and 2A at 220V DC.

#### 8.1.5.4 Interlock

- i) All electrical and mechanical interlocks, which are necessary for safe and satisfactory operation of the circuit breaker, shall be furnished.
- ii) Breaker operation shall be locked in case of low SF<sub>6</sub> gas pressure and/or low control air pressure at pre-set values. Alarms shall be provided for low gas pressure and low air pressure at values higher than lockout pressure of SF<sub>6</sub> gas and/or air. It is intended that before lockout occurs, the breaker shall be in trip position.
- iii) Gas analyser contacts, pressure switch contacts, etc. shall be suitable for direct use as permissive in closing, tripping, annunciation and control circuits.
- iv) DC supplies for all auxiliary circuits shall be monitored, and provision shall be made for remote annunciations.

#### 8.1.5.5 Insulator

- i) Insulator shall be wet-process porcelain/Silicon rubber, brown glazed and free from all blemishes. Metal parts and hardware shall be hot-dip galvanized. Galvanization of the member shall conform to IS:2629 and IS:4759. The minimum weight of galvanization shall be 610 gms/sqm.
- ii) Insulator shall have adequate mechanical strength and rigidity to withstand the duty involved.

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- iii) When operated at maximum system voltage, there shall be no electrical discharge. Shielding rings, if necessary, shall be provided.
- iv) Insulation shall be coordinated with basic impulse level of the system. The creepage distance shall be as per the system requirement.

#### 8.1.5.6 Operating Mechanism

- i) Operating mechanism shall be stored energy type, with motor operated spring charged or pneumatic or electrohydraulic closing mechanism. Anti-pumping and trip free features complete with 2x100% shunt trip coils shall be provided.
- ii) The mechanism of the breaker shall be such that the position of the breaker is maintained even after leakage of operating media and/or gas.
- iii) All three breaker poles shall close simultaneously. Pole discrepancy feature shall be provided to trip the breaker out if all the poles do not close simultaneously within the stipulated time.
- iv) Circuit Breakers shall have provision of both single and three phase auto re-closing.
- v) The mechanism shall be designed for electrical control from remote as well as local position. In addition, local manual trip button shall be provided.
- vi) Operation counter and mechanical ON-OFF indicator shall be provided for each pole.
- vii) The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.
- viii) Each breaker pole shall be provided with two (2) independent tripping circuits, valves, pressure switches and coils each connected to a different set of protective relays.
- ix) The trip coils shall be suitable for trip circuit supervision during both open and close positions of the breaker.

#### 8.1.5.7 Spring Operated Mechanism

- i) The mechanism shall have spring charging motor, opening and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit.
- ii) The charging of closing spring for spring charged operating mechanism shall take place automatically after each breaker closing operation. One open - close open operation of the circuit breaker will be possible after failure of power supply to the spring charging motor. It shall be provided with the facility of spring charging manually.
- iii) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

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- iv) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

#### 8.1.5.8 Control Cubicle


- i) A common control cubicle shall be furnished to house electrical, controls, monitoring devices and all other accessories except those which must be located on individual poles.
- ii) The cubicle shall be IP55 of gasketed weather-proof construction, fabricated from sheet steel minimum 2mm thick.
- iii) The cubicle shall have front access door with lock and keys and removable gland plate at the bottom for cable entry.
- iv) Control cubicle shall be provided with single phase 240V, 50Hz thermostat controlled space heater, internal illumination lamp of CFL 11W and 3 pin 5A socket with individual ON-OFF switches shall be provided in the cubicle.
- v) All electrical and pneumatic connections between the control cubicle and individual poles shall be furnished
- vi) For local operation following shall be provided:-
  - a) LOCAL/REMOTE selector switch.
  - b) TRIP/CLOSE push buttons.

#### 8.1.5.9 Wiring

- i) Wiring shall be complete in all respects to ensure proper functioning of the control, protection, and monitoring and interlocking schemes.
- ii) DC circuit for trip coil 1 and 2 shall be wired separately so as to connect with duplicate DC supply.
- iii) Wiring shall be done with flexible 1100V grade, PVC insulated, switchboard wires with 2.5mm<sup>2</sup> stranded copper conductors. Wiring between individual poles and control cubicle shall be routed through G.I/ PVC rigid conduits.
- iv) Each wire shall be identified at both ends with printed ferrules bearing wire numbers as per Contractor's Wiring Diagrams AC / DC wiring shall have separate colour-coding.
- v) Wire termination shall be done with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.
- vi) All spare contacts of relays, push buttons, auxiliary switches etc. shall be wired up to terminal blocks in the control cubicle.

#### 8.1.5.10 Terminal Blocks

- i) 1100V grade, terminals shall be rated for adequate capacity which shall not be less than 10A.

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- ii) Multi way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the wiring. Terminals shall be stud type, suitable for terminating 2 nos. 2.5mm<sup>2</sup> stranded copper conductor and provided with acrylic insulating cover.
- iii) Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Separate terminal blocks shall be used for AC/ DC wiring termination.
- iv) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

#### 8.1.5.11 Sulphur Hexafluoride (SF<sub>6</sub>) Gas

- i) The SF<sub>6</sub> gas shall be new and comply with relevant IEC/IS standard and shall be suitable in all respects for use in the circuit breakers under the various operating conditions.
- ii) SF<sub>6</sub> gas shall be tested for quality, dew point, air, hydrolysable fluorides and water content as per IEC/IS standard and test certificates shall be furnished covering all tests for each lot of SF<sub>6</sub> gas.
- iii) The handling and storage of SF<sub>6</sub> gas shall comply with requirements of relevant IEC/IS standard.

#### 8.1.5.12 Support Structure

- i) The equipment shall be supplied with support structures, which are integral part of the breaker.
- ii) All support structure shall be hot dip galvanized with minimum 610g/m<sup>2</sup> net of zinc after full chemical treatment as per relevant standard.
- iii) The loading data to be considered by the Contractor for design of support structure shall include the following.
  - a) Dead weight of the Circuit Breaker, Structure and Bus bars.
  - b) Operational steady state and impact loading.
  - c) Wind load on a Circuit Breaker, Structure, Bus bars.
  - d) Short circuit forces.
- iv) The height of the support structure shall be decided based on, whichever is higher, of the following:
  - a) The minimum vertical distance from the bottom of lowest porcelain part of the bushing shall be at least 2400mm from top of the plinth level of the foundation.
  - b) The height of the lower terminal pad at the specified elevation above the plinth level.

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#### 8.1.5.13 Auxiliary Equipment

- i) A Portable SF6 gas filling and evacuating system shall be supplied with necessary gas valves, safety devices, gas purity monitoring devices, regulators, vacuum pump, pressure gauges/switches, hose pipes etc.
- ii) The sensing probe of SF6 gas leaked detector shall be able to reach all the points on the breaker where leakage is to be sensed. The accuracy of the equipment shall be at least 10ppm.


#### 8.1.6 Pre-dispatch Quality and Testing

8.1.6.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.

#### 8.1.6.2 Type Test

- i) Following types tests shall be performed on the circuit breaker:
  - a) Dielectric tests on main circuits
  - b) Radio interference voltage test
  - c) Measurement of resistance of the main current path
  - d) Temperature rise test
  - e) Short time withstand current and peak withstand current test
  - f) Making and breaking tests
  - g) Tests to verify the degrees of protection of enclosures
- ii) Reports of the following type tests carried out on circuit breaker/ circuit breaker panels, of each voltage class and current rating shall be submitted.
  - a) Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs , bushing and separators
  - b) Power frequency withstand test on breaker mounted in side panel
  - c) Lightning impulse withstand test on breaker mounted in side panel.
  - d) Internal Arc Test as per IEC 62271-200
  - e) Mechanical operation test.
  - f) Making and breaking tests
  - g) Short circuit withstand test of earthing device (truck / switch).
- iii) However if the contractor is not able to submit report of the type test(s) conducted not earlier than ten years prior to the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract free of cost 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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#### 8.1.7 Specific Erection Requirement

8.1.7.1 Erection of circuit breaker structures to the designated place and placement of all circuit breaker poles on structure and levelling alignment.

8.1.7.2 Complete assembly of circuit breaker including erection of control cabinet and mechanism box interconnecting piping works, erection of all accessories of the equipment's and making inter connections (pole to marshalling box and pole to pole).

8.1.7.3 Preliminary check / test including test for leakage of air/gas.


8.1.7.4 If required, the contractor shall provide suitable platform with steps on both sides for easy accessibility for monitoring the density / pressure of gas inside operating mechanism. Same shall be finalized during detailed engineering.

#### 8.1.7.5 Onsite Testing

- i) The circuit breaker shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.
- ii) An authorised testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.
- iii) Following tests shall be performed at site:
  - a) Insulation resistance of each pole.
  - b) Breaker closing and opening time.
  - c) Power closing and opening operation.
  - d) Trip free and anti-pumping operation.
  - e) Minimum pick-up voltage of coils.
  - f) Dynamic contact resistance measurement.
  - g) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
  - h) Insulation resistance of control circuits, motor.
  - i) Resistance of closing and tripping coils.
  - j) SF6 gas leakage check.
  - k) Operation check of pressure switches and gas density monitor during gas filling.
  - l) Checking of mechanical 'CLOSE' interlock.
  - m) Resistance measurement of main circuit.
  - n) Check for annunciations in control room.

#### 8.2 220kV Isolator with/Without Earth Switch



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8.2.1 This Specification describes the requirements governing engineering, design, manufacture, inspection/ testing at works, packing, and delivery at site of high voltage outdoor 220 kV Isolators. The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.

8.2.2 Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

- a) The isolator with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlocks etc.
- b) All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

8.2.3 Codes and Standards


8.2.3.1 The Isolator assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below which is non-exhaustive.

IEC 62271 - 102	High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches
IEC 62271-1	High-voltage switchgear and controlgear
IS 9921 (Part 1-5)	Disconnector and earthing switches above 1000 V
IEC 60383 / 61109	Insulators for overhead lines with nominal voltage above 1000 V
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759	Hot-dip zinc coatings on structural steel and other allied products

8.2.3.2 The Contractor shall be responsible to be, or to become, knowledgeable of the requirements of these Standards and Codes. Any alternations or changes to the equipment to make it meet Standards and Codes requirements shall be at his expense only

8.2.3.3 Compliance by the Contractor with the provisions of this specification shall not relieve the Contractor/Manufacturer of the responsibility of furnishing apparatus and accessories of proper design, electrically and mechanically suited to meet the operating requirements under the specified service conditions and be suitable for the purpose of which they are intended

8.2.4 Specific Design Requirements

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#### 8.2.4.1 Type and Duty


- i) The disconnecting switches shall be centre break type / double end break, centre post rotating type with contact blades moving through horizontal plane / vertical break type / pantograph type as indicated in the specification.
- ii) The disconnect switch shall carry rated current continuously and short-time current for 1 second.
- iii) In addition, the disconnecting switch shall be capable of making and breaking -
  - a) Magnetizing current of the voltage transformer.
  - b) Capacitive current of the buses and short connections.

#### 8.2.4.2 Constructional Features

- i) The isolator shall be off load type, gang operated type, motorized, double break, centre post rotating type with contact blade moving through a horizontal plane. The isolator shall be with the earthing switch.
- ii) The 3-pole disconnecting switch shall be gang operated type so that all the poles make and break simultaneously. 1-pole disconnecting switch shall have individual pole drive.
- iii) The disconnecting switch shall be designed for upright mounting on steel structure unless otherwise indicated.
- iv) The disconnecting switch shall have padlocked arrangement in both 'Open' and 'Closed' positions.
- v) All current carrying parts shall be non-ferrous metal or alloy. All live parts shall be designed to avoid sharp points and edges.
- vi) All metals parts shall be of such material and treated in such a way as to avoid rust, corrosion and deterioration due to atmospheric conditions. Ferrous parts shall be hot dip galvanized. Galvanisation of the members shall conform to IS:2629 and IS:4759. The minimum weight of galvanisation shall be 610 gms/sqm
- vii) Bolts, nuts, pins, etc. shall be provided with appropriate locking arrangements such as locknuts, spring washers or keys.
- viii) Bearing housing shall be weather-proof with provision for lubrication.
- ix) All bearings in the current path shall be shorted by flexible copper conductor of adequate size.

#### 8.2.4.3 Main Contacts

- i) The main contacts shall be silver-plated copper alloy and controlled by powerful springs designed for floating and pressure point contact.
- ii) The contacts shall have sufficient area and pressure to prevent excessive heating liable to bring about pitting or welding.

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- iii) Contacts shall be adjustable to allow for wear, shall be easily replaceable and shall have minimum movable parts and adjustments.
- iv) The blade shall be made of electrolytic copper/aluminium tube of liberal section. Rotating features of the blade at the end of travel for contact wiping shall be provided.
- v) Arcing horns shall be provided to divert the arc from main contacts to the separating horns after the main contacts have opened.

#### 8.2.4.4 Auxiliary Contacts

- i) Each disconnect switch shall be provided with eight (8) normally closed and eight (8) normally open electrically separated spare contacts, in addition to the auxiliary contacts required for its operation and indication.
- ii) The contacts shall be convertible type so that normally open contact may be converted to normally closed contact and vice-versa at site.
- iii) The auxiliary contacts shall be rated 10A at 240V AC and 2A at 220DC The auxiliary contacts shall be adjustable type to suit the following requirements:
  - a) Signaling of 'Closed Position' shall not take place unless the main power contacts have reached a position so that rated normal and short time current can be carried out safely.
  - b) Signaling of 'Open Position' shall not take place unless the main power contacts are at a safe isolating distance.

#### 8.2.4.5 Interlocks


All electrical and mechanical interlocks necessary for safe and satisfactory operation of the disconnect switch and its earthing switch shall be furnished.

#### 8.2.4.6 Insulators

- i) Insulators shall be post type and composed of stacked units. Insulators of identical rating shall be interchangeable.
- ii) Insulator shall be of wet-process porcelain/Silicon rubber, brown glazed and free from all blemishes. Metal parts and hardware shall be hot-dip galvanized. Galvanisation of the member shall conform to IS:2629 and IS:4759. The minimum weight of galvanisation shall be 610 gms/sqm
- iii) Insulator shall have adequate mechanical strength and rigidity to withstand the duty involved.
- iv) When operated at maximum system voltage there shall be no electrical discharge. Shielding rings, if necessary, shall be provided.
- v) Insulation shall be co-ordinated with basic impulse level of the system. The creepage distance shall be as per the system requirement.

#### 8.2.4.7 Operating Mechanism

- i) The operating mechanism of the disconnect switch shall be motor operated type, with electrical control from remote as well as local position.

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- ii) The mechanism shall also have provision for manual operation with detachable handle. The arrangement shall be such that one operator may be able to operate without undue efforts.
- iii) Interlock shall be provided such that electrical power to the motor is cut off on insertion of manual operating handle.
- iv) The mechanism of disconnect switch shall be so designed that its blade(s) are in positive continuous control throughout the cycle of operation.
- v) Visible indication of switch position and means to prevent false indication if the mechanism fails to complete the operation shall be provided.
- vi) Starters, relays, limit switches shall be provided as required for operation, indication and interlocks. Electromagnetic brakes and/or adjustable mechanical stop shall be provided to limit over-travel.
- vii) The operating links of Tandem disconnect switches shall be such as to suit the switchyard layout.

#### 8.2.4.8 Mechanism Box

- i) The mechanism box shall house the operating mechanism, electrical, controls, monitoring devices and all other accessories.
- ii) The box shall be IP55 with gasketed weather-proof construction, fabricated from sheet steel minimum 2mm thickness.
- iii) The box shall have front access door with lock and key and removable gland plate at bottom for cable entry.
- iv) The box shall be suitable for mounting on disconnect switch support structure.
- v) The mounting height shall be such as to permit easy manual/electrical operation standing at grade level.
- vi) Thermostat controlled space heater, internal illumination lamp and 5 pin 16A sockets with individual ON/OFF switches shall be provided in the box. For local operation following shall be provided:
  - a) LOCAL/REMOTE selector switch.
  - b) OPEN / STOP/ CLOSE push buttons.

#### 8.2.4.9 Wiring

- i) Wiring shall be complete in all respects to ensure proper functioning of the control, protection, monitoring and interlocking schemes.
- ii) Wiring shall be done with flexible 1100V grade, PVC insulated switchboard wires with stranded copper conductor of 2.5 mm<sup>2</sup>.
- iii) Each wire shall be identified at both ends with permanent markers bearing wire numbers as per contractor's wiring diagram.
- iv) Wire terminations shall be done with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

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- v) All spare contacts of relays, push buttons, auxiliary switches etc. shall be wired up to the terminal blocks in the mechanism box.

#### 8.2.4.10 Terminal Blocks


- i) Terminal blocks shall be 1100V grade and its contacts shall be rated for 10A continuous current. Enclosed clamp type with engraved numbers suitable for termination of at least two numbers of 2.5mm<sup>2</sup> stranded copper conductors.
- ii) Not more than two wires shall be connected to any terminal. Spare terminals equal in number of 20% active terminals shall be furnished.
- iii) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of external cables can be connected to consecutive terminals.

#### 8.2.4.11 Earthing Switch

- i) Earthing switch for 3-pole disconnect switch shall be triple-pole, gang operated type, with provision for padlocking in both open and close positions.
- ii) Earthing switch for 1-pole disconnect switch shall be single-pole, with provision for padlocking in both open and close positions.
- iii) Earth switch shall have manual along with motorized operating mechanism. The manual operating mechanism shall be located such that it can be easily operated from standing height at ground level.
- iv) Mechanical and electrical safety interlocks shall be provided to prevent closing of earthing switch when the main disconnect switch is closed and vice-versa.
- v) Earthing switch shall be provided with 4NO + 4NC contacts for indication and interlocking.
- vi) All auxiliary switches and interlocking coils shall be wired up to terminal blocks in mechanism box through G.I. Conduits.
- vii) The earthing switch shall be possible to interchange position on either side of the Isolator.
- viii) The earthing switches shall be capable of discharging trapped charges of the associated lines. 220 kV earth switch shall also comply with requirements of IEC 62271 - 102, in respect of induced current switching duty as defined for Class B and short circuit making capability Class E-0 for earthing switches.

#### 8.2.4.12 Grounding

- i) Equipment shall be provided with two ground pads for connection to station ground.
- ii) The ground pad shall comprise buffed metal surface with two tapped holes, M10 G.I bolts and spring washers for connection to 50x6mm G.I flat. However same shall be finalized during detailed engineering.
- iii) Disconnect and earth switch operating rod shall be separately grounded at a point above the mechanism box. This is done by flexible copper braid of

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adequate section but in no case less than 70mm<sup>2</sup>. Same shall be finalized during detailed engineering.

#### 8.2.4.13 Painting

- i) Base frame, operating rod and all hardware shall be hot dip galvanized. Galvanization of the members shall conform to IS:2629 and IS:4759. The minimum weight of galvanization shall be 610 gms/sqm
- ii) Mechanism box will be finished with two coats of finished paints after surface treatment, involving chemical cleaning, phosphate and application of undercoats.
- iii) Sufficient quantity of touch-up paints shall be supplied for application at site.

#### 8.2.5 Pre-dispatch Quality and Testing

8.2.5.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality Assurance plan (QAP) with the approval of Owner.

8.2.5.2 The isolator along with operating mechanism shall conform to the type tests and shall be subjected to routine tests and acceptance tests in accordance with IEC 62271-102.

8.2.5.3 In addition to all type, routine and acceptance tests, as per IEC-62271-102, following tests/checks shall also be done.


- i) Visual and Dimensional Checks
  - a. Base channel assembly.
  - b. Isolator and earth switch contact assembly.
  - c. Phase and coupling pipes and operating pipes.
  - d. Insulators.
- ii) Measurement of Resistance of main circuit.
- iii) Tests on operating mechanism boxes.
- iv) Mechanical and electrical operation test.
- v) Galvanizing checks on metal parts. Galvanization of the member shall conform to IS:2629 and IS:4759. The minimum weight of galvanization shall be 610 gms/sqm.
- vi) Creepage of insulator.
- vii) Power frequency dry withstand test on main circuit.

#### 8.2.6 Specific Erection Requirement

8.2.6.1 Placement of complete Isolator with/without earth switch on all 3-Phase of Isolator structure. Supply of isolator structure is also in the scope of contractor.

8.2.6.2 Erection / mounting of mechanism box, interconnection, piping alignment of contacts and all associated activities to make the installation complete including



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checking of successful mechanical and electrical operation. The operating mechanism of the three poles shall be well synchronized and interlocked.

#### 8.2.6.3 Onsite Testing

- i) The isolator shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.
- ii) An authorized testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.
- iii) Following tests shall be performed at site:
  - a) Insulation resistance of each pole.
  - b) Manual and electrical operation and interlocks.
  - c) Insulation resistance of control circuits and motors.
  - d) Ground connections.
  - e) Contact resistance.
  - f) Proper alignment so as to minimise vibration during operation.
  - g) Measurement of operating Torque for isolator and Earth switch.
  - h) Resistance of operating and interlocks coils.
  - i) Functional check of the control schematic and electrical & mechanical interlocks.
  - j) 15 operations test on isolator and earth switch.
  - k) Mechanical interlocked should be checked between Isolator main contacts and earth switch


### 8.3 220kV Current Transformer (CT)

8.3.1 This Specification describes the requirements governing engineering, design, manufacture, inspection/testing at works, packing, and delivery at site of high voltage outdoor current transformers (CT). The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.

#### 8.3.2 Codes and Standards


8.3.2.1 The current transformer assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below which is non-exhaustive.



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IEC 61869-1	Instrument transformers - Part 1: General requirements
IEC 61869-2	Instrument transformers - Part 2: Additional requirements for current transformers
IS 2705	Current Transformers
IEC 60038	IEC standard voltages
IEC 60060-1	High-voltage test techniques - Part 1: General definitions and test requirements
IEC 60071- 1	Insulation co-ordination - Part 1: Definitions, principles and rules
IEC 60270	Partial discharge measurements
IEC 60567	Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases
IEC 60599	Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service
IS 5621	Hollow insulators for use in electrical equipment
IEC 61462	Composite hollow insulators used in electrical equipment with rated voltage greater than 1000 V
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
CISPR 18-2	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 2: Methods of measurement
IS 2629	Recommended practice for hot-dip galvanizing of iron and steel
IS 4759	Hot-dip zinc coatings on structural steel and other allied products

8.3.2.2 The Contractor shall be responsible to be, or to become, knowledgeable of the requirements of these Standards and Codes. Any alternations or changes to the equipment to make it meet Standards and Codes requirements shall be at his expense only

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8.3.2.3 Compliance by the Contractor with the provisions of this specification shall not relieve the Contractor/Manufacturer of the responsibility of furnishing apparatus and accessories of proper design, electrically and mechanically suited to meet the operating requirements under the specified service conditions and be suitable for the purpose of which they are intended.


### 8.3.3 Specific Design Requirements

#### 8.3.3.1 Type and Rating

- i) The Current Transformers shall be oil immersed, self-cooled and hermetically sealed type live tank / dead tank.
- ii) Current Transformers shall have single primary - ring type or hair pin type winding. Each current transformer shall be furnished with a number of independent cores with ratios and other ratings as specified in the specification. The rated extended primary current shall be 120% on all cores of the CT.
- iii) Different ratios of each core specified shall be achieved by secondary taps only and primary reconnection is not acceptable.

#### 8.3.3.2 Constructional Features

- i) The current transformer shall be single pole unit, designed for upright mounting on steel structure and furnished complete with fixing hardware.
- ii) Insulator shall be of wet process porcelain, brown glazed and free from imperfections. All metal parts and hardware's shall be hot dip galvanized. Galvanisation of the member shall conform to IS:2629 and IS:4759. The minimum weight of galvanisation shall be 610 gms/sqm
- iii) Current transformer shall be provided with oil level gauge, drain plug and pressure relief device. An inert gas cushion/ stainless steel bellow shall be provided on top for expansion of the oil.
- iv) Current transformer shall be so constructed as to ensure that the oil does not flow out or leak out even when the current transformer is used continuously at the maximum allowable temperature.
- v) Polarity shall be marked on each primary and secondary terminal, provision of short circuiting and grounding CT secondary terminals shall be made in terminal box.
- vi) The current density adopted for the design of terminal connector shall in no case exceed 1.6 A/ mm<sup>2</sup> for copper and 1.0 A/ mm<sup>2</sup> for terminal contactor made of other material.
- vii) Metering CT shall maintain the required accuracy as specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations and its amendments. Further, metering CT shall maintain the required accuracy for current ranging from 5% to 120% of rated current or specified rated extended current whichever is higher and for 0.2S and 0.5S class CT accuracy shall be maintained between 1% to 120% of rated current

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- viii) The instrument security factor of metering core shall be low enough but not greater than 5.

#### 8.3.3.3 Terminals


- i) Primary terminals shall be made of non-ferrous corrosion resistant material and provided with bimetallic terminal connectors and the terminal connectors required for connection of the instrument transformer shall be an integral part of it. These terminal connectors shall be suitable for connecting suitable ACSR conductor.
- ii) Secondary terminals shall be brought out to a terminal box and suitable for connection to 2 x 2.5mm<sup>2</sup> stranded copper conductors per way.
- iii) The terminal box shall be of 3mm thick sheet steel, IP-55, weatherproof and dust-tight, complete with gasketed front access cover and removable gland plate at bottom for cable entry.

#### 8.3.3.4 Grounding

- i) Each current transformer shall be provided with two ground pads for connection to station ground mat.
- ii) The ground pad shall comprise buffed metal surface with two holes, M10 G.I. bolts and spring washers to receive 50x6mm G.I flat. Same shall be finalized during detailed engineering.

#### 8.3.4 Pre-dispatch Quality and Testing

- 8.3.4.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner. The current transformers shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. CTs shall also conform to the following tests as applicable.
- a) Verification of terminal marking and polarity.
  - b) Power frequency dry withstand tests on primary windings
  - c) Power frequency dry withstand tests on secondary windings
  - d) Over voltage interturn test.
  - e) Composite error test.
  - f) Knee point voltage test.
  - g) Determination of errors.
  - h) Partial discharge test.
  - i) Tan delta and capacitance test.
  - j) Multiple chopped impulse test on Primary winding.
  - k) Thermal withstand test i.e. application of rated voltage and rated current simultaneously by synthetic test circuit.

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### 8.3.5 Specific Erection Requirement

8.3.5.1 Always consider transformer as a part of the circuit to which it is connected and do not touch the leads and terminals or other parts of the transformer unless they are known to be grounded.

8.3.5.2 Always ground the metallic bases of instrument transformer.

8.3.5.3 Always ground one secondary terminal of the transformer, except if the windings are connected to open delta. When the secondary of transformer is interconnected, there should be only one grounded point to prevent accidental paralleling with system grounding wire. In case of disconnection from the ground, the grounding screw has to be removed from the secondary terminal.


8.3.5.4 Always short-circuit the secondary of the current transformer, which is not currently in use to prevent secondary voltages which may be hazardous to personnel or damaging to the transformers secondary.

### 8.3.5.5 Onsite Testing

- i) The CT shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.
- ii) An authorized testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.
- iii) Following tests shall be performed at site:
  - a) Power frequency test on primary winding.
  - b) Insulation Resistance Test for primary and secondary.
  - c) Polarity test.
  - d) Ratio and phase angle error identification test - checking of all ratios on all cores by primary injection of current.
  - e) Dielectric test of oil (wherever applicable).
  - f) Magnetizing characteristics test.
  - g) Tan delta and capacitance measurement.
  - h) Secondary winding resistance measurement.
  - i) Contact resistance measurement (wherever possible/accessible).
  - j) Dissolved gas analysis to be carried out at the time of commissioning. CTs must have adequate provision for taking oil samples from the bottom of the CT without exposure to atmosphere.

## 8.4 220kV Voltage Transformer (CVT)

8.4.1 This Specification describes the requirements governing engineering, design, manufacture, inspection/testing at works, packing, and delivery at site of high


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voltage outdoor Potential transformers (PT). The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.

#### 8.4.2 Codes and standards

8.4.2.1 The potential transformer assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below:

IEC 60028	International standard of resistance for copper
IEC 60038	IEC standard voltages
IEC 61869-5	Instrument transformers - Part 5: Additional requirements for capacitor voltage transformers
IEC 60050 (321)	International Electrotechnical Vocabulary - Chapter 321: Instrument transformers
IEC 60060-1	High-voltage test techniques - Part 1: General definitions and test requirements
IEC 60071-1	Insulation co-ordination - Part 1: Definitions, principles and rules
IEC 60085	Thermal evaluation and classification of electrical insulation
IEC 60270	Partial discharge measurements
IEC 60567	Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases
IEC 60599	Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service
IEC 60721	Classification of environmental conditions
IEC 60815	Guide for the selection of insulators in respect of polluted conditions

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CISPR 18-2	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 2: Methods of measurement and procedure for determining limits
IEC 60358-3	Coupling capacitors and capacitor dividers - Part 3: AC or DC coupling capacitor for harmonic-filters applications
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759	Hot-dip zinc coatings on structural steel and other allied products

8.4.2.2 The Contractor shall be responsible to be, or to become, knowledgeable of the requirements of these Standards and Codes. Any alternations or changes to the equipment to make it meet Standards and Codes requirements shall be at his expense only

8.4.2.3 Compliance by the Contractor with the provisions of this specification shall not relieve the Contractor/Manufacturer of the responsibility of furnishing apparatus and accessories of proper design, electrically and mechanically suited to meet the operating requirements under the specified service conditions and be suitable for the purpose of which they are intended.


#### 8.4.3 Specific Design Requirements

8.4.3.1 Type and Rating: Voltage Transformer shall be of capacitor type with three secondary windings.

8.4.3.2 Capacitor Voltage Transformer complying with relevant standards shall be used as the same are suitable for carrier coupling and the capacitance of Capacitor Voltage Transformer shall be decided depending on Power Line Carrier Communication requirements.

#### 8.4.3.3 Constructional Features

- i) Voltage Transformer shall be single phase unit designed for upright mounting on steel structure and furnished complete with anchoring hardware.
- ii) Insulator shall be wet process porcelain, brown glazed and free from imperfections. All metal parts and hardware shall be hot dip galvanized. Galvanisation of the member shall conform to IS:2629 and IS:4759. The minimum weight of galvanisation shall be 610 gms/sqm
- iii) Grading ring shall be provided to maintain voltage gradient within permissible limit.
- iv) The secondary terminals shall be provided with HRC fuses for protection and polarity shall be invariably marked on each secondary winding terminals.

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- v) The current density adopted for the design of terminal connector (TC) shall in no case exceed 1.6 A/mm<sup>2</sup> for copper and 1.0 A/mm<sup>2</sup> for T.C. made of other material.
- vi) The voltage transformer burden for metering class winding shall not be less than 50VA to achieve 0.2 accuracy class.
- vii) Voltage transformer shall be oil-filled, self-cooled, hermetically sealed type.
- viii) Voltage transformer shall be provided with oil level gauge and pressure relief device. An inert gas cushion/stainless steel bellow shall be provided on top for expansion of the oil.
- ix) Voltage transformer shall comprise a number of capacitor units mounted on a steel base containing the potential device and other accessories. The capacitors shall be oil-impregnated type enclosed in an inert gas atmosphere within porcelain shell hermetically sealed.
- x) Voltage transformer shall be designed to cover its rated output range without any adjustment of its electromagnetic unit.
- xi) Accessories housed in the steel base shall include:
  - a) Device for ferro-resonance suppression.
  - b) Protective gap for over-voltage.
  - c) Series reactor which along with the capacitance of the divider shall be tuned to the power frequency.
- xii) Voltage transformer shall be designed to cover its rated output range without any adjustment of its electromagnetic unit and also to provide required accuracy level up to the rated burden. Capacitance Voltage Transformer (CVT) shall be designed to perform transient response requirements as per relevant IEC i.e. during transient oscillations following a short circuit on primary side, the secondary output voltage shall not fall to a value less than 10% of peak value before short circuit within 20ms.
- xiii) Carrier Signal shall be prevented from flowing to electromagnetic unit (EMU) circuit of VT with radio frequency (RF) choke/reactor over entire carrier frequency range (40 to 500 kHz).

#### 8.4.3.4 Terminals

- i) Primary terminals shall be made of non-ferrous corrosion resistant material and provided with bimetallic terminal connectors.
- ii) Secondary terminals shall be brought out to a terminal box and suitable for connection to 2 x 2.5mm<sup>2</sup> stranded copper conductors per way.
- iii) The terminal box shall be of 3mm thick sheet steel, IP-55, weatherproof and dust-tight, complete with gasketed front access cover and removable gland plate at bottom for cable entry.

#### 8.4.3.5 Grounding



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- i) Each Voltage Transformer shall be provided with two ground pads for connection to station ground mat.
- ii) The ground pad shall comprise buffed metal surface with two holes, M10 G.I bolts and spring washers to receive 50x6mm G.I flat. Same shall be finalized during detailed engineering.

#### 8.4.4 Pre-dispatch Quality and Testing

8.4.4.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.

8.4.4.2 The voltage transformers shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. CVTs shall also conform to the following tests as applicable.


- a) Verification of terminal marking and polarity.
- iii) Induced overvoltage withstand test at 460kV for 40Seconds at 150Hz. As per Table 2 of IEC 61869-1:2007
  - b) Power frequency dry withstand tests on primary windings
  - c) Power frequency dry withstand tests on secondary windings
  - d) Determination of errors
  - e) Partial discharge test
  - f) Tan delta and capacitance test

#### 8.4.5 Specific Erection Requirement

- i) Always consider transformer as a part of the circuit to which it is connected and do not touch the leads and terminals or other parts of the transformer unless they are known to be grounded.
- ii) Always ground the metallic bases of instrument transformer.
- iii) Always ground one secondary terminal of the transformer, except if the windings are connected to open delta. When the secondary of transformer is interconnected, there should be only one grounded point to prevent accidental paralleling with system grounding wire. In case of disconnection from the ground, the grounding screw has to be removed from the secondary terminal.
- iv) Never short-circuit the secondary terminal of a voltage transformer even this is not in use. A secondary short-circuit will cause the unit to overheat and fail in a very short period of time.

##### 8.4.5.1 Onsite Testing

- i) The PT shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.

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ii) An authorised testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.

iii) Following tests shall be performed at site:

- a) Insulation Resistance test for primary (if applicable) and secondary winding.
- b) Ratio test.
- c) Dielectric test of oil (wherever applicable).
- d) Tan delta and capacitance measurement of individual capacitor stacks.
- e) Secondary winding resistance measurement.

#### 8.4.6 Junction Box for CT and PT

8.4.6.1 The CT & PT shall be provided with separate junction box. The Boxes shall be of outdoor type having IP-55 class or better as per IS/IEC 60529 with suitable canopy of gasket weather-proof construction fabricated from sheet steel minimum 2mm thick.

8.4.6.2 The box shall have front access door with lock and key and removable 2mm thick gland plate at the bottom for cable entry. The junction box shall have stud type (disconnecting) terminals. The arrangement shall be made for shorting of the CT secondary terminals while the CT is in energized condition for testing and other purposes, if necessary.

8.4.6.3 Number of terminals shall be 20nos each in a terminal block and 5nos such blocks in CT junction box and 3nos such terminal blocks in PT junction box, the PT junction boxes shall be provided with fuses.

8.4.6.4 All incoming and outgoing connections in the junction box shall be properly marked with ferrules.


#### 8.5 198kV Lightning Arrestor

This Specification describes the requirements governing engineering, design, manufacture, inspection/ testing at works, packing, and delivery at site of high voltage outdoor lightning arrestors. The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.

##### 8.5.1 Codes and standards

8.5.1.1 The lightning arrestor assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below:

IEC: 60099	Surge Arresters
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IEC: 62205	Protection against Lightning Protection Safety
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759	Hot-dip zinc coatings on structural steel and other allied products

## 8.5.2 Specific Design Requirements

### 8.5.2.1 Type and Rating


- i) Surge arrester shall be station class, heavy duty, and metal oxide gapless type without any series or shunt gaps with ratings as per the system requirements.
- ii) The arrester shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes.
- iii) Surge Arrester shall discharge over - voltage due to switching of unloaded transformer and line, also discharge energy equivalent to Class 3 of IEC 60099 on two successive operations.

### 8.5.2.2 Constructional Features

- i) Surge arrester shall be single pole, hermetically sealed with non-linear blocks of sintered metal oxide material so as to obtain a robust construction with excellent electrical, thermal and mechanical characteristics even after repeated operation.
- ii) Insulator shall be wet process porcelain, brown glazed and free from imperfections. All metal parts and hardware shall be hot dip galvanized. Galvanisation of the member shall conform to IS:2629 and IS:4759. The minimum weight of galvanisation shall be 610 gms/sqm
- iii) Grading ring shall be provided to maintain voltage gradient within permissible limit.
- iv) Surge arrester shall be provided with pressure relief device to prevent shattering of porcelain in case excessive gas pressure builds up.
- v) The sealing arrangement of surge arrester stacks shall be of grooved flanges with the O-rings/elliptical cross section gaskets of Neoprene or Butyl rubber.

### 8.5.2.3 Accessories

- i) Surge arrester shall be furnished complete with insulating base, surge counter, leakage current meter and anchoring hardware for mounting on structure.
- ii) A leakage current detector shall be furnished with the counter as an integral part. This is for monitoring the leakage to indicate any possible breakdown Surge counter and leakage current meter shall be housed in an IP55 enclosure and their reading shall be visible through inspection glass panel in the front.
- iii) The surge counter housing shall be mounted at a convenient height for reading.

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- iv) Counter terminals shall be such as to permit connections with minimum possible bends. The mounting arrangement shall be such that it can be tilted 45 degree from horizontal plane for convenient of reading.
- v) A suitably sized by-pass shunt along with necessary terminals shall be furnished for bypassing the discharge counter if required.
- vi) Discharge counter shall not require any auxiliary supply and shall be provided for each single pole unit and the Connection of surge arrester base and surge monitor shall be through a 2m (minimum) long insulated copper rod/strip of minimum cross sectional area of 75mm<sup>2</sup>. It shall be terminated at rear/bottom side of the surge monitor.

#### 8.5.2.4 Terminals

- i) All connection terminals shall be of corrosion resistant material and complete connection hardware.
- ii) High voltage line terminal shall be provided with bimetallic terminal connector suitable for connection to the type and size of conductor indicated in specification.
- iii) All ground terminals shall have provision of connection to 50 x 6mm G.I. flat. Same shall be finalized during detailed engineering.


#### 8.5.3 Pre-dispatch Quality and Testing

8.5.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner. The lightning arrester shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. Lightning arrester shall also conform to the following tests as applicable.

- a) Surge arrester routine test
- b) Surge monitor routine test
- c) Surge arrester acceptance test
- d) Surge monitor acceptance test
- e) Reference voltage test
- f) Lightning impulse residual voltage test
- g) Partial discharge test
- h) Seal leakage test

#### 8.5.4 Specific Erection Requirement

8.5.4.1 Shifting and placement of lightning / surge arrester on structure including all accessories, making all inter connections, checking and installation of insulator base and surge counter. Supply of structure and all the accessories is in the scope of contractor.

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#### 8.5.4.2 Onsite Testing

- i) The LA shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.
- ii) An authorised testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.
- iii) Following tests shall be performed at site:
  - a) Operation checks of LA counter.
  - b) Insulation resistance measurement.
  - c) Capacitance and Tan delta measurement of individual stacks.
  - d) Third harmonic resistive current measurement (to be conducted after energisation).

#### 8.6 220 kV Insulator

This Specification describes the requirements governing engineering, design, manufacture, inspection/testing at works, packing, and delivery at site of Disc insulator and BPI (Bus Post Insulator). The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.


##### 8.6.1 Codes and Standards

- 8.6.1.1 The insulator assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below.

IEC : 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V Applies to post insulator
IEC: 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759	Hot-dip zinc coatings on structural steel and other allied products

##### 8.6.2 Specific Design Requirements

- i) Insulators shall be uniform brown colour. The glaze shall be unaffected by sudden changes in temperature and by atmospheric pollution of ozone, acids, alkali dust etc.

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- ii) Under surfaces and grooves shall be shaped for easy cleaning shells shall be substantially symmetrical in shape without any wrapping. Insulators shall be designed to avoid excessive concentration of electrical stresses in any section or across leakage surfaces.
- iii) The insulators shall be made by wet process and shall be homogeneous and free cavities. Cap and pins shall be of highest quality malleable iron or forged steel and smoothly galvanized.
- iv) Strain and suspension strings shall comprise of the conventional ball and socket type disc insulators. Individual insulators as well as strings of the same type shall be interchangeable with one another and it shall be possible of form either suspension or strain string using the same disc.
- v) The locking clips shall be made of phosphor Bronze and shall provide positive locking of coupling.
- vi) Bus post insulators shall be of solid core type. All ferrous parts shall be hot dip galvanized conforming to IS:2629 and IS:4759. The minimum weight of galvanisation shall be 610 gms/sqm
- vii) The items of hardware and fittings shall make complete assemblies and shall include all bolts, nuts washers, locknuts and centre pins.

#### 8.6.3 Pre-dispatch Quality and Testing

8.6.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner. The insulators shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. Insulators shall also conform to the following tests as applicable.

- a) Visual examination
- b) Verification of dimensions
- c) Temperature Cycle Test
- d) Cantilever strength Test
- e) Porosity Test
- f) Galvanising Test


#### 8.6.4 Specific Erection Requirement

8.6.4.1 Placement of complete Insulator on single Insulator structure, supply of the same is under contractor's scope.

8.6.4.2 Alignment with ACSR conductor / IPS tubing for required clearance.

#### 8.6.4.3 Onsite Testing

- i) The Solid core post Insulator shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.
- ii) An authorised testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.

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iii) Following tests shall be performed at site:

- a) Proper alignment so as to minimise vibration during operation.
- b) Visual examination
- c) Verification of dimensions

## **8.7 Fiber Optic Terminal Equipment (FOTE):**

### **8.7.1 General requirements:**

8.7.1.1 This is a technical specification for equipment design and Engineering of fiber optic equipment complete for speech communication in dialing mode or through express telephone, data communication, fiber optic based power system protection, suitable for fiber optic network for Sub-Stations end to end.

8.7.1.2 The fiber optic link shall be based on minimum STM-16-bit rate. The Contractor, however can propose a system based on higher bit rate systems meeting the fiber optic link budget requirements. One complete equipment meeting the specifications requirement in lieu of the separate Fiber Optic Terminal Equipment and Multiplexer may also be referred to. Mandatory spares for the offered equipment should be available.

### **8.7.2 Scope of work**

8.7.2.1 This technical specification covers the 66KV requirements of design, manufacture, works, packing, supply, transportation, installation, termination, testing and commissioning and documentation.

8.7.2.2 Fiber Optic Transmission System (FOTS) suitable for fiber optic network which can be designed for linear type/mesh type/ring type as required including optical & electrical interfaces, DDF, racks, synchronization, Network Management System (NMS) etc. As per the utility/SLDC requirement.


8.7.2.3 Multiplexer including Voice, data & protection cards to achieve simultaneous transmission/reception of voice & data from/to one station to/from another Station.

8.7.2.4 All required cabling, wiring, and interconnections to the supplied equipment at the defined interfaces. All the subscriber channels shall be terminated on the Main Distribution Frame (MDF).

8.7.2.5 Integration with Grid Sub Station (GSS) existing carrier, Tele-Protection and EPAX will be in scope of Contractor.

8.7.2.6 Integration of fiber optic system with power system for power system protection. The power system signal may be either electrical shall meet all CCITT Recommendation required for Fiber optical communication.



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8.7.2.7 Installation of power supply system (48 Volt DC with positive ground) wherever required.

8.7.2.8 The required no. of port optical interface card for optical interface substation for connecting to digital protection coupler/to provide distance and differential protection will be finalized after detailed engineering. The PDH equipment with a controller card, FXO, RS232, E&M, and E1 interface card and all other required to be provided for suitable smooth operation work to be provided by Contractor.

8.7.3 Functional requirement

8.7.3.1 The proposed fiber optic communication network shall support the voice & data communication requirements for Power system protection, and other operational requirements. The communication system shall provide data & voice connectivity across substation end-end through using IEC 60870- 5-101 or IEC 60870-5-104 Protocol.

8.7.3.2 SDH Equipment


- i) The fiber optic network shall be based on the Synchronous Digital Hierarchy (SDH) having a bit rate of STM-16. SDH Equipment along with suitable interfaces and line cards etc. Associated termination equipment system including E-1 channel banks and drop-insert multiplexer & subscriber line interface cards. System integration of supplied sub-system and also integration with existing communication equipment such as SDH etc.
- ii) SDH equipment is considered to be divided into three parts i.e. Optical interface /SFP, Tributary card (Electrical tributaries such as E1 & Ethernet 10/100Mbps) base equipment (Consisting of common cards, control cards, Optical base card, and Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).
- iii) If the Contractor is offering equipment with multifunction cards such as cross-connect or control cards with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as a common control card and shall be part of base equipment.

8.7.3.3 Redundancy and Protection

Two fiber rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibers shall be implemented.

8.7.3.4 All the Type test and Routine test should be as per IEC or any other relevant Standard

**8.8 Wave Trap:**

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8.8.1 The Wave Trap covered under the package shall conform to IEC 60353 or IS:8792, IS:8793 and relevant IEC/IS Specifications except to the extent modified by the specification.

8.8.2 Wave Traps shall be installed at the respective transmission line bays in two phases as required. The foundation shall be provided for all the three phases however, the location of wave trap shall be decided based on the attenuation results.

8.8.3 The Wave Trap for shall be suitable for outdoor pedestal mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind pressure of 195 kg/square metre.

8.8.4 For pedestal mounting, each Wave trap shall be mounted on a tripod structure formed by three solid core type insulators shall be of non-magnetic material.

#### 8.9 Control and Relay Panel (220 kV and 33 kV)

This Specification describes the requirements governing engineering, design, manufacture, inspection/ testing at works, packing, and delivery at site of Control & Relay (C&R) Panels, if required, with various components as specified. The equipment shall be manufactured in accordance with latest Indian/IEC Standards applicable to such equipment and components and requirements detailed in this technical specification. The work shall be executed according to most stringent of these requirements.


##### 8.9.1 Codes and standards

8.9.1.1 The Control & Relay Panel assembly and components used in it shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the applicable portions of the latest edition of the Standards and Codes listed below:

IEC: 61850	Interoperability for Advanced Protection and Control Applications
IEC: 60529	Degrees of Protection Provided by Enclosures (IP Code)
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759	Hot-dip zinc coatings on structural steel and other allied products

##### 8.9.2 Specific Design Requirements

The C&R Panels shall be designed for providing effective control and monitoring of Incoming Feeders, Bus couplers and Power transformers as specified in SoR. The panels shall also contain the protective relays to perform function of providing effective and efficient protection system.


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#### 8.9.2.1 Construction

- i) The Control Boards shall be totally enclosed, floor mounted, dead front assemblies, free standing including vibration damping pads, Simplex vertical with flush mounted relays conforming to degree of protection minimum IP- 5X or better as per IS/IEC 60529. Same shall be finalized during detailed engineering
- ii) Each Control Board shall consist of a number of panels mounted side by side and bolted together to form a compact unit. Where two panels meet, the joints shall be smooth, close-fitting.
- iii) Simplex type control panel shall have adequate size central corridor and front shall be lined up with the simplex type control panel is not acceptable. Only simplex type control panel shall be considered.
- iv) The control panels shall be of folded sheet steel construction, assembled on channel/angle base plates with anti-vibration mountings.
- v) Panels shall be rigid free standing and floor mounting type and comprise of structural frames enclosed completely with specially selected texture finished, cold rolled sheet steel of thickness not less than 3.15 mm for weight bearing members of the panels such as base frame, front sheet and door frames and not less than 2.0 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation
- vi) All doors, removable covers and panels shall be sealed all around with synthetic rubber gaskets Neoprene/EPDM generally conforming to provision of IS 11149. However, XLPE gaskets can also be used for fixing protective toughened glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.
- vii) The operating handle shall have locking arrangement.
- viii) The boards shall be complete with floor channel sills, vibration damping pads and stainless-steel kick plates.

#### 8.9.2.2 Features required

- i) The control panel shall be Bay Control Unit (BCU) type.
- ii) Guided local control of all motorized switching objects via HMI of bay control Intelligent Electronic Device (IED).
- iii) Two-step operation (select-before-operate)
- iv) Bay, station and double-operation interlocking
- v) Station and double-operation interlocking information via hardwired station bus or IEC 61850 GOOSE messages
- vi) Primary and secondary system super-vision and alarm visualization
- vii) Circuit breaker control and supervision

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- viii) Disconnecter and earthing switch control and supervision
- ix) IEC 61850-8-1 interface
- x) Transformer voltage regulator option
- xi) Back-up protection option
- xii) CB emergency control in marshalling kiosk option
- xiii) Integration of non-conventional instrument transformers or stand-alone merging units using IEC 61850-9-2 process bus option

#### 8.9.2.3 Equipment Mounting


- i) Panel front (facing switch yard) shall house all control switches, metering and synchronizing items with mimic and semaphore.
- ii) All instruments, relays, switches, etc. shall be of flush or semi-flush type.
- iii) All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services to others.
- iv) All equipment inside the panels shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.

#### 8.9.2.4 Name Plate

- i) Name plates of approved design shall be furnished for each panel and for each instrument or device mounted on the panel.
- ii) The material shall be lamacoid, 3mm thick, with white letters on black background.
- iii) The nameplates shall be held by self-tapping screws. The size of nameplate shall be approximately 20mm x 75mm for equipment and 40mm x 150mm for the panels. Same shall be finalised during detailed engineering.
- iv) The name plates for panels shall be provided both on the front and on the rear.
- v) Control and meter selection switches shall have integral name plate. Name plates for all other devices shall be located below the respective devices.
- vi) Instrument and devices mounted on the face of the control boards shall also be identified on the rear with the instrument or device number. The number may be painted on or adjacent to the instrument or device case.

#### 8.9.2.5 Illumination, Space Heating and Receptacles

- i) Each panel shall be provided with interior illumination lamp with door switch, space heater with thermostat and 16A, 5 pin receptacles with plug.
- ii) Lamp, heater and receptacle circuits shall be suitable for available AC supply and furnished with individual ON-OFF switch.
- iii) The lamp shall be located at the ceiling and guarded with protective cage.

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- iv) Space heater shall be located near the floor so as not to pose any hazard to service personnel.
- v) 240V AC or 220V DC power supply.
- vi) The following power supplies shall be made available to each control board: -
  - a) AC Supply: Single Feeder
  - b) DC Supply : Double Feeder
- vii) The Contractor shall provide isolating switch fuse units for the incoming AC/DC power supplies and run bus wires for power distribution to different panels.
- viii) Fuse and link shall be provided for individual circuits for protection and also for isolation from bus wire without disturbing other circuits.
- ix) The Contractor shall group the fuse requirements in each panel in a neat, orderly and easily accessible fuse blocks or distribution panel.
- x) Alarm relays shall be provided to annunciate failure of incoming AC and DC power supplies to each control board.

#### 8.9.2.6 Wiring

- i) The control board shall be fully wired up at the factory to ensure proper functioning of control, protection and metering schemes.
- ii) All spare contacts of relays and switches shall be wired up to terminal blocks.
- iii) All interconnections between the panels of the control board shall be furnished.
- iv) Wiring shall be done with flexible, heat resistant, 1100V grade; PVC insulated, switch board wires with stranded copper conductor, 2.5mm<sup>2</sup> for Voltage and current circuits and 1.5mm<sup>2</sup> for control circuits.
- v) Each wire shall be identified at both ends with wire designation as per Contractor's wiring diagram. Interlocking type ferrules shall be used for identification.
- vi) All wire termination shall be made with insulated sleeve crimping type lugs.
- vii) Wire shall not be tapped or spliced between terminals.
- viii) Wiring shall be neatly bunched in groups by non-metallic cleats or bands.
- ix) Each group shall be adequately supported along its run to prevent sagging or strain on the termination.

#### 8.9.2.7 Terminal Block

- x) Terminal blocks shall be of 1100 volts grade and have 10 amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Terminal block designs include a white fibre-marking strip with clear plastic/silicon chip on terminal covers. Marking on the terminal strips shall correspond to block and terminal number on the wiring diagram.

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- xi) Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. Current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.
- xii) Not more than two wires shall be connected to one terminal. If necessary, a number of terminals shall be jumpered together to provide wiring points.
- xiii) Each terminal shall be identified with designation as per approved schematic.
- xiv) Spare terminals equal in number of 20% active terminals shall be furnished.
- xv) The wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.
- xvi) The terminal blocks shall be located to allow easy access and also to suit floor openings for cable entry.
- xvii) Unless otherwise specified, terminal blocks shall be mounted vertically with adequate spacing (not less than 150mm) between adjacent rows.
- xviii) The bottom of the terminal block shall be at least 250mm above the incoming cable gland plate.

#### 8.9.2.8 Cable Entry

- i) The panel shall have provisions of cable entry from the bottom. Bottom plate shall be provided to make entry dust-tight.
- ii) The panels shall have provisions inside for fixing the multi-core cable glands. The cable gland support plate shall be 4mm thick and mounted not less than 200mm above floor level.


#### 8.9.2.9 Grounding

- i) 25 x 6mm copper ground bus shall be provided on each control board extending along the entire length of the assembly. Sizing shall be finalized during detailed engineering phase.
- ii) The ground bus shall have two-bolt drilling with GI bolts and nuts at each end to receive ground connection of GI flat.
- iii) The ground bus shall be bolted to the panel structures and effectively ground the entire assembly. The cases of meters, relays and switching devices shall be grounded through the steel structure.
- iv) Whenever a circuit is shown grounded, a single wire from the circuit shall be run independently to the ground bus and connected to it.

#### 8.9.2.10 Painting

- v) All steel surfaces shall be sand blasted to remove all rust, scale and foreign adhering matters. The steel surfaces shall be then chemically cleaned, rinsed, phosphated in accordance with IS 6005, rinsed and dried.



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- vi) Immediately after phosphating, the surfaces shall be given two coats of high quality primer and stoved after each coating.
- vii) The control panels shall be finished with two coats of synthetic enamel paints, white inside and the light grey or dove grey outside. The panels shall be stoved after spraying of each of the finish coatings. Base frame shall be painted black.
- viii) The boards shall have a smooth and uniform matt finish, free from scratches, dents and any other imperfections. Sufficient quantity of touch-up paints shall be furnished for application at site.
- ix) The Contractors are required to furnish the details process adopted by OEMs for pre-treatment and painting of sheet metal for the control boards.

#### 8.9.2.11 Switches

- i) Switches shall be dust protected, heavy duty, and switchboard type complete with name plate. Contacts shall be silver surfaced and rated minimum 10A at operating voltage.
- ii) Breaker control switch shall be multistage, spring return to normal, with lost motion device and pistol-grip handle, EE type ODS or approved equivalent make or model.
- iii) Synchronizing/maintenance transfer switch shall be similar to breaker control switch except it is stay-put type with key interlock. The interlock shall be such that only switch can be operated at a time and that too only on insertion of the key.
- iv) Isolator control switch shall be discrepancy type with knob handle and built-in lamp, ASEA type OMHB 3-4. The lamp shall flicker on discrepancy but normally remain OFF with provision for testing.
- v) Meter selection switch shall be maintained contact, stay-put type, with knob handle, make of the same to be provided for the approval of Owner.

#### 8.9.2.12 Push buttons


- i) Push button shall be oil tight, heavy duty, push to actuate type with coloured button and inscription plate marked with its function.
- ii) Each push button shall have minimum 1 NO + 1 NC contacts, rated 10A at operating voltage.
- iii) Push button shall be shrouded type except for emergency trip button which shall be mushroom type for easy identification.

#### 8.9.2.13 Operating Range

- i) Unless otherwise specified, all instruments and relays shall be suitable for operation on 1A or 5A C.T. secondary circuits and/or 110V V.T.

#### 8.9.2.14 Meters



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- i) All indicating instruments shall be conventional switchboard type, 96 x 96mm with 250° scale, antiglare glass and accuracy class of  $\pm 2\%$  of the full scale or Microprocessor based Multifunction meter (MFM) with RS-485 communication port.
- ii) Meters shall have provision for zero adjustment from front of the panel.
- iii) Auxiliary supply for all meters shall be 220V DC derived from battery and battery charger.

#### 8.9.2.15 Integrators (If Applicable)

- i) Integrating meter shall be rectangular in shape and furnished in draw out type case with built-in test facilities.
- ii) Watt-hour meter shall be 2 element type suitable for 3 phase, 3 wire connection and shall have cyclometer register with six digits.


#### 8.9.2.16 BCU and Relays

- i) BCU and Relays shall be furnished in rectangular, dust tight, draw out type cases with built-in test facilities. Small auxiliary relays may be furnished in fixed casing and mounted inside the panels.
- ii) Bay Control Unit (BCU) is equipped with digital inputs and outputs along with display comprising of bay wise SLD representing all equipment's as per approved SLD.
- iii) Protective relays shall be equipped with externally reset positive action operation indicator.
- iv) All relays, unless otherwise approved, shall have minimum two electrically separate pairs of contacts. Contacts shall be silver surfaced, bounce-free and capable of repeated operation without deterioration.
- v) The Contractor to carefully study the system requirement and accordingly offer relays of suitable type and setting range to meet the system requirements.
- vi) While selecting the numerical relays, the CT details including burden, protection class, and accuracy limit factor shall be selected by the Contractor and Design basis shall be provided for the same. Same shall be finalized during detailed engineering stage.
- vii) The protective relays shall be suitable for efficient and reliable operation of the protective scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protective schemes described in the specification shall be provided. All protective relays shall be provided with at least two pair of potential free isolating output contacts.
- viii) Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme. Contacts shall be faced with spring action. Relay case

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shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

- ix) All protective relays auxiliary relays and timers except the lockout relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operating indicators (flag relays) for this purpose.
- x) Auxiliary relays (Self reset type with hand reset flags) shall be provided for supervisory functions of buchholz relays, oil and winding temperature protection, PRV, fire protection system etc.
- xi) Timers shall be of electromagnetic or solid state type. Pneumatic timers are not acceptable. Short time delays in terms of milliseconds may be obtained by using copper slugs on auxiliary relays. In such case it shall be ensured that the continuous rating of the relay is not affected. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided to the extent possible.
- xii) No control relay which shall trip the power circuit breaker when the relay is de-energized shall be employed in the circuits.
- xiii) Contact multiplication relays for CB and Isolator shall be provided if required for various relay inputs by multiplying contacts using single latch relay(electrically operated type) having NO and NC as per the scheme requirement.
- xiv) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- xv) Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be provided separately by the contractor with the approval of Owner.
- xvi) Contractor to depute authorized representative of relay OEM at Owner's office for finalization of relay setting and configuration during detail engineering stage. All numerical protection relay configuration and setting shall be done as per approved setting and configuration at switchgear manufacturer work by authorized representative of relay OEM. All numerical relay testing and logic/interlock checking during commissioning stage at site shall be done under the supervision of authorized representative of Relay OEM.
- xvii) Wherever numerical relays are used, the scope shall include the following:
  - a) Necessary software and hardware to up-down load the data to/from the relay from/to the personal computer installed in the sub-station.
  - b) The relay shall have suitable communication facility for connectivity to SCADA. The relay shall be capable of supporting IEC- 61850 protocols as per UTILITY requirement.

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**8.9.2.17 The numerical relays shall have following minimum features:**


- i) It will monitor permanently all of the analogue inputs and displays the values on the LCD and store the measurements in memory.
- ii) Disturbance recording functions (minimum five records for 3 seconds) with current/voltage waveform storing facility in the relay triggered through programmed thresholds.
- iii) Fault records (minimum last 5 faults) with fault time stamping, faulted phase, protection operation, magnitude of fault etc.
- iv) The 32 bit alphanumeric back-lit LCD display provides the user for key information and provides the user for programming.
- v) Dedicated and programmable LEDs for providing information for any alarm, trip, watch-dog etc.
- vi) Local and remote communication with RS-232 port at front and RS-485 at back end.
- vii) The data offered to local / remote with open ended protocol (compatibility with SCADA/PLC/SAS)
- viii) Continuous self-monitoring facility for high degree of reliability.
- ix) Non-volatile memory.
- x) Circuit breaker monitoring / maintenance facility.
- xi) Breaker trip circuit supervision facility.
- xii) Test blocks and tests plug for secondary injection testing of the relay.
- xiii) Window based software (latest version) for connecting through RS-232 port for relay programming, testing, diagnostics, retrieving fault and disturbance etc.
- xiv) Software in SCADA/PLC/SAS for remote programming / calibration /data retrieval.

**8.9.2.18 Auxiliary Devices**

- i) The Contractor shall furnish, install and wire-up all auxiliary devices such as interposing current or voltage transformers, timing/switching/lockout/auxiliary relays as specified or as required for the proper functioning of the schemes offered.

**8.9.2.19 Remote Annunciation System**

- i) Annunciation system shall include as required annunciation for 33kV & 220kV Switchyard.
- ii) Annunciation system shall generally include but not limited to alarm/trip of isolators, breakers, transformers, synchronization, PT fuse failure, Battery charger failure, AC/DC control supply failure etc.

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- iii) The annunciation system shall be solid state type with optical isolation for input signals.
- iv) Each annunciation group shall be independent, complete with its own power supply, audible alarms, acknowledge-reset-test buttons and other necessary accessories.
- v) The annunciation shall be non-integral type with hardware box mounted separately for easy access and maintenance.
- vi) Audible alarms with different tones shall be used for fault and ring back functions.
- vii) The window size shall be such as to accommodate minimum three (3) lines of twelve (12) characters each. Each character shall be minimum 4.75mm high.
- viii) The annunciators system shall be suitable for operation from both NO and NC type initiating contacts.


#### 8.9.2.20 MIMIC DIAGRAM:

- i) Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.
- ii) Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.
- iii) Mimic bus colour will be decided during detailed Engineering by the Owner and shall be furnished to the successful Contractor during Engineering.
- iv) When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.
- v) Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition

#### 8.9.3 Pre-dispatch Quality and Testing

8.9.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner. The control panel shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. Control panel shall also conform to the following tests as applicable (indicative list).


- a) Dimensional check.
- b) Visual check.
- c) Functional check.
- d) Bill of material check.

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e) Insulation resistance test


f) Primary and secondary injection testing

8.9.3.2 Type Test: Reports of the following type tests carried out on the model of Numeric Relay shall be submitted.

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SN	Test item	Standard
(a)	Dimensions of structure and visual inspection	IEC 60297-3-101
(b)	Functional requirements	
(c)	Steady-state simulation	Relevant IEC 60255-100
(d)	Dynamic simulation	
(e)	Product safety requirements	IEC 60255-27
(f)	EMC requirements -Emission -Immunity	IEC 60255-26
(g)	Energizing quantities: -Burden -Change of auxiliary energizing quantity	IEC 60255-11
(h)	Contact performance	
(i)	Communication requirements	IEC 61850
(j)	Climatic environmental requirements Cold Dry heat Change of temperature Damp heat	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
(k)	Mechanical requirements: - Shock Vibration Bump Seismic	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
(l)	Enclosure protection	IEC 60529, IEC 60255-27

8.9.3.3 However if the contractor is not able to submit report of the type test(s) conducted not earlier than ten years prior to the date of bid opening, or in the

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case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract free of cost 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.

#### 8.9.4 Specific Erection Requirement

- i) The contractor shall carry out placement of panel complete with all modules and accessories including all connections grouting and earthing of panel at designated place in control room building. Before that contractor shall ensure proper alignment, earthing connections of panel.
- ii) Making of all AC / DC interconnections on terminal block for the control and relay panel in accordance with the corresponding equipment manufacturers drawing. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.
- iii) Wire termination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from the terminal block.
- iv) The contractor shall be solely responsible for the completeness and correctness of the wiring and for proper functioning of the connected equipment including testing and commissioning.

##### 8.9.4.1 Onsite Testing


- i) The control and relay panel shall be fully tested on site prior into putting into service to ensure that all items are in proper working condition, correctly installed and free from damage.
- ii) An authorised testing Professional Engineer shall be engaged by the contractor to perform the site testing and commissioning.
- iii) Following tests shall be performed at site:
  - a) Interconnection verification
  - b) Secondary injection test.
  - c) Insulation resistance test.

#### 8.10 Installation testing and commissioning of Power transformer

##### 8.10.1 Codes and standards:

IS:10028-1981	Code of Practice for Selection Installation and Maintenance of Transformers, Part 2: Installation
IS:335-1983	New Insulating Oil
IS:6792-1992	Method for Determination of Electrical Strength of Insulating Oils




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CEA (Erection testing and comissioning)	Standard Specifications and Technical Parameters for Transformers and Reactors (66 kV and above Voltage Class)
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#### 8.10.2 Receipt of transformer at site

- 8.10.2.1 When a transformer arrives at site a careful external inspection must be made of the unit, its cooling system and all sealed components, referring to the general arrangement drawing and the shipping list.
- 8.10.2.2 Inspect all packing cases and loose components for damage or missing items.
- 8.10.2.3 Check whether the transformer has arrived at site with a positive gas pressure in case of dispatch without oil. In case of dispatch of main body in oil filled condition, check oil level and leakages if any.
- 8.10.2.4 Should the transformer arrive at site without pressure (owing to gas leakage), it must be assumed that moisture has entered the tank and that the moisture will have to be driven out. In such cases, the manufacturers advise must be sought.
- 8.10.2.5 In case of any oil leakage or damage is discovered, the transportation company, the transport insurer and manufacturer shall be informed immediately.
- 8.10.2.6 A record of damage must be prepared in conjunction with other participants and supplier representative. Minor damage which may appear unimportant should also be recorded.
- 8.10.2.7 Confirm that case numbers match with the packing list. Check their contents tally with the packing list if the packing case is damaged.
- 8.10.2.8 Fill in the check list for external as well as internal inspections.
- 8.10.2.9 For oil filled transformers a sample of oil should be taken from the bottom of the tank and tested for BDV and moisture content. If the values do not meet the relevant standards the matter should be taken up with the manufacturer.
- 8.10.2.10 Down load impacts recorded by impact recorder and analyse the same in consultation with supplier.
- 8.10.3 Installation of bushings
  - 8.10.3.1 Bushings shall be checked for any damage at oil end as well as porcelain and shall be thoroughly cleaned before fixing and Tan Delta should be carried out As per IEC 60137 and results should be satisfactory before installation Bushings shall be lifted by using the lifting eyes and soft manila ropes or polyester slings. Steel wire rope slings should not be used.
  - 8.10.3.2 The line lead of HV winding, if coiled inside transformer, shall be drawn out through the bushing using string when the bushing shall be lowered into position on top of the transformer. The cable ferrule shall be fixed in position at the top of bushing brass tube. The lower end of the bushing shall be inspected through inspection cover for proper sealing.

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- 8.10.3.3 The line connection should be tight and should not strain the terminals. Sufficient flexibility in connection leads should also be maintained to avoid mechanical stress on the bushing.
- 8.10.3.4 The bushing shall be carefully held in position at required angle and slowly lowered in position.
- 8.10.4 Topping of Oil in transformer
- 8.10.4.1 Prior to topping of oil, it shall be ensured that the transformer shall be fitted with all accessories supplied loose as provided in Clause 8.5.5. The samples shall be drawn from each oil drum and tested for dielectric strength. The oil with desired strength shall be used for topping in case the quantity is small. It shall be ensured during oil filling activity that no air pockets are left in the tank and that no dust or moisture enters the oil. All air vents shall be opened.
- 8.10.4.2 It may be necessary to filter the oil before filling into the transformer in case the quantity of oil to be filled is large. The oil shall be filled through a streamline filter using metal hose. To prevent aeration of the oil, the transformer shall be filled through the bottom drain valve. The flow shall be reduced when the level is almost up to the bottom of main cover to prevent internal pressure from rupturing the pressure relief diaphragm. Sufficient time shall be allowed for the oil to permeate the transformer and also for the locked-up bubbles to escape through air vents. The Buchhloz relay shall be checked for air trapped inside and trapped air shall be released.
- 8.10.4.3 Drying out by streamline oil filter machine
- The most practical method of drying out is by circulation of hot oil through a streamline filter machine having built-in oil heater and vacuum chamber. The vacuum pump of the filter machine should have the capacity of creating vacuum as high as possible, but not less than 710mm of mercury. Drying out process can be made faster by creating vacuum in the transformer tank by lagging the transformer tank to prevent heat loss. The oil temperature should be of the order of 75°C and the winding temperature should in no case exceed 90°C. The winding temperature can be monitored by measuring winding resistance.
  - It should be observed that the oil temperature at filter machine end should not exceed 85°C.
  - The oil samples may be drawn at suitable intervals and the routine testing may be carried out and parameters should be recorded.
  - Simultaneously, measurement of IR values may be carried out, initially at interval of around 4hours or less as suitable and derive Absorption Coefficient and Polarisation Index. Initially, the value of PI may reduce, but after some hours, it will again increase steadily. Thereafter the IR measurements may be carried out at shorter intervals.
  - Generally IR value reading of 2 mega Ohm/kV at 60 deg C temperature, taken using 5kV motorized megger, may be a rough indication for stoppage of drying

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out process. However, the Engineer-in-charge may decide to run drying out for few more cycles, if found necessary.

- vi) Drying out can be terminated when the transformer oil characteristics are found within permissible limits and when 3-4 readings of more or less stable PI are observed.

#### 8.10.5 Erection testing and commissioning


- 8.10.5.1 The erection, testing and commissioning of the transformer, including provisions related to condition monitoring and life cycle management, shall comply with the requirements specified in the “Standard Specifications and Technical Parameters for Transformers and Reactors (66 kV and above Voltage Class)” issued by the Central Electricity Authority, including amendments issued from time to time.

#### 8.10.6 SCADA INTEGRATION

- 8.10.6.1 All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyzer, On-line insulating oil drying system (Cartridge type) etc. for individual transformer, shall be IS/IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IS/IEC 61850. This Ethernet switch shall be provided in IMB. The switch shall be powered by redundant DC supply (as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C.
- 8.10.6.2 All required power & control cables including optical cable, patch chord (if any) upto IMB, all the cables from RTCC to DM and any special cable between IMB to switchyard panel room/control room shall be in the scope of the contractor.
- 8.10.6.3 Integration of above said IS/IEC-61850 compliant equipment with Substation Automation System also included in the scope of the contractor. Cooling and OLTC of transformers shall also be monitored and controlled from SCADA. Contractor shall ensure provision of adequate number of redundant Bay control Units (BCUs).

#### 8.11 Fire Protection system

- 8.11.1 Power Transformer shall be provided with suitable Nitrogen Injection based Fire Protection System which should comply with relevant standards/TAC/IS 10028/IS 1646 and Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010. In case Nitrogen based fire protection system is used, CBIP manual shall be duly followed for compliance.
- 8.11.2 Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults. The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at

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high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly). Electrical isolation of transformer shall be an essential pre-condition for activating the system.

#### 8.11.3 Operational Controls:

8.11.3.1 The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following two situations:

- a) Prevention of transformer from explosion and fire to prevent transformer from explosion and fire in case of an internal fault. The exact logic for system activation with available electrical/mechanical/Breaker trip signals shall be finalized by the Owner during detailed engineering.
- b) Prevention of transformer from fire, sensed by fire detectors (type tested and calibrated), the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

#### 8.11.4 Operation of System

8.11.4.1 On receiving activation signal, the following shall take place


- a) Open the quick opening drain valve to drain the top layer oil
- b) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
- c) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

8.11.4.2 There shall be interlock to prevent activation of the system if the transformer is not electrically isolated. There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

#### 8.11.5 Specific technical requirements

8.11.5.1 The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from the Owner.

8.11.5.2 Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen. The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve. Contractor shall provide two distinct station auxiliary 220 V DC feeders for control purposes. The

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system shall work on station DC supply with voltage variation +10% to -15%. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.


8.11.5.3 Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box:

- a) Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- b) Nitrogen cylinder pressure low
- c) Fire in Transformer/ Reactor
- d) Oil drain started
- e) Conservator oil isolation valve closed
- f) Nitrogen injection started
- g) DC supply fail
- h) Oil drain valve closed
- i) Gas inlet valve closed

8.11.6 Supply of System Equipments and Other related activities

8.11.6.1 The scope of supply shall include the following items and any other items required for safe and trouble free operation of the system.

- i) Fire extinguishing cubicle with base frame and containing at least the following:
  - a) Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
  - b) Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit
  - c) Mechanical release device for oil drain and nitrogen release
  - d) Limit switches for monitoring of the systems
  - e) Panel lighting
  - f) Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
  - g) Back up pressure switch to operate nitrogen gas valve
  - h) Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator
  - i) Fire Extinguishing Cubicle shall have oil leakage detection arrangement for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.
  - j) shall have minimum IP55 degree of protection
- ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

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- iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. Fire detectors shall have minimum IP- 67 class degree of protection.
- iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.
- v) Flow sensitive conservator Isolation valve to isolate the conservator oil from the main tank is to be provided by the transformer/reactor supplier. This valve shall be located in the piping between the conservator and the buchholz relay.

#### 8.11.7 Under Ground Oil Storage Tank

8.11.7.1 Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non-Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPS. The tank shall be painted with Color shade RAL 7035 from outside as per table below.

Painting	Surface Preparation	Primer coat	Intermediate Undercoat	Finish Coat	Total dry film thickness (DFT)
Oil storage tank	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30- 40 micro m)	Epoxy high build Micaceous iron oxide (HB MIO) (75 micro m)	Aliphatic polyurethane (PU) (Minimum 50 micro m)	Minimum 155micro m

Note: (\*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1

8.11.7.2 The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

8.11.7.3 This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalised during detailed engineering.


#### 8.11.8 Installation and pre-commissioning test

8.11.8.1 After installation the system pre-commissioning tests shall be carried out jointly with the Owner's representative before the system is put in service.

#### 8.12 Online Dissolved Gas Analyzer (DGA) System

8.12.1 Each Power Transformer in operation shall be fitted with on-line DGA equipment. The terminals shall be wired up to the M. Box/CMB/CMS to enable remote



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alarm/trip and status information to SCADA/SAS. The Online DGA monitoring equipment shall be able to monitor (minimum) H<sub>2</sub>, CO, C<sub>2</sub>H<sub>4</sub> & C<sub>2</sub>H<sub>2</sub>.

#### 8.12.2 General technical requirement


SN	Description	Details
a)	Detection & measurement of gases	H <sub>2</sub> , CO, C <sub>2</sub> H <sub>4</sub> , C <sub>2</sub> H <sub>2</sub> with 100% sensitivity to H <sub>2</sub> & C <sub>2</sub> H <sub>2</sub>
b)	Accuracy (maximum)	H <sub>2</sub> : $\pm 10\%$ / $\pm 5$ ppm (whichever is greater); CO: $\pm 10\%$ / $\pm 10$ ppm (whichever is greater); C <sub>2</sub> H <sub>4</sub> : $\pm 10\%$ / $\pm 3$ ppm (whichever is greater); C <sub>2</sub> H <sub>2</sub> : $\pm 10\%$ / $\pm 1$ ppm (whichever is greater)
c)	Technology	Gas chromatography/ Spectrometry
d)	Oil temperature range of sensor	10°C to 100°C
e)	Sensor attachment Degree of protection	Minimum IP55
f)	Minimum detection sensitivity to C <sub>2</sub> H <sub>2</sub>	1 ppm

8.12.2.1 The system offered shall be suitable for online monitoring of dissolved gases in oil filled (Naphtanic / Paraffanic based oil) power transformer. It shall atleast measure dissolved gases such as H<sub>2</sub>, CO, C<sub>2</sub>H<sub>4</sub> & C<sub>2</sub>H<sub>2</sub> with 100% sensitivity to H<sub>2</sub> & C<sub>2</sub>H<sub>2</sub>.

8.12.2.2 The system shall be suitably fitted to transformer in accessible location to be decided by contractor with employer's approval. Contractor shall provide necessary adopter /fittings for this purpose. The attachment shall be provided with an oil sampling port to facilitate oil collection for manual off-line DGA by Owner. All software/hardware/cables/PC for monitoring from control room shall be in the scope of the contractor. The supplier shall also provide a suitable calibrating arrangement for each online DGA. The software for remote monitoring in control room shall facilitate real time data logging & also historical data/trend display.

8.12.2.3 Potential free alarm contacts for high gas concentration (user programmable) of each gas shall be wired up to transformer M. Box/CMB/CMS. These will be used for facia alarm in control room and SAS/SCADA. Also, real time data for concentration of each gas shall be provided at control room (SAS/SCADA) through



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M. Box with Owner required format & communication. All required cable, software, hardware & cable laying for the above communication shall be in the scope of contractor.

8.12.2.4 Installation and cable connection drawing shall be furnished for approval.

8.12.2.5 System shall be suitable for operation at 50-degree centigrade ambient temperature & 85% relative humidity.

### 8.13 GI STRUCTURAL STEEL GANTRY TOWERS, EQUIPMENT SUPPORTS, ETC

8.13.1 Design supply and Erection of gantry structures, equipment mounting structures, supports, supports, etc. using GI steel sections shall be carried out in accordance with the following Indian standards


IS:816	Specification for General Welding Work
IS:2062	Hot Rolled Medium and High Tensile Structural Steel
IS:4759	Hot-Dip Zinc Coatings on Structural Steel and Other Allied Products
IS:5624	Foundation Bolts
IS:1367	Technical Supply Conditions for Threaded Steel Fasteners
IS:7203	Indian Standard = Safety during erection of steel structures
IS:7205-1973	Safety code for erection on structural steel work
IS:800	Code of Practice for General Construction in Steel

8.13.2 The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipment and all other accessories and ancillaries required for carrying out the erection without causing any abnormal stresses in the members which may cause deformation and permanent damage.


8.13.3 The Contractor shall strictly follow at all stages of fabrication, transportation and erection of steel structures, raw materials and other tools and tackles, the stipulations contained in Indian Standard Code for Safety during erection of structural steel work as provided in IS:7203

8.13.4 Structural steel conforming to Grade IS:2062 shall be galvanized in accordance with the provisions of IS 4759. 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>. Foundation bolts shall conform to IS: 5624, property class 4.6 as specified in IS: 1367.

8.13.5 Erection of Gantry/Portal and equipment support structures

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- 8.13.5.1 Structures shall be erected as described in preceding paragraphs. All tests mentioned in the standard field quality plans shall have to be carried out and conformity of the materials and workmanship shall be ascertained.
- 8.13.5.2 The erection works shall be carried out generally in accordance with IS:802. A reference however may be made to IS:800 in case of non-stipulation of some particular provision in IS:802. All erection materials received at site shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.
- 8.13.5.3 The steel members shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in the member, the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) and shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.
- 8.13.6 Bolting
- Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together. For all the members that are subjected to vibrations under normal working conditions, spring washers shall be used along with plain washers.
- 8.13.7 Welding
- The welding work shall be carried out as per the fabrication drawings to be provided by the Employer, which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld, etc. A symbol for welding on erection and shop drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper joints due to constructional difficulties.
- 8.13.8 Foundation Bolts
- Foundation bolts for the gantry structures shall be supplied in advance by the Contractor. The foundation bolts shall be erected by the Contractor while constructing the switchyard foundations.
- 8.13.9 Stability of structure
- The Contractor shall be responsible for the stability of the structure at all stages of erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.
- 8.13.10 Grouting

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The method of grouting the column bases shall be subject to approval of the Employer and shall be such as to ensure a complete uniformity of contact over whole area of the steel base. The Contractor shall be fully responsible for the grouting operations.

#### 8.13.11 INSTALLATION OF CONNECTORS & CLAMPS

8.13.11.1 The connectors shall be examined before fixing for availability of all hardware and accessories and shall be thoroughly cleaned by suitable cleansing chemical.

8.13.11.2 Contact paste shall be applied on all contact surfaces during installation of non-tensile, rigid and flexible connectors. Contact paste shall effectively prevent corrosion occurring on the contact surfaces between aluminium and copper throughout the service period. Contact paste shall be easy to apply to the contact surfaces within temperature range -30°C to + 50°C. The paste shall have good adherence and chemical bonding with aluminium conductors and other materials included in the connector. Contact paste shall not be poisonous or inflammable. Contact paste shall not decay, evaporate, run away, harden or crack under the service conditions described in the specification.

8.13.11.3 The joints shall be properly made and bolts/nuts shall be tightened using torque wrench so as to apply exact force during tightening

### 9 HT Switchgear Equipment

#### 9.1 33 kV Switchboard Panel with Vacuum Circuit Breaker


9.1.1 This Specification describes the requirements governing engineering, design, manufacture, inspection/ testing, installation and testing 33 kV HV Switchboard Panel with Vacuum Circuit Breaker (VCB) complete in all respect with all equipment, fittings and accessories for efficient and trouble-free operation.

9.1.2 Irrespective of fact whether it is specifically mentioned or not, all the components shall be deemed to have been included in the specification and shall be provided by the Contractor as required for proper functioning of the offered equipment.

#### 9.1.3 Codes and standards

9.1.3.1 The switchboard, VCB and components used in assembly shall be constructed, wired and tested in accordance with, but not limited to, this Specification and the relevant Indian/International Standards and Codes listed below

IEC 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IS:13118, IEC 62271-100	Specification for High Voltage Alternating Current Circuit Breakers
IS:10118-1982	(Part 1 to 4) Code of practice for Selection, Installation and Maintenance of Switchgear and Controlgear


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IS:7987-1976	Guide for Selection of High Voltage Circuit Breakers
IS:325-1970	Specification for Three Phase Induction Motors
IS:2099-1973	Specification for Bushing for Alternating Voltage above 1000 Volts
IS:12063-1987	Classification of Degrees of Protection Provided by Enclosures of Electrical Equipment
IS:1248-1993 (Part 1 to 2)	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories General Requirements (Third Revision)
IS:2705-1992 (Part 1 to 4)	Current Transformers Specification
IS:3156-1992 (Part 1 to 3)	Voltage Transformers Specification
IS:4201-1983	Application Guide for Current Transformers (First Revision)
IS:4146-1983	Application Guide for Voltage Transformers (First Revision)
IS:5082	Specification for Wrought Aluminium and Aluminium Alloy Bars, Rods, Tubes and Sections for Electrical Purposes
IS:772-1986 (Part 1)	AC Electricity Meters: General Requirements and Tests (Second Revision)
IEC 60947	Terminal block for copper conductor.
IS 13118	Alternating current circuit breakers
IS 3427	AC metal enclosed switchgear and control gear

#### 9.1.4 Specific design requirements


##### 9.1.4.1 Panel

- i) The switchboard panels shall be metal enclosed, free standing, floor mounted, outdoor type, fully compartmentalized, damp and dust protected to use in an enclosed room. The panels shall be constructed of MS angle frame and CRCA

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sheets of minimum 2mm thick Each panel shall generally consist of the following compartments.

- a) Vacuum circuit breaker compartment
- b) Instrument and relay compartment
- c) Bus bar chamber
- d) Current transformer and cable termination compartment
- ii) Base frame shall be of adequate strength to take load of the truck mounted VCB. Foundation bolts with hardware in required numbers shall be supplied along with the equipment. Guide rails shall be provided in the cubicle to ensure accurate and positive line up of the VCB and self-aligning of main and secondary contacts. 3mm thick removable gland plates for the HT cables and control cables shall be suitably provided at bottom of the panel.
- iii) The switchboard structure shall be provided with barriers to prevent transfer of ionized gases between compartments and shall be self-ventilated.
- iv) The switchboard shall be supplied with all manual operating devices and shall be equipped with positive mechanical positive indicators to show that the VCB is in the service, isolated or test position in the cubicle.
- v) The test facilities shall be provided to permit operation of VCB whist in the test and isolated positions.
- vi) The perimeter of all doors, removable covers and gland plates shall be provided all around with high density polyurethane foam sealer or neoprene rubber gaskets. All the covers shall be bolted type except, the front hinged doors of VCB and metering compartments. The hinged doors shall be provided with concealed type hinges.
- vii) All the components mounted in the panel shall be easily accessible through front / back opening in the panels for inspection and maintenance. The VCB operating mechanism components shall be easily accessible once the truck is drawn out from the cubicle.
- viii) The switchboard shall be panel extensible on both the sides.
- ix) The equipment shall be constructed such that no major adjustments shall be required at site during erection and thereafter during normal service.
- x) The cable termination and CT compartment shall have adequate space for termination of specified type, size and nos. of HT cables using indoor heat-shrink termination system.
- xi) MS angle of 32x6 mm having length of panel width with clamp and hardware shall be provided in the cable chamber at about 250mm from bottom of the panel to support the cable termination so as to avoid stress on the terminations made on the bus.


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- xii) All indicating meters, control switches, relays and indication lamps shall be mounted on the front door at an easily accessible height, of, generally, not more than 1700mm.
- xiii) The Degree of protection to the switchboard shall be IP:55 or better as per IS/IEC 60529.
- xiv) The busbar shall be rated as mentioned in SoR/ drawings. The bus bars shall be insulated with heat shrink sleeves, which shall be track-resistant, flame-retardant to provide adequate mechanical and thermal strength under normal and abnormal conditions. The bus joints shall be covered with moulded PVC shrouds. Phase identification marks shall be provided appropriately on each bus at every 300mm.
  - a) Bus bars shall be Aluminium and shall be completely isolated and coated with an epoxy insulation that is flame retardant, non-hygroscopic and high dielectric, except at bolted joints. The bus shall be mechanically braced for the close and latch rating of the breaker having the highest interrupting rating within each assembly. All bolted bus joints shall be (Standard – silver-plated). The bus connections to the Circuit breaker shall match the breaker rating. Bus supports shall be flame retardant, track resistant.
  - b) Bus joint cover boots shall be manufactured from moulded PVC and shall be removable and reusable for field inspection and maintenance. Taping of bus joints is not acceptable. The shape of the bus bar shall be full round edge. The main bus shall not be tapered. Bus bar connections shall be mechanically secured with reusable fastening devices that shall maintain adequate pressures at the joints within the operating temperature range of the switchgear.
  - c) The bus bars and support systems shall be designed to withstand the forces created during short circuit conditions at the rated momentary and short-time (3-second) conditions of the highest rated circuit breaker. Supports shall be made of (Standard - glass polyester).
  - d) Solidly grounded metal (Optional – non-metallic poly carbonate) shutters shall automatically open when the breaker or G&T device is racked into the connected position and close (covering the primary contacts and current transformers) when racked to the test or disconnected positions or withdrawn from the cell. Shutter grounding shall be by dedicated ground wires, and shall not be dependent on grounding through hinges or moving contact surfaces. The actuation of the shutters must be by the movement of the circuit breaker. Gravity and spring-operated shutters are not acceptable.
- xv) The earth bus shall run throughout length of complete panel.

#### 9.1.4.2 Switchgear components

- i) The VCB shall be truck mounted, arranged for horizontal isolation and full horizontal draw out, three pole, single throw, electrically operated having a



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stored energy mechanism, which is charged by electrical motor. The cradle mounting arrangement is not acceptable.


- ii) The vacuum interrupter bottle shall be hermetically-sealed to protect contacts from oxidation, corroding elements and contamination.
- iii) The VCB operating mechanism shall be such that closing speed of the contacts is independent of control voltage and the operator, and that it is electrically and mechanically trip-free. Immediately after the breaker is closed and closing spring is released, the spring charging motor shall start automatically and charge the spring to ready the breaker for next closing operation.
- iv) The breaker shall have in-built anti-pumping feature.
- v) The VCB shall be equipped with following components
  - a) Mechanical push buttons for VCB CLOSE/TRIP.
  - b) Mechanical indication for VCB ON/OFF.
  - c) Operation counter.
  - d) Mechanical indication for spring CHARGED/DISCHARGED.
  - e) Scrapping earth contact block for earthing of truck in any position inside panel.
  - f) Low voltage and socket for connection of the low voltage auxiliary circuits associated with the opening/closing and interlocking of the circuit-breaker.
  - g) Auxiliary contact block with minimum 08 NO + 08 NC contacts, rated for 10A, 230V AC/220V DC power supply, for breaker control and interlocking.
- vi) Breaker control switches, indicating lamps shall be provided as mentioned in drawings as minimum requirements.
- vii) CLF type panel illumination lamp and door operated control switch shall be provided in each panel.
- viii) Anti-condensation heater with thermostat for auto switching shall be provided in each panel.

#### 9.1.4.3 CURRENT TRANSFORMER (CT)

- i) The CT shall be epoxy cast resin, bar primary type, 36 kV class, wound secondary construction as per specification and quantity provided in data sheet and drawings.
- ii) Secondary windings of CT shall be wired to suitable test terminal blocks and grounded at one point using removable links. CT shall be identified by anodized aluminium label giving type, ratio, class, serial number, over-current factor and time rating.

#### 9.1.4.4 POTENTIAL TRANSFORMER (PT)



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- i) The PT mounted on a draw out or trunnion mechanism. With the compartment door closed, the primary and secondary disconnect contacts shall be engaged with their respective stationary contacts to complete the circuit. On opening the panel door, PT shall be automatically withdrawn, breaking primary and secondary connections and grounding PT's Primary terminal.
- ii) The PT shall be epoxy cast resin moulded, single pole, feeder connected construction as per specification provided in data sheet and drawings.


9.1.4.5 Surge arresters of polymer type, conforming to the specified class and ratings as per the approved Single Line Diagram (SLD), shall be provided at appropriate locations such as feeder terminations, and cable entry/exit points, ensuring effective protection of equipment from overvoltage surges.

#### 9.1.4.6 INDICATING AND RECORDING INSTRUMENTS

- i) All indicating instruments and meters shall be provided conforming to the relevant standard. All indicating instruments and meters shall be capable of carrying continuously their full load currents and full voltage across their pressure coils. They shall not be damaged by the passage of fault currents or the existence of over pressure on the primary side of their instrument transformers for the maximum permitted duration of fault conditions which may occur during normal operation. All instruments and meters shall be back connected.
- ii) Multi-function meter (MFM) as per drawings. MFM shall be suitable for connecting with 230V AC, 50 Hz, PT power supply and system catering to unbalance load.
- iii) The AC ammeters, voltmeters, PF meter, frequency meter, etc. shall be digital and flush mounted type. Ammeters and voltmeters shall preferably be with in-built selector switch to observe 3-phase currents and voltages. The quantity of indicating meters shall be as provided in the specification for respective equipment/Bill of materials.

#### 9.1.4.7 PROTECTIVE RELAYS

- i) All main protective relay shall be numerical, microprocessor based, programmable. Other relays such as master trip/lockout relay, auxiliary relay, alarm relays, under-voltage relay, etc. shall be electro- magnetic type as specified in datasheets.
- ii) The numerical relay shall be conforming to applicable parts of IEC 60255-2000, IEC 61000-4. The Protection and Control unit shall meet the applicable IEEE/ IEC design standards.
- iii) The numerical relays shall have provision for selectable 1A/5A CT secondary and electro-mechanical relays shall be suitable for 5A CT secondary.
- iv) No deterioration of contacts shall occur in service. Tripping relays shall be provided with operation indicators, which can be hand reset without opening the case. All relays shall be marked with function, phase colour, characteristic

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curve (where applicable), rated current and/or voltage of coils and current making capacity of contacts.


- v) Test blocks/test plugs shall be provided, wherever required, to enable all protective relays to be tested in their cases without any removal or disconnection or wires.
- vi) switchgear panels shall have communicable numerical protection relays (IEDs) complying with IEC-61850 on all feeders which shall be networked on Ethernet to communicate with substation SAS/SCADA system on IEC-61850. These IEDs shall also be used for control & monitoring the switchgear from SAS.

vii) Numerical Transformer Protection Relay

- a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protections.
- b) The over current element should have the minimum setting adjustable between 20- 200% of CT secondary rated current and high set setting 500-2000%.
- c) The relay shall have selectable directional & non-directional feature  
The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current (IDMT) and high set 100-1000%.
- d) For transformers of rating 5MVA and above, High-speed percentage biased differential relay with harmonic restraint, 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 and other applicable protection as per CBIP recommended Transformer Protection.
- e) The relay shall allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.
- f) Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips (as applicable) shall be wired to separate binary inputs of the relay and shall be configured to issue trip command to the breaker.
- g) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

viii) Numerical Feeder Protection Relay

- a) The relay shall have instantaneous(50/50N) as well as IDMT(51/51N)three over current (50) and one earth fault (50N) protections with directional overcurrent(67) and earth(67N) fault element wherever applicable.
- b) The over current element should have the minimum setting adjustable between 20- 200% of CT secondary rated current.
- c) The relay shall have selectable directional & non-directional feature

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- d) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.
- e) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.
- f) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protections.
- g) The over current element should have the minimum setting adjustable between 20- 200% of CT secondary rated current.
- h) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.
- i) Bus no volt signal shall be configured in the relay for use in control logics and other Protections and Control functions in the Relays.
- j) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.
- ix) Control of breakers shall be carried out from the station HMI of SAS/SCADA system through the LAN and the numerical relays.

#### 9.1.4.8 SAFETY INTERLOCKS

- i) The VCB truck can be withdrawn from the switchgear panel only when the breaker is in OPEN condition.
- ii) The VCB truck cannot be withdrawn unless the plug unit meant for secondary connection is isolated from the socket. Vice-versa, the secondary plug shall not be connected unless the breaker truck is fully racked in the test position.
- iii) Auxiliary contacts shall be interlocked in closing tripping circuit, which shall close to permit closing of breaker only when the spring is fully charged.
- iv) The breaker can be closed from remote only when it is in service position. However, the breaker shall trip on giving OPEN command from local operating switch even when it is in service position. Mechanical CLOSE push button shall operate only when the VCB truck is in TEST position and Mechanical OPEN push button shall operate when the truck is in TEST or SERVICE position.
- v) The panels shall be equipped with safety shutter of metallic sheets, which shall be operated by a movement of VCB truck to expose the busbars to breaker contacts when the VCB is inserted in service position. The shutter shall automatically drop as soon as the VCB is withdrawn from the service to test position.


#### 9.1.4.9 Erection requirement

- i) All required hardware such as bolts, nuts, washers (round and spring type), anchor fasteners, screws, etc. of sizes and type as required shall be conforming to relevant IS. All hardware shall be hot-dip galvanized or zinc

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passivated/cadmium plated as per requirement of work either mechanical fabrication or electrical jointing.

- ii) Equipment Grouting material such as cement, metal, sand, bricks, etc., if required, shall be supplied by the Contractor. The material shall be of approved make (Wherever applicable) for which the Contractor shall consult Engineer-in-charge before procuring the material.
  - iii) Generally, the cubicles are supplied along with VCB and PT truck inside cubicle and hence entire assembly shall be handled and shifted to place of erection secured on the wooden pallet.
  - iv) The base frame for the foundation shall be supplied by the Contractor and shall be grouted on the floor as shown in the layout drawing maintaining accurate levelling. Necessary difference of level between finished floor level and ISMC meant for VCB movement shall be maintained to ensure easy movement of VCB on ISMC for insertion and withdrawal. The defect, if any, shall be set right in consultation with Engineer-in-charge, who shall also arrange for involvement of civil contractor, if required.
  - v) Before the cubicle is erected on the foundation, the VCB shall be removed arranging a roll of ramp of required height (as per height of pallet) and by following procedure described in the manufacturer's manual. While rolling out the VCB using ramp, necessary care shall be exercised to avoid VCB tip over.
  - vi) The cubicles shall be carefully removed from the pallet and placed on the foundation and levelled properly. Interconnection between shipping sections shall be carried out and then interconnection between bus bars and inter-panel control wiring shall be completed. The bus bars shall be taken from one cubicle to another through epoxy inter-panel bushings, which shall be fixed, if supplied loose.
  - vii) Through Aluminium / G.I. earth bus provided in each cubicle shall be interconnected by means of interconnecting links supplied in each cubicle. The earth bus at the end cubicles on both sides shall be connected to the plant earthing system through slot provided in end sheet of cubicle for this purpose.
  - viii) After completing alignment of panels, the VCB shall be inserted in the cubicle and the engagement and alignments of fixed and moving contacts shall be checked. If not found correct, necessary adjustments for the panel and VCB shall be made.
  - ix) The erected panels shall be either bolted or welded with the foundation base frame. The bus joints shall be finally checked with the torque wrench maintaining torque as recommended by the manufacturer.
- 9.1.4.10 Following tests shall be performed before charging HT panel with regular supplies:
- a) Mechanical spring charging, close and trip operation in circuit breaker


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- b) Measurement of insulation resistance of R, Y, B phase to earth and between phases before and after HV test (All CB inserted and closed).
- c) Measurement of insulation resistance of various control circuits before and after HV test.
- d) DC or AC high voltage withstand test of R, Y, B phase to earth and between phases at 75% of specified withstand voltage (All CB inserted and closed)
- e) DC or AC high voltage testing of each control circuit to earth.
- f) Testing of CT, VT, meters and relays separately by secondary injection.
- g) Testing of CB for motorised spring charging, electrical closing and tripping, and also tripping through relays by simulation.

## 9.2 HT Cable

### 9.2.1 Quality Certifications

- 9.2.1.1 Cables shall be compliant to most recent standards (and latest amendments if any) developed by the IS/IEC Standards. Below Table presents a non-exhaustive list of standards to which the cables should conform.


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IS 7098	Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV up to & including 33 KV
IS 3961	Recommended current ratings for cables
IS 3975	Low Carbon Galvanized steel wires, formed wires and tapes for armouring of cables
IS 4905	Methods for random sampling
IS 5831	PVC insulation and sheath of electrical cables
IS 8130	Conductors for insulated electrical cables and flexible cords
IS 10418	Specification for drums for electric cables
IS 10810	Methods of tests for cables

## 9.2.2 Specific Design Requirements


- 9.2.2.1 Cables sizes shall be selected considering the power loss, current carrying capacity, voltage drop, maximum short circuit duty and the period of short circuit to meet the anticipated currents. Cable sizing calculations shall be finalized during detailed engineering phase.
- 9.2.2.2 High quality XLPE insulating compound of natural colour shall be used for insulation. Insulation shall be applied by triple extrusion process and shall be chemically cross linked.
- 9.2.2.3 Cable shall be provided with conductor shielding as well as insulation shielding and shall consist of extruded semi conducting compound, additionally insulation shield shall be provided with semi conducting and metallic tape shield over the insulation shield. XLPE insulation and outer core shielding shall be extruded in single operation.
- 9.2.2.4 Outer Sheath and Inner sheaths shall be of suitable grade PVC compound applied by extrusion process. Colour of the outer sheath shall be black. Armouring may be of galvanised steel wires or galvanised steel strips.
- 9.2.2.5 The cable shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.
- 9.2.2.6 The HT cable shall be supplied in drum size not less than 500m. No part or broken quantities will be accepted.
- 9.2.2.7 Cable Drums



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- i) Cable shall be supplied in non-returnable wooden/steel drum. The wood used for construction of the drum shall be properly seasoned and free from defects. Wood preservative shall be applied on the entire drum. Wooden drums shall comply with IS: 10418. All ferrous parts shall be treated with a suitable rust preventive coating to prevent rusting during transit or storage. Cable drums shall conform latest Indian standards. Cable ends shall be sealed with non - hygroscopic cap. Allowable tolerance on individual drum length is  $\pm 5\%$ .
  - ii) The cable drums should carry the following details in printed form:
    - a) Manufacturer's name or trade make.
    - b) Owner's name, address.
    - c) Type of cable & voltage grade.
    - d) Year of manufacture.
    - e) Type of insulation.
    - f) No. of core and size of cables.
    - g) Cable code.
    - h) Length of cable on drum.
    - i) No. of length on drum, if more than one.
    - j) Direction of rotation, by arrow.
    - k) Handling Instructions.
- 9.2.2.8 Cable Identification: Cable identification shall be provided by embossing on every meter on the outer sheath the following:
- a) Manufacturer's name or trademark.
  - b) Voltage grade.
  - c) Year of manufacture.
  - d) Type of insulation.
  - e) No. of core and size of cables.
- 9.2.3 Pre-dispatch Quality and Testing
- 9.2.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.
- 9.2.3.2 Indicative list of tests shall be performed on cables is as below:
- i) Routine Test
    - a) Conductor Resistance test.




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- b) Insulation resistance test.
- c) High voltage test.
- ii) Factor Acceptance Test
  - a) Tests on conductor:
    - Conductor resistance.
    - Tensile strength (before & after stranding).
    - Wrapping test (before stranding).
  - b) Thickness of Insulation and sheath.
  - c) Hot set test on insulation.
  - d) Tensile strength and elongation at break test for Insulation & sheath.
  - e) Insulation resistance test.
  - f) High voltage test.
- iii) 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.
- iv) During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- v) However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the Owner either at third party lab or in presence of Owner's/Owner appointed PMC's representative and submit the reports for approval.
- vi) The reports for following type tests shall be furnished:

SN	Type Test	Remarks
1.	Conductor	
a)	Resistance test for Armour Wires / Formed Wires	

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SN	Type Test	Remarks
b)	Measurement of Dimensions	
c)	Tensile Test	
d)	Resistance test	
e)	Wrapping test	
f)	Torsion test	For GS round wires only
g)	Elongation test	For GS wire only
h)	Mass& uniformity of Zinc Coating tests	For GS wires/formed wires only
i)	Adhesion test	For GS wires/formed wires only
2.	For XLPE insulation & PVC Sheath	
a)	Test for thickness	
b)	Tensile strength and elongation test before ageing and after ageing	
c)	Ageing in air oven	
d)	Shrinkage test	
e)	Hot set test	For XLPE insulation only
f)	Water absorption test	For XLPE insulation only
g)	Loss of mass test	For PVC outer sheath only
h)	Hot deformation test	For PVC outer sheath only
i)	Heat shock test	For PVC outer sheath only
j)	Thermal stability test	For PVC outer sheath only

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SN	Type Test	Remarks
k)	Oxygen index test	For PVC outer sheath only
l)	Smoke density test	For PVC outer sheath only
m)	Acid gas generation test	For PVC outer sheath only
n)	Flammability test as per IEC-332	For completed cable only

#### 9.2.3.3 On Site test


Cables shall be tested on site prior into putting into service to ensure that all items are in required working condition, correctly installed and free from damage. An experienced and qualified testing Engineer shall be engaged by the contractor to perform the site testing and commissioning.

- Conductor Resistance test.
- Insulation resistance test.
- High voltage test.
- Jointing kit and Termination kit shall be inspected and tested as per the applicable standards and approved Quality Assurance Plan.


### 10 Control and Protection

#### 10.1 SAS general requirements


- 10.1.1 The Substation Automation System (SAS) shall be based on the communication protocol IEC61850 and meet the requirements stipulated herein as a minimum. The Sub-station Automation system being offered shall generally conform to provision of IEC 62351, IEC 62443 (Industrial Automation and Control System Security, formerly known as ISA S99), IEEE1686 and NERC CIP for cyber security.
- 10.1.2 The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment and HT Switchgear and Solar Plant through dedicated SCADA from Owner's Remote Control Centre (1 no.), RLDC/SLDC and as well as from local control centre.
- 10.1.3 The SAS shall contain redundant Gateways (stand-alone/in-built in network controller), for remote monitoring and control via industrial grade hardware (to RCC) through Secure IEC 60870-5-104. Each gateway shall be capable of communicating with at least 03 no's of RCCs and same shall be finalized after detailed engineering

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- 10.1.4 It is the Contractor responsibility to send all the required data of solar plant and switchyard to SLDC/RLDC/Owner's Remote Control Center for control and monitoring. Data points for control and monitoring shall be finalized during detailed Engineering. Solar plant SCADA data shall be available at Substation local control centre in the Solar plant network. All required hardware's, software's, communication links and modification as per requirement shall be in the Contractor scope.
- 10.1.5 The point-to-point testing of all signals for the HV AND EHV network at the plant end, protection equipment ends and the terminal end (Substation Controller and Operator Workstations) at the substation shall be the responsibility of the contractor.
- 10.1.6 The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchyard bay equipment without the need of interposing components and perform control, protection, and monitoring functions
- 10.1.7 The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.
- 10.1.8 The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling, and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records. IP addressing of the system shall be as per the IP plan provided by the owner/finalized during detail engineering.
- 10.1.9 The system shall be remotely accessed for collection of disturbance records and other functions as mentioned elsewhere in the specification and hence shall be provided with a firewall/router to comply at least with the requirements of Cyber Security standards
- 10.1.10 The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC 61850.


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- 10.1.11 The communication shall be made in fault tolerant ring, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fibre shall not affect the normal operation of the SAS. However, failure of fibre shall be alarmed in SAS. Each fibre optic cable shall be as per specification of fibre optic cable mentioned elsewhere separately.
- 10.1.12 At Station Level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to always control and monitor the bay from the bay level equipment.
- 10.1.13 The station level contains the station-oriented functions, which cannot be realised at bay level, e.g., alarm list or event list related to the entire substation, gateway for the communication with remote control centres.
- 10.1.14 The contractor shall be responsible for all the works on switchyard SAS. However, the architecture for the SAS shall be finalized during detailed engineering stage and same shall be in line with industry practices for HV AND EHV switchyard SAS system.
- 10.1.15 The SAS shall be a computer-based system that shall integrate independently operating subsystems, such as Bay Control Units, Bay Protection Units, Metering and alarm annunciation into a unified data acquisition, monitoring, protection and control system in the substation including 33KV Switchgear.
- 10.1.16 The SAS architecture shall be flexible to allow future extensions in switchyard. Only IEC 61850 protocols shall be used for inter-device communication
- 10.1.17 The SAS at substation level and the communication network(s) shall be designed in a dual redundancy configuration. No single failure of any component/module of the SAS, including the communication links, shall cause loss of functionality of the SAS of more than a single bay.
- 10.1.18 Each component/module of SAS, 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.
- 10.1.19 The SAS shall be designed such that no periodic testing and maintenance is required for various subsystems comprising SAS. On-line testing routines for various subsystems of SAS shall be provided.
- 10.1.20 SAS shall be designed such that maintenance, modification or extension of its components/modules shall not cause shutdown of the complete SAS.
- 10.1.21 The GPS time synchronising signal (as specified elsewhere in the specification) for the synchronization of the entire system shall be provided. The SAS and all

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its components shall be synchronized from this GPS time referenced clock receiver. The Time Synchronization Equipment shall also be in Contractor's scope of supply. A timing accuracy of better than 1 milli sec shall be achieved for all the devices within the SAS except PMU. For PMU, dedicated GPS is to be provided as per timing accuracy requirement.

- 10.1.22 The Contractor shall provide all the documentation required during project implementation and during the life cycle of SAS for operation and maintenance. A list of such documentation shall be reviewed and approved by the Owner during detailed engineering.
- 10.1.23 Owner intends to ensure interoperability of any third party IEC61850 compatible IEDs to be incorporated in future with the offered SAS. Contractor to provide all necessary data, configuration files, information in this regard.
- 10.1.24 The SAS supplied as per this specification shall be designed and constructed to meet all specification requirements for 25 years. Further, the Contractor should guarantee for hardware and software support for 25 years to guard against obsolescence. All requirements / devices of the SAS that are not listed under recommended spares shall have a normal life expectancy exceeding the specified expected life of the SAS.
- 10.1.25 Contractor shall offer the Bay Level Units for the HV AND EHV system (each circuit breaker with associated dis-connector, Earth switches and instrument transformer shall comprise one bay) complete with Bay Control Units (BCUs) and Bay Protection Units (BPUs). Bay Level Units, common panels like bus bar protection/ metering panels, Station HMI, LVS, FOTE/PLCC and other workstations/gateways etc. shall be located in Air-conditioned switchyard control room.
- 10.1.26 Dedicated Bay Control Unit and Bay Protection Units shall be provided for each bay in the Contractor's scope of work as per offered bay configuration.
- 10.1.27 Contractor shall offer BCUs/RTUs for all feeders like outgoing/incoming, TIE/Bus coupler, Bus PTs etc. of 33KV pooling switchgear and integration with EHV SAS & the same will be finalized during detail engineering.
- 10.1.28 In case of RTU is being offered for 33KV Switchgear for SAS interfacing, the IO modules shall be hot swappable and as per the specification mentioned elsewhere in the tender documents.
- 10.1.29 The offered BCUs for 33KV Switchgears shall be as per the SAS standards and it shall be used for signal interfacing with the SAS. The data exchange between BCUs/RTUs and switchgear shall be hardwired.


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- 10.1.30 The data exchange between the 33KV IEDs, RTUs and SAS shall be on 61850 communication protocol.
- 10.1.31 All the control logics for auxiliary systems required for EHV substation and 33KV switchgear shall be built in RTU/BCUs and interfaced with the SAS system and made available at HMI for control and monitoring of auxiliary system.
- 10.1.32 For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.
- 10.1.33 At Bay Level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. Each bay control IED shall be independent from each other, and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.
- 10.1.34 The high-voltage apparatus within the station shall be operated from different places:
- a) Remote control centres
  - b) Station HMI
  - c) Local Bay controller IED (in the bays)
- The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, control-inhibit tags etc.

## **10.2 SAS Reliability Requirements**

- 10.2.1 Each component and equipment offered by the Contractor shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established considering its failure rates/meantime between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete system is assured. The guaranteed annual system availability shall not be less than 99.9%.
- 10.2.2 The Contractor shall submit reliability and maintainability values including detailed calculation for the projected overall system availability along with all assumptions supported by relevant standard for each device/equipment/system module which, with the help of a schematic of various systems connected in series or in parallel as the case may be, and Mean Time Between Failures (MTBF)



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& Mean Time to Repair (MTTR) values for the various equipment shall show that availability calculation is as specified in IEEE standard-P-1046 or equivalent.

- 10.2.3 The contractor shall furnish during detailed engineering stage composite list of bought out items (i.e. items not from his own manufacturing range) which the Contractor has included in his proposal along with the name of proposed sub vendors, as a part of his proposal. However, the make and model of all bought out items supplied by the Contractor shall be as approved by the Owner during the detailed engineering stage.


### 10.3 SAS Performance Requirements

- 10.3.1 It shall be the responsibility of the Contractor to predict and indicate during the detailed engineering, the worst-case loading conditions and design the system accordingly to meet the same. The worst-case loading conditions shall include the following tasks as a minimum:

- 10.3.1.1 All analog inputs scanning, and processing is in progress and all the data is being transmitted over the system bus every one second.
- 10.3.1.2 Four operator comments for information from any Operator Workstation within a base period of one minute.
- 10.3.1.3 A burst of 1000 alarms is generated over a period of 10 s.
- 10.3.1.4 One operator control is generated every 10 s.
- 10.3.1.5 Data collection for logs/reports.
- 10.3.1.6 Data collection for historical storage and trend function.
- 10.3.1.7 Data collection of fault records.
- 10.3.1.8 All health monitoring functions/diagnostics.
- 10.3.1.9 All output devices are in operation with rated performance/speed.
- 10.3.1.10 All data are transferred to the Operator Workstations.

### 10.3.2 Duty Cycle

- 10.3.2.1 Time The Substation Controller processor spare duty cycle (free time): Under the worst case loading conditions, each processor shall have:
- a) 40% free time when measured over any two second period
  - b) 60% free time when measured over any one-minute period
- 10.3.3 Inter Bay Bus and Substation Network Spare Duty (free time)
- 10.3.3.1 The Inter Bay Bus and Substation Network shall have a minimum of 50% free time during the worst-case loading conditions measured over any two-second period.

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10.3.3.2 The Contractor shall furnish all necessary data to fully satisfy the Owner that the processor spare duty cycle figures quoted by the contractor are realistic and based on configuration and computational capability of the offered system and these shall be actually implemented system as commissioned at project site.

#### 10.3.4 Display Response Time


10.3.4.1 The display response time under worst case conditions for all displays shall not be worse than 1.5secs for HMI displays. The display response time is defined as the time interval between the pressing of the last key demanding a display and completion of the requested display on LCD/LED with full foreground and background information, and/or the updating of status indications according to plant changes, and/or the updating of event / alarm register according to alarm conditions.

#### 10.4 Software License and Upgrades

10.4.1 The contractor shall provide all software licenses for all the software being used in SAS system. The license shall be provided on a site license basis and shall be valid for the plant / equipment life cycle. The license shall not be hardware / machine specific i.e. if any hardware / machine is changed / upgraded, the same software license shall be valid, and the Owner shall not have to seek fresh license or renewal of license. The contractor shall provide the license considering sufficient number of I/O s catering to the complete switchyard as shown in tender SLD including future bays. In the case of anti-virus software, the license shall be valid till the completion of O&M (including all updates in this period).

10.4.2 The Contractor shall guarantee that all software is defect free and meets the system specifications and undertake to fix any defects which may arise during the life of the system at no cost to the Owner.

10.4.3 All software versions in components of the SAS shall be the latest official releases as on the date of shipment from works and shall include all software updates etc. released till that date. A certificate to this effect shall be furnished by the contractor at the time of pre-dispatch inspection for each software package. All new software revisions and/or patch updates that are released before the end of the warranty period which addresses system defects shall be implemented on site and the system re-tested to validate system integrity by the contractor at no cost to the owner (This excludes new revisions which provides additional functionality). The contractor shall periodically inform the designated officer of the Owner about software updates / new releases that would be taking place after the system is commissioned.

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## 10.5 Design and Operating Requirements of SAS

### 10.5.1 Bay/station interlocking and blocking

10.5.1.1 Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

10.5.1.2 In addition to software interlocking hardwired interlocking are to be provided for:

- a) Bus Earth switch Interlocking
- b) Transfer Bus interlocking (if applicable)

10.5.1.3 It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the Contractor shall describe the scenario while an IED of another bay is switched off or fails.

10.5.1.4 A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

10.5.2 Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled and an alarm shall be generated to indicate the failure of command.

10.5.3 The control hierarchy and control levels of the SAS shall be based on the logical structure of the SAS, which is as follows:

Control Level 3 - Remote Control Center


Control Level 2 - Substation Level (HMI)

Control Level 1 - Bay Control Units and IEDs

Control Level 0 - Switchyard and Switchgear Equipment

10.5.4 The data exchange between Control Level 3 and Control Level 2 shall take place via the communication links for remote telemetry and control of the substation using the IEC60870-5-101/104/OPC protocol (actual protocol to be notified during detailed engineering).

10.5.5 The data exchange between Control Level 2 and Control Level 1 shall take place via the inter-bay/ Station communication bus using the IEC61850 protocol. The inter bay communication bus shall support peer-to-peer communications capability.

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10.5.6 The data exchange between Control Level 1 and Control Level 0 shall be by means of hard-wired status / control signals between Switchgear Equipment and Bay Control /Protection Units and analog signals from CTs / CVTs.

## **10.6 Substation Level Functionality**

### **10.6.1 Control Functions:**

10.6.1.1 The SAS shall perform control functions on various switchyard and HT switchgear equipment based on the status, analog and logical inputs acquired by SAS and SCADA from various bay control units and IEDs.

10.6.1.2 It shall be possible to monitor and control all the switchyard bays and HT switchgear feeders in the Contractor's scope and the status of the plant (status and analog signals such as MW, MVAR, information etc) from any of the Operator Workstations at Control Level 2 i.e. from switchyard Control Room. However, in the case of maintenance, failure or emergency, it shall be possible to control the individual bays/feeders from the Bay Control Units/IEDs at Control Level 1.


10.6.1.3 Clear control priorities shall ensure that operation of particular bay equipment (Circuit Breaker or Isolator) cannot be initiated simultaneously from more than one of the control levels. The priority shall always be on the lowest enabled control level. The selected control level shall be indicated at all the levels so that the operator is aware of his control capabilities.

10.6.1.4 The SAS shall have provision of Device Tagging for all the substation devices. This function is to block the control of any substation device in such a manner that its command is prevented from Operator's Workstations for purpose of maintenance. The devices under maintenance shall be provided with tags which shall include provision for entering text (256 Characters).


10.6.1.5 Interlocking shall be implemented and shall ensure that no illegal switch operation can be performed by any control initiated from Control Level 3, Control Level 2 or Control Level 1. Interlocking shall be implemented on bay level as specified in relevant section of this specification.

### **10.6.2 Sequence of Events and Alarm Management**

10.6.2.1 The SAS shall be capable of reporting on all Operator Workstation and printers, the time sequenced record of events occurring in the substation. Separate logs shall be created for alarms and events and both the logs shall be time-tagged. Suitable filters, based on date and time, bay/feeder number, device number, function etc. shall be provided for both alarm as well as event logs for ease of viewing.

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- 10.6.2.2 The SAS shall record in non-volatile memory all changes of alarms and plant statuses of switchyard and HT Switchgear equipment, including the alarms generated by Bay Control and Bay Protection units. It shall be possible to print historic events and real-time (unacknowledged and non-cleared) alarms after a system failure or reset with no loss of information.
- 10.6.2.3 All the alarms and events shall be time tagged at the Bay Controller or Bay Protection unit with a time resolution of 1 ms.
- 10.6.2.4 The SAS shall include all the alarms and changes of plant statuses of the HV AND EHV networks.
- 10.6.2.5 The SAS shall acquire the alarm signals from IEDs of bays and feeders with pre-set priorities and on receipt of an alarm shall generate an audible signal and report it either upon request or automatically to the respective printer.
- 10.6.2.6 The Owner shall approve the list of alarms and plant statuses to be wired for Sequence of Events log and Alarm Management, during detailed engineering stage. During detailed engineering, the list of alarms and plant statuses shall be submitted for review of owner, but final responsibility will lie with Contractor only. As per the approved SAS architecture and scheme for HT switchgear and Control and relay panels documents, list of signals for alarms and events is to be prepared.
- 10.6.3 Historical Data Management and Trending
  - 10.6.3.1 The SAS shall maintain historical data in bulk non-volatile memory. The historical data shall be available for review and editing by authorized user.
  - 10.6.3.2 The SAS shall monitor specified incoming information for historical data base, perform calculations on some of the incoming data and store incoming and calculated data in the non-volatile memory as historical data.
  - 10.6.3.3 The historical data shall include Digital Fault Records and Sequence of Event logs received from IEDs.
  - 10.6.3.4 It shall be possible to trend any measurement signal or summation of signals available in real time or data available in the historical database, in the shape of trend curves.
- 10.6.4 Operations Log

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It shall be possible to create a daily operations log, in a user-defined format, about the substation operations as well as any failures / tripping therein. It shall also be possible to include on daily basis all the information required to keep a historical record of equipment behavior.

#### 10.6.5 Reports

The SAS should be capable of generating different types of reports, which can be presented in the operator interface screens upon request or programmed for automatic presentation in printers. It shall be possible to generate reports with information from both historical database and real time information.

#### 10.6.6 Mass Storage Back up

Industry standard DVD writer shall be provided to permit mass storage of all information existing in the computer hard disks such as application programs, database configuration, historical data, operations log etc.

#### 10.6.7 System Security


10.6.7.1 Security features shall be provided at each level for safeguarding against unauthorized access. An alarm message will be displayed at the Control Centre and recorded in the logs for any unauthorized access attempts. The contractor shall provide software locks and passwords to the Owner's engineers at site for all operating and application software at all levels.

10.6.7.2 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.

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

10.6.7.4 To ensure system security, the complete functionality of SAS shall be divided into various system security levels, to be decided by Owner during detailed engineering. Each security level shall offer certain functionality of the SAS to users e.g.



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Security Level 0 - Display only of Graphics, Real Time data and Historical Data

Security Level 1 - Normal Control Operations, Access to acknowledge alarm logs

Security Level 2 - Restricted Control Operations; access to edit / defeat bay interlocks

Security Level 3 - Complete access, engineering and maintenance of Configurations and databases.

10.6.7.5 The users shall be grouped into various user-groups with each user having a user name and password. The level of accessibility to each user group shall be pre-defined.


10.6.7.6 The system administrator group shall have complete access to SAS and shall be able to add / remove users and redefine access rights. vii. The various system security levels and various user groups shall be defined by the Owner during detailed engineering.

10.6.7.7 The Operating system of the Servers, HMIs and Gateways shall be hardened in line with the following suggested guidelines to reduce its vulnerability to cyber-attacks.

10.6.7.8 Secure Build Strategy

- i) Packages unnecessary for system operation are not to be installed during the initial build of the servers and workstations, reducing the amount of post-build hardening required. Any package that must be installed but is not required to be actively running has to be disabled.
- ii) The software to be removed and/or disabled includes, but is not limited to:
  - a) Messaging services
  - b) Servers or clients for unused Internet services
  - c) Software compilers (except where required, i.e. development platform)
  - d) Unused networking and communication protocols
  - e) Unused operating system features
  - f) free utilities delivered with OS

10.6.7.9 Generic and Default Accounts

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Disable or remove all unnecessary generic and default user accounts from the operating system and third party applications. Application accounts (such as daemon) that exist strictly for identification and ownership are disabled from interactive, network, or other access to prevent unauthorized access. Required accounts and their functions have to be documented.

#### 10.6.7.10 Insecure Protocol

Insecure protocols which are vulnerable to cyber threat, such as telnet, FTP, RSH, and RCP have to be disabled from operation.

#### 10.6.7.11 Malicious Software Prevention

Implementation of malicious software prevention tools to detect, prevent, deter, and mitigate the introduction, exposure, and propagation of malware. Supplier shall verify that commercially available anti-malware products do not cause harm to the product and the anti-malware software should not hinder during installation/ commissioning or normal operation of SAS. Provide procedures on how to update the signature database of the anti-malware software, if provided.

#### 10.6.7.12 System Whitelisting


System whitelisting is to be done i.e. the software takes an inventory of the host in a known good state, and any applications not present at that time such as viruses, malware, games, portable applications, etc.) are prevented from executing in later stages. Thus, by creating “application whitelist”, malicious softwares are prevented from getting executed.

#### 10.6.7.13 Ports and Services

The system shall be configured by the supplier to only use those ports and services required for normal and emergency operations. The ports and services required for operation are documented and supplied to the customer as part of the deliverable system documentation.

#### 10.6.7.14 Host-based Firewalls

- i) The host-based firewalls shall be configured with a standardized set of rules as an additional layer of security if the network firewall to fail. The host-based firewalls are configured with a default deny rule that logs any traffic not explicitly allowed.
- ii) In the case where a service cannot be disabled but does not require communication with hosts external to itself, this host-based firewall also serves to prevent any communication to the port(s) used by that service.

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#### 10.6.7.15 Removable Media

Removable media (CD and DVD, USB Drives, etc.) is not required for the operation of the SAS and may be inhibited from operation except in case of data back up on CD/DVD as per specification.

#### 10.6.8 Remote Interface with RLDC/SLDC

10.6.8.1 The SAS shall have provision for interfacing with remote RLDC/SLDC through suitable redundant gateways with adequate number of ports along with modems at Substation Level. The modems shall be suitable for use with PLCC/ OPGW Communication, being provided for HV AND EHV lines and to be used for data communication between switchyard and RLDC/SLDC using communication protocol IEC 60870-5-101 or IEC 60870-5-104.


10.6.8.2 Each port shall allow for remote telemetry and control of the HV AND EHV networks in the substation using IEC 60870-5-101/104. The interface ports for communication with RLDC/SLDC shall use V.24/V.28 communication standard (CCITT Std.) for interfacing with modems. The interoperability requirements for above shall be furnished during detailed engineering. One (1) number of suitable modems shall also be supplied as loose item for each of the above serial ports for the remote end.

10.6.8.3 Only selected information such as bus voltage, frequency, active / reactive power through various feeders, status of OLTC, open / close status of circuit breakers, isolators etc is required to be shared with SLDC/RLDC. However, actual list of information to be shared shall be finalized during detailed engineering as per updated RLDC/SLDC requirement.

10.6.8.4 Necessary hardware/software (both end) to ensure Remote Interface for data telemetry with SLDC/RLDC shall also be provided by the contractor. All required communication with SLDC/RLDC shall be in the scope of the contractor.

10.6.8.5 Provision for interfacing with owners PI (Plant Information) system on OPC and the OPC Server requirements are as follows:

- i) The OPC Server is envisaged for connectivity with owner's PI Server like AVEVA PI System or other similar platforms.
- ii) OPC Data Access Server with latest OPC version shall be supplied. All data should be accessible through this OPC server. The details of Owner PI server shall be furnished during the detailed engineering.
- iii) Timestamp when the measurement was made is to be used in the OPC Server. OPC Server should not use the time of the server as timestamp of the measured signal.

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- iv) Vendor to indicate the latency between measurement and availability in OPC server.
- v) All switchyard data like MW, MVAR, CB status, Metering Master Station Data etc shall be communicated through this OPC Server. The number of tags to be licensed for the OPC Server as well as the maximum number of tags the OPC server can support shall be approved during detailed engineering.
- vi) Vendor should inform the method of testing the OPC Compliance. Vendor should demonstrate that data is accessible from the OPC server using a standard 3rd party OPC client such as PI-OPC client like AVEVA PI System or other similar platforms.

10.6.9 Remote Interface with Owner's Remote-Control Center:

10.6.10 The SAS shall have provision for interfacing with Owner's remote control centre through suitable redundant gateways with adequate number of ports to be used for data communication between Switchyard Control Centre and Remote Control Centre using communication protocol IEC 60870-5-104.

10.6.11 Technical Requirements for Standalone Network Firewall


SN	Feature	Required parameter
a)	Form Factor	The firewall should be a 19" Rack with redundant power supply.
b)	High Availability	The system is to be offered in High availability (1+1) configuration
<b>A.</b>	Hardware Specifications & Performance Parameters	
a)	Device Throughput	3 (Three) Gbps or higher firewall throughput.
b)	Interfaces	<ul style="list-style-type: none"> <li>At least 8 nos of gigabit 10/100/1000 base T Ethernet ports must be provided</li> <li>Provision for Later addition of at least 2 nos of 10G fiber ports must be present.</li> </ul>
<b>B.</b>	Fire wall inspection	
a)	Granular Access control	<ul style="list-style-type: none"> <li>Source IP/ Destination IP/ Port</li> <li>Time and date access</li> <li>Type of service/ application/ protocol</li> <li>Customizable services</li> <li>Time based</li> </ul>

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SN	Feature	Required parameter
		<ul style="list-style-type: none"> <li>Combination of one or multiple of above mentioned parameter</li> </ul>
b)	NAT & PAT	Dynamic NAT as well as one-to-one NAT Port / IP Address Forwarding


## 10.7 Substation Controllers and Operator Workstations

- 10.7.1 Redundant Controllers and Operator Workstations shall be provided and shall be based on the latest state of the art workstations and servers and technology suitable for industrial applications and switchyard environments.
- 10.7.2 The main memory shall be sized sufficient to meet the functional and parametric requirements as specified. The bulk memory shall be sized at least 1.5 times the capacity required sufficient to meet the functional and parametric requirements. However, both the main and the bulk memory shall be subject to minimum hardware specification. The exact system configuration and sizing shall be approved by the Owner during detailed engineering.
- 10.7.3 Graphic Mimic display for entire switchyard shall be provided in each OWS.
- 10.7.4 All operators' functions shall be possible from any of the OWS at any point of time regardless of which controller is active. Each OWS shall be able to access all the substation information related data under all operating conditions.
- 10.7.5 Single failure in any Controller shall not lead to non-availability of any of the OWS.
- 10.7.6 The Workstation shall be based on industry standard hardware and software which will ensure easy connectivity and portability of all the software being provided for various IEDs under this contract.
- 10.7.7 Power Fail Auto Restart (PFAR) facility, with automatic time synchronization to GPS time shall be provided. The only operation required will be the login of operators.
- 10.7.8 All AC powered Workstations, Communication and/or other SAS devices shall be powered from 2X100% Inverter Supply connected to the 220V DC rated batteries, so as to have bump less changeover in case of failure of one of the UPS. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% station Battery bank for providing minimum Four hours backup and LT switchgear. Details specifications are provided elsewhere in the specification.
- 10.7.9 All DC (Station Battery) powered SAS components shall also be acceptable. Aux Supply tolerance will be +10%/-15%.

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- 10.7.10 A color wall mounted rear projection MIMIC display shall be provided in the SWITCHYARD control room on which a dynamic substation overview display screen is projected. The MIMIC shall be flat. The rear projection MIMIC display shall be on a reputed make 50 inches (diagonal) LED monitor. The MIMIC shall be suitable for continuous operation in a substation control room environment and shall be clearly visible during all hours from the operator positions at the control desk. Display of Mimic view selected from any of the OWS in the SWITCHYARD Control Room shall be possible. Details of the MIMIC shall be finalized during detail engineering stage.
- 10.7.11 Functional Requirements of the HMI Software
- 10.7.11.1 The HMI shall have an intuitive graphical design to ensure effective use of the SAS with minimal confusion. The amount of keyboard typing needed for using the SAS shall be minimized.
- 10.7.11.2 The HMI shall be strictly divided into various levels depending on the system security levels.
- 10.7.11.3 The complete Single Line Diagram of the HV AND EHV network, including the status of the plant equipment, shall be displayed on one or more graphical displays. A high-level overview display shall be provided, with the ability to zoom to more detailed displays. Different colors shall be used to differentiate voltage levels, earthed network components, selected object on screen, selected object for command, blocked / tagged equipment etc. on the graphical displays. A library of standard symbols shall be used to represent switchyard equipment on the graphical displays. The same symbols and colors used on the HV and EHV network SAS shall be used. The graphic displays shall be subject to Owner's approval.
- 10.7.11.4 The process status of the complete switchyard in terms of actual values of currents, voltages, frequency, active and reactive powers, as well as the positions of the circuit breakers, isolators and earth switches, tap positions, winding temperature etc, shall be displayed on the station single line diagram.
- 10.7.11.5 All the Substation Level Functionality described in relevant Clause of this specification shall be possible through HMI.
- 10.7.11.6 Highest degree of security shall be provided to prevent unwanted operation of any equipment through SAS. 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 brought out in appropriate project-specific documentation of SAS, which shall be approved by Owner. Once a device is "Selected" for operation, the operator shall be able to



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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. 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, implemented at the Bay Level, shall be checked before releasing the “execute” command. The operator shall receive suitable feedback about the successful or unsuccessful execution of the command. 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. 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.

10.7.11.7 The following functionality shall be available at the Engineer and Fault Recording Workstation.

- i) Formulation and Implementation of interlocking logic for various bay equipment into Bay Control Units.
- ii) Downloading or altering the protection relay settings in the Bay Protection Units.
- iii) Automatically upload, archive, review and analyze graphically the Digital Fault Data available from the BCU and Bay Protection Units.
- iv) Ability to export fault records in COMTRADE format.

10.7.11.8 All workstations shall work on the same Operating system, preferably Windows (latest version). Latest anti-virus software shall be supplied on all workstations.


## **10.8 Communication Network Bus**

### **10.8.1 General**


10.8.1.1 The Data communication network shall be made on fault tolerant ring, excluding the links between individual bay IEDs to switch wherein redundant connections are not required, such that failure of one set of fibre shall not affect the normal operation of the SAS

10.8.1.2 The contractor shall submit details regarding the communication system like communication protocol, bus utilization calculations etc. during detailed engineering.

10.8.1.3 Built-in diagnostics shall be provided for easy fault detection and to alarm any single bus failures. The design and installation of the main communication bus shall take care of the environmental conditions and hazardous area classification as applicable to similar services.

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- 10.8.1.4 The system architecture shall allow a number of application protocols to co exist on the application layer of the LAN stack.
- 10.8.2 Substation Network Bus
- 10.8.2.1 The substation network LAN shall be an Ethernet LAN based on IEEE802.3 Ethernet standard using the IP protocol. It shall allow inter-operability with LANs from other vendors or with IEDs (Intelligent Electronic Devices) from other vendors in future, supporting IEC 61850.
- 10.8.2.2 fibre optic cables shall be employed for all Ethernet data communication bus. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure. The communication shall be made in 1+1 mode, excluding the links between individual bay IEDs to switch, such that failure of one set of fibre shall not affect the normal operation of the SAS. Each fibre optic cable shall have at least four (4) spare fibres.
- 10.8.2.3 Fibre optic cables shall be used wherever the Ethernet connection is in excess of 50m, or where the connection extends between rooms/ buildings. The Contractor shall ensure that structured cabling philosophy and good engineering practices as per internationally accepted standards are followed, for ease of maintenance and traceability, and that fibre-optic cables are adequately protected. Armored Fibre Optic cables shall be used in all cable routes containing other armored electrical cables. The armoured fibre optic cables shall be run in G.I. conduit wherever laid underground or without trays.
- 10.8.2.4 The LAN shall have a data communication speed of minimum 1 GBPS. It shall be sufficient to meet the responses of the system in terms of displays, monitoring and control commands according to the design.
- 10.8.2.5 Suitable hardware and software interface shall be provided to link solar plant SCADA bus.
- 10.8.3 Inter bay Network Bus
- 10.8.3.1 An Inter Bay Communication bus shall be provided for the HV and EHV network, which shall support peer-to-peer communication, and communication to the Substation Controller.
- 10.8.3.2 The communication protocol used for all devices including Bay Control Units and Bay Protection Units shall be the IEC61850 protocol. No hardwiring of alarms shall be permitted between Bay Protection Units and Bay Control Units. As a minimum, all Bay Controller Units and primary relays i.e., Distance, Differential,

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Bus-Bar protection and multi-functional Over current and Earth fault protection relays, etc. offered shall support the IEC61850 protocol.

- 10.8.3.3 Fibre optic cables shall be used for Inter Bay/Station Level Communication Bus. Contractor shall ensure that structured cabling philosophy and good engineering practices as per internationally accepted standards are followed, for ease of maintenance and traceability. Electrical data connections may only be used within a cubicle of the same bay.

## **10.9 Bay Level Functionality**

- 10.9.1 All the Bay Level Functionality shall be built into Bay Control Units (BCUs) and Bay Protection Units (BPU).

- 10.9.2 BCUs and Bay Protection Units shall be provided at Control Level 1 i.e. Bay Level of Logical Architecture, to facilitate control, monitoring and protection of switchyard equipment. One Bay Control Unit shall provide complete functionality for one HV and EHV bay. Each set of BCUs shall have sufficient analog and digital inputs to acquire the status of each and every circuit breaker, isolator, earth switch, Transformer gas parameters / tap position etc. of all the bays in Contractor's scope.


- 10.9.3 For AIS minimum of 64 Digital Inputs and 24 Digital Outputs per bay shall be provided in associated Bay Control Units. The BCUs shall have adequate capacity for the estimated hardwired inputs and outputs plus at least five spare binary inputs and three spare binary outputs. A minimum number of 12 Analogue input channels per bay shall also be provided in the associated BCU. Rating of the various analogue input channels (110 V / 1 A / 4-20 mA) shall be decided during detail engineering.

- 10.9.4 All BCUs and Bay Protection Units shall be provided with self-diagnosis and supervision functions to ensure maximum availability. BCUs shall require no periodic routine maintenance and testing. An alarm contact shall be provided for hardware failures, failures of internal and external auxiliary supplies etc. Special algorithms shall be provided to check the microprocessor's memories. A watchdog function shall supervise the execution of program by the microprocessor.

- 10.9.5 Space for mounting Controlled Switching Device (if required) of circuit breaker shall be provided in respective BCU Panel.

- 10.9.6 The layout of equipment/panel in air-conditioning (AC) SWITCHYARD control Room shall be subject to Owner's approval.


- 10.9.7 Bay Control Units (BCU)

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#### 10.9.7.1 Control and Protection Features of BCUs

The Bay Control Units shall have the following built-in functions:

- i) Mimic control panel to display graphically the bay configuration, status of the plant, analogue measurands, alarms, and offer bay level control.
- ii) Switching of Switchyard Bay Equipment depending on conditions such as interlocking, synch-check, control mode, or external status condition. Adequate safety features like prevention of double operation, command supervision, block/de-block, over-riding the interlocking etc. shall be provided. All such security features shall be finalized and approved by Owner during detailed engineering.
- iii) Status Supervision of switchyard equipment
- iv) Interlocking Function to prevent unsafe operation of switchyard equipment such as circuit breakers, isolators, earth switches etc. Interlocking shall be implemented on bay level, by user-friendly, menu-driven configuration software within the BCU, Interlocking shall operate independent from the Substation Controller. Signalling of statuses between bays shall be performed by inter bay communication (peer-to-peer) i.e. Goose messaging. The auxiliary contacts of each of the equipment shall be wired to the BCU for this purpose. However, for that equipment, which are required for interlock of other bay equipment, two sets of their contacts shall be wired to BCUs of two different bays. Such interlocks involving more than one bay equipment shall be realized through goose messaging. An over-riding / bypass function for bay-level interlocking shall be provided at appropriate security level for maintenance or during emergency conditions. Failure of any one BCU shall not affect the interlocking at any other bay, only the bay with failed BCU shall not be able to operate. This shall be achieved by providing a backup mechanism in case of failure of one BCU which affects the interlocking in another BCU (e.g. a backup mechanism for monitoring the status of the bus bar earths), to allow the remainder BCUs to function with full interlocking. The interlocking logic shall be defined during the detailed engineering phase to prevent illegal operation.
- v) Analogue Measurements for bay voltage (per phase), current (per phase), frequency, MW and MVAR, tap position / gas parameters / winding temperature of Transformers. These measurements shall not require the use of any intermediate transducers. The accuracy of measurement shall be 0.5% for voltage, current and frequency, and 1.0% for MW and MVAR. The measured and computed values shall be displayed locally on BCU and on operator's workstation located in central control room.


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- vi) Event and Alarm Handling: BCUs shall acquire all the bay level alarms and events from field inputs with a resolution and time tagging of 1 milli sec and shall transfer these to operator's workstation over substation LAN.
- vii) Synchronization Check Feature: Synchronization Check feature shall determine the difference between the amplitudes, phase angles and frequencies of two voltage vectors. Checks shall be provided to detect a deadline or bus bar. The voltage difference and phase angle difference settings shall be adjustable.

#### 10.9.8 Bay Protection Units

##### 10.9.8.1 General

- i) All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.
- ii) All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Protective relays shall also fulfil the requirements specified for Protection IEDs somewhere else in the specifications.
- iii) Trip commands from Bay Protection Units shall be hard-wired directly to appropriate switchyard equipment. Also, critical interlocking data between Bay Protection Units and Bay Control Units, including the substation level interlocks such as bus bar protection trip etc shall also be hard-wired to ensure complete bay level functionality even in case of failure of substation LAN. The interlocking information to be hard-wired between Bay Protection Units and Bay Control Units shall be decided by Owner during detailed engineering stage.
- iv) The interface of Bay Protection Unit for HV and EHV lines with PLCC/communication panels shall be in contractor's scope.
- v) Relay parameterization for SWYD relays shall be possible from the respective EWS.
- vi) Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the owner.
- vii) Necessary software and hardware to up/download the data to/from the relay from/to the personal computer shall be provided by the contractor.
- viii) In case of line protection and transformer protection, the features like fault recorder and event logging function in these relays shall be supplied and activated at no extra cost to the owner. Also, necessary software/ hardware


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for automatic uploading to station HMI/DR workstation (as applicable) shall be supplied.

#### 10.9.8.2 General Requirements of Numerical Relays and Auxiliary Relays

- i) All numerical relays, auxiliary relays and devices comprising the Bay Protection Units shall be of types, proven for the application, satisfying the requirements specified elsewhere and shall be subject to the Owner's approval.
- ii) The necessary auxiliary relays, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. No relay, which shall trip the circuit breaker when the relay is de-energized, shall be employed in the circuits.
- iii) Relays shall be provided with self-reset contacts except for the trip lockout, which shall have contacts with a manual reset feature. Manual resetting shall be possible from Control Level 2 as well as Control Level 1 with suitable authorization.
- iv) Transients present in CT & VT connections due to extraneous sources in the HV AND EHV system shall not cause damage to the numerical and other relays. CT saturation/ transients shall not cause mal operation of numerical relays.
- v) Only DC/DC converters shall be provided in the solid-state devices / numerical relays wherever necessary to provide a stable auxiliary supply for relay operation. Except for event logging, alarm and annunciation type of non-trip functions, protective relay contact multiplication shall be done through high speed trip relay only.
- vi) DC batteries inside protective relays necessary for relay operation shall not be acceptable. Equipment shall be protected against voltage spikes in the auxiliary DC supply.
- vii) Each numerical relay shall have a serial interface on the front for local communication to a Personal Computer and Printer. Additionally, facilities shall be provided to access each discrete protection function including modification in relay settings and monitoring of the relay from a HMI or a separate Protection / Disturbance Recorder Station provided and permanently wired to all the numerical relays comprising various Bay Protection Units. For numerical relays of switchyard, the HMI shall be located in SWYD control room at the Substation Level. Dedicated engineering /DR workstation has to be provided in switchyard control room. A printout of all settings, scheme logic, event records etc. shall be accessible through the HMI. The display of various measured parameters during normal as well as fault conditions on a segregated phase basis shall be provided. LEDs and a backlit LCD screen shall be provided for visual indication




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and display of messages related to major trips / alarms. Necessary multilevel password protection shall be provided.

- viii) The Bay Protection Units shall be arranged to provide two independent, high performance and reliable systems housed in different panels with separate DC supplies, separate CT/VT cores, separate cables and trip relays to obtain 100% redundancy. Associated trip relays of the two systems shall be separate, having a sufficient number of contacts for all the functions along with at least 10% spare contacts.
- ix) The numerical relays shall be provided with built-in disturbance recording functionality. The data from DR function shall be available in IEEE/COMTRADE format and shall be compatible with the dynamic relay test system being supplied under this contract.
- x) The manufacturer of the numerical protection system offered shall carry out the complete engineering, testing and commissioning on site of the offered protection equipment including the associated relays and protection panels. The testing and commissioning protocols for the numerical protection systems offered shall be approved by the Owner before commissioning on site.
- xi) Pick up range of the Binary inputs shall be as per IEC 60255-1
- xii) All the numerical relays shall have adequate processor capability to carry out programmable scheme logics (PSL) required for implementing approved protection and control schemes over and above its inbuilt protection functions algorithm.
- xiii) All numerical relays shall be supplied with all the protection function/features in disabled condition. Relevant features/protection function shall be enabled at the time of commissioning at site as per approved logic and relay settings.
- xiv) BPU offered shall have adequate I/Os for function realization. Use of auxiliary relays (contact multiplication) shall be permitted only when the entire product range does not support any further hardware augmentation for additional I/Os.
- xv) Configuration/ scheme logics /relay settings shall be submitted by the Contractor for approval during detailed engineering.

#### 10.9.8.3 Protection for HV AND EHV System

- i) The total critical fault clearing time, including the circuit breaker operating time, from fault initiation in any part of the system under all conditions shall not be more than 80 ms for faults within zone-I reach (i.e. up to 80% of line

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length) and 100 ms (as per the latest revision of CEA Grid standards regulation) for end zone faults including carrier transmission time of 20ms.

- ii) The SIR values to be considered for the operating time of relays for the SWYD feeders shall be between 4 and 15. The rated break time for the HV AND EHV circuit-breaker, as offered, shall be considered for the purpose of circuit breaker operating time. The Contractor shall furnish the operating time curves at various SIR values for all types of faults.

#### **10.10 Line Protection**

10.10.1 The line protection relays are required to protect the line and clear the faults online within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 220KV/230kV transmission lines and Main and back up protection for 66 kV transmission lines.

10.10.2 The maximum fault current could be as high as 50kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.


10.10.3 Each 220kV/230kV Line shall be provided with the following protection:

- i) Main-I : Numerical Line Differential Protection with built-in distance protection function suitable for carrier aided protection
- ii) Main-II: Numerical Line Differential Protection with built-in distance protection function suitable for carrier aided protection and with a hardware platform different from that of the Main-I Protection
- iii) The Main-I and Main-II protection shall be of equal performance capability.

10.10.4 The Main-I and Main-II relays shall be connected to two different protection groups (Main-I to Group-A and Main-II to Group-B) to meet the requirements of relevant clauses.

10.10.5 Other Protections to be implemented for all lines are mentioned below


- i) Local Over voltage Function: The over voltage function shall have adjustable voltage and time settings. It shall monitor all phases and be tuned to the power system frequency. The over voltage function shall have at least two independent voltage and time stages. It is also acceptable for the local over voltage function to be a built-in feature of the Main-I and Main-II protection relays.

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- ii) Back-up IDMT Earth fault Function: A back-up IDMT Directional earth fault protection function shall be provided in each Main protection system. The function shall measure zero sequence current and have a current/timer setting range.
- iii) Open Jumper Protection: The open jumper protection function shall operate upon detecting negative sequence current and shall provide an alarm. The open jumper protection function, as a built-in feature of the Main-I and Main-II protection is also acceptable. The protective relays shall be suitable for use with capacitor voltage transformers (CVTs) having non-electronic damping and transient response as per IEC.
- iv) Back-up over-current Protection: Distance protection gets disabled, in case of its connected VT fuse, failure. Consequent to this, a back-up over-current function shall get activated in the respective line differential cum distance relay.

#### 10.10.6 Numerical Distance Protection Scheme

- i) The numerical distance relays shall be the latest version meeting the in-service criteria specified elsewhere.
- ii) The distance protection schemes shall be such as to facilitate compatibility with the protection at the remote ends of the HV AND EHV transmission lines.
- iii) The reaches of relay for zones 1, 2 & 3 should be able to cover line lengths associated with this contract.
- iv) The distance protection shall be of the non-switched type with separate measurements for all phase-to-phase and phase-to-ground fault types.
- v) The protection shall have two, independent, continuously variable, time settings each with a range of 0 to 5 s for zone-2 and zone-3.
- vi) The characteristics shall have adjustable characteristic angle setting ranges of 45 to 85.
- vii) Tripping characteristics shall be polygonal and / or mho circle with adjustable offset and with independently adjustable reactive and resistive reaches (for polygonal characteristics) separately settable for each zone. The type of tripping characteristics shall be user selectable.
- viii) The protection shall operate correctly for close-up three-phase faults and other adverse conditions. It shall operate instantaneously when the circuit-breaker is closed onto a zero-volt 3-phase fault. ix. The protection shall provide Phase segregated tripping i.e., single phase as well as three-phase tripping.

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- ix) The protection shall have a maximum resetting time of 60 milliseconds. xi. Zone 3 shall have a reverse offset capability adjustable to 10 to 20% of zone 3 setting, or alternatively, an independent reverse zone 4 shall be provided.
- x) The earth fault measurements shall have zero sequence compensation variables from 0.5 to 5 (scalar Z0/Z1).
- xi) The setting / reach should not be affected by mutual coupling effects.
- xii) It shall have a continuous current rating of 2 times rated current. The relay shall also be capable of carrying a high short time current of 100 times the rated current without damage for a period of 1.0 s. The voltage circuit shall be capable of continuously withstanding 1.2 times the rated voltage and 1.7 times for 3 s.
- xiii) The protection shall include Power Swing Blocking protection. The power swing blocking feature shall:
  - a) be of three pole type
  - b) Block/unblock tripping during power swing conditions, separately for each zone.
  - c) Have a continuously adjustable time delay on pick up of 0 to 5s.
  - d) Be in service during the dead time of a single pole Reclosing cycle.
  - e) Have user configurable unblocking criteria in the case of fault detection during a power swing.
- xiv) Shall include Fuse Failure Protection, which shall
  - a) Monitor all the three fuses of the CVT and associated cabling against open circuit
  - b) Inhibit trip circuits on operation and initiate annunciation
  - c) Have an operating time of less than 7.0 ms
  - d) Remain inoperative for system earth faults
- xv) It shall have user configurable scheme logic such as permissive under reach (PUTT), Permissive over-reach (POTT), Direct Transfer Trip, blocking scheme etc. using communication channels. The scheme shall be complete so that the user can select any option on site without any modification. Non carrier aided schemes such as Zone-1 extension, Loss of Load etc. shall be provided to ensure high-speed clearance during channel failure.
- xvi) The protection shall be able to distinguish between short circuit and heavy load conditions.

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- xvii) It shall have supplementary over current and earth fault protection functions.
- xviii) The deadline charging feature shall have adjustable minimum and maximum voltages.
- xix) The protection shall have a multiple settings group feature. It shall be possible to switch between the various available setting groups when the relay is in service without compromising the protection during the switch-over.
- xx) The protection shall include the following additional functions:
  - a) Weak-in feed tripping
  - b) Echo function
  - c) Current reversal guard
  - d) Switch onto fault logic
  - e) It shall be suitable for series compensated lines.

#### 10.10.7 Digital Fault Recording


10.10.7.1 A Digital Fault Recorder shall be provided for each HV AND EHV line. The Digital Fault Recorder shall meet the following requirements:

10.10.7.2 Shall be used to record the graphic form of the instantaneous values of analog inputs such as voltages and currents in all the three phases, open delta voltage and neutral current in the primary circuits in the case of a short circuit (fault) and a disturbance in the Power System, as per the required technical parameters.

10.10.7.3 Shall be provided with a self-monitoring facility.


10.10.7.4 Fault / disturbance logs shall be clearly identified by Fault ID, Fault date and time (hour, minutes, seconds and ms). Time stampings on fault records shall be synchronized with a GPS clock.

10.10.7.5 The disturbance recorder shall comprise distributed individual acquisition units, one for each feeder and an evaluation unit which is common for the entire substation. The acquisition units shall acquire the disturbance data for the pre-fault, fault and post-fault periods and transfer them to the evaluation unit automatically for storage on a mass storage device. The acquisition unit shall be suitable for inputs from current transformers with 1 A rated secondary and capacitive voltage transformers with 63.5 V (phase to-neutral voltage) rated secondary.

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- 10.10.7.6 Shall have Scan rate of 1000 Hz or better for sampling each of the analog channels having a fundamental frequency of 50 HZ. The frequency response for these channels shall be DC on the lower side to 500 HZ or better on the upper side. Any interposing devices provided with the DFR system shall not compromise this frequency response.
- 10.10.7.7 Shall be provided with sensors based on threshold values of voltage, current and frequency and rate of change of system frequency. External signals if required can also be used for triggering the DR. The starting sensors of the DFR, and pick-up, shall preserve the disturbance/fault data on the non-volatile solid-state memory of the acquisition unit. The setting of the starting sensors shall be flexible and shall have reasonable range/steps. The settings of the starting sensors shall be field programmable.
- 10.10.7.8 The fault data from the Digital Fault Recording feature shall be available in IEEE / COMTRADE format. The data format shall be compatible for dynamic protection relay testing with the relay test kit to be supplied by the Contractor. The necessary equipment for interfacing and transfer of data shall also be supplied by the Contractor.
- 10.10.7.9 All the fault records shall be transferred to the Protection / DR Station at the Substation Level automatically or on request for further detailed analysis. The software for analyzing the fault data shall be available at the Substation Level. The software shall be capable of the complete analysis of fault data, including the display of RMS/Peak envelop of any voltage / current, fundamental power frequency deviation, display of instantaneous values of Real Power (computed value), Reactive Power (computed value), power factor angle etc. A facility to edit the fault data shall also be provided.
- 10.10.7.10 Following analog values shall be recorded
- Currents (R-phase, Y-phase, B-phase and Neutral),
  - Voltages (VRY, VYB, VRB, Open Delta)
  - The pre-fault recording time shall be at least 200 ms and the post-fault recording time shall be at least 5.0secs.
  - 8 Analogue channels (IR, IY, IB, IN, VRY, VYB, VBR AND OPEN DELTA)
  - 16 Nos. Digital Channel Amplitude Résolution of Analogue Channel (minimum): 16 bit
  - Event Resolution of Digital Channel (minimum): 1 milli sec
  - Aux. voltage: 220VDC (+10%,-15%)



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10.10.7.11 DFR system offered shall also have a built-in Distance-to-Fault Locator Function. This function shall be an on-line function and shall be suitable for circuit-breaker operating times of 2 cycles. The computed distance-to-fault shall be available as a percentage of line length or kilometers without requiring any further calculations. It shall have a provision for mutual zero sequence compensation. It shall have an accuracy of 3% or better for all types of faults and fault levels. This accuracy shall not be impaired under following conditions:


- a) Presence of remote end in-feed
- b) Predominant DC component in fault current
- c) High fault arc resistance
- d) Severe CVT transients
- e) Mutual zero sequence coupling between adjacent lines

Digital Fault Recorder, having specified technical Parameters, as a built in feature in Main Numerical Distance Relay is also acceptable.


#### 10.10.8 Numerical Line Differential Protection scheme

10.10.8.1 The line current differential relay with built-in distance protection function shall be capable of being selected to differential function with back up distance function or shall activate back up distance automatically when the differential relay is out of service or manually through settings. Apart from fulfilment of the requirement specified somewhere in technical specification for distance relay function, the line current differential function shall also conform to the following main requirements:

- i) The current differential shall be a unit system of protection.
- ii) The line Current differential Protection shall comprise a well-proven high-speed phase segregated numerical current differential protection scheme, which shall be designed for the selective protection of the EHV network.
- iii) The High speed numerical current differential protection shall be suitable to work through directly connected fiber optics and the relay shall have the requisite teleprotection communication capability.
- iv) Shall have built-in redundant signalling modules for communication with the remote end relay via direct optical fiber cables.
- v) The contractor shall coordinate the requirements of the current differential relay with the communication system in order to ensure compatibility between the two.

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- vi) The relay shall incorporate inter-tripping, VT Supervision functions and heavy duty contacts for tripping of the feeder circuit breaker as well as provide all flagging, alarms etc.
- vii) Shall have high-speed fault detection capability with typical relay operation time of less than 30 ms for 220kV/230kV line faults.
- viii) Shall have high sensitivity for all types of faults.
- ix) Shall detect and clear faults along the whole length of the feeder within the specified operating time when the remote end breaker is open or there is a weak in feed.
- x) Shall remain stable for fault on a parallel feeder under subsequent current reversal in the healthy feeder due to slow opening of one of the faulty feeder's circuit breakers.
- xi) Shall not be affected by heavy load transfer, power swings, CT saturation, distorted primary currents and voltages, VT fuse failure, line charging currents external switching, arc or tower footing resistance, sudden power reversal, zero sequence mutual coupling, fault resistance and out of phase source at the two line terminals producing misleading apparent fault reactance, power frequency variations, collapse of voltage on the faulted phase(s), etc.
- xii) Shall have features to clear close in faults at high speed in the event of failure of signalling channel.
- xiii) Shall have features to test at one end all the functions associated with the protection, without the presence of personnel at the remote end.
- xiv) Shall have features to block relay in case of signalling channel failure or remote relay out of service / block or setting mismatch or dc failure etc., to avoid inadvertent tripping and shall produce alarm during blocking.
- xv) Shall have inter-tripping compliant with IEC60834-1 and IEC60834-2 respectively for signalling as appropriate. xvi. The line differential device address shall be settable and shall be suitable to set for no. of feeders shown in SLD.
- xvi) CT supervision / VT Supervision shall be configured to initiate alarm locally and to SAS or event recorder as per requirement.
- xvii) Shall have single pole and three pole tripping feature.
- xviii) Shall have built-in SOTF logic feature.


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- xix) Shall have features to block auto-reclose internally or externally at local end and facility to send blocking signals to remote end relay internally (through FO communication channels) during SOTF trips.
- xx) Shall have facility to configure signal transferred between local and remote end relays in the internal event recorder and disturbance recorder.
- xxi) Shall have configurable time delayed thermal protection element and back up earth fault protection element.
- xxii) Shall have features for satisfactory Performance of relay under CT saturation during through faults, under conditions of CT saturation for in zone fault, during transient (jitter) and permanent changes in signalling propagation delays.
- xxiii) Shall include necessary Optical fibre cable, associated accessories to meet the operational requirement of line differential relays at both ends.


#### **10.11 Auto-Reclose and Synchronizing Check**

10.11.1 Auto-reclose (AR) and Synchronizing Check (SC) functionality shall be provided in a separate device i.e. other than line protection relay. The interfacing between BCUs and Bay Protection Units for achieving the AR function logic shall be achieved at Bay Level using communication LAN as well as standby hard-wired logic between BCU and Bay Protection Units. The intent of providing the hard-wired logic as a back-up to the software logic is to ensure that in the event of failure of Substation LAN, the bay level functionality is not hampered. The AR function shall meet the following criteria:

- a) Be of single shot type
- b) Have single-phase and/or three phase Reclosing facilities. It shall have a user-selectable option of single phase, three phase, single & three phase Reclosing or non-auto reclosure mode.
- c) Incorporate a normal/delayed auto reclosure option with a time range of 1 to 60 s.
- d) Have a continuously variable three-phase and single-phase dead time of 0.1 to 5 s.
- e) Have a continuously variable reclaim time of 5 to 300 s.
- f) Be properly configured for the breaker-and-a-half arrangement, permitting sequential closing of breakers.
- g) Incorporate the necessary auxiliary relays and timers to provide a comprehensive reclosing and synchronizing scheme.


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- h) Have facilities for selecting check synchronizing or dead line charging features. The user shall have an option to change the required feature.
- 10.11.2 The built-in Synchronization Check feature shall determine the difference between the amplitudes, phase angles and frequencies of two voltage vectors. Checks shall be provided to detect a dead line or bus bar. The voltage difference, phase angle difference and slip frequency settings shall be adjustable.
- 10.12 Transformer Protection**
- 10.12.1 The Bay Protection Unit offered for each transformer should be such that it provides a comprehensive protection for the transformer for all types of faults and abnormal operating conditions.
- 10.12.2 The numerical relays, comprising the Bay Protection Unit, for each transformer shall be configured into two protection groups operating on two separate DC supplies, such that one protection group shall always be available to detect and operate for any type of fault in the transformer, under condition of failure of other protection group or of associated DC supply of the other protection group.
- 10.12.3 Should the protection functions specified for a transformer be available as a single discrete numerical relay, two such relays shall be supplied to meet the requirements of relevant clause above. Differential, REF and Back-up protection of any transformer shall be realized in separate numerical relays with Differential, Back-up E/F in one channel and REF, Back-up O/C in another channel.
- 10.12.4 Transformer differential protection shall:
- 10.12.4.1 be of numerical type, suitable for three phase three winding transformer and shall have continuous self-monitoring and diagnostic features. Relay suitable for three phase three winding transformer shall also be approved by owner during detail engineering if the same is satisfying the functional requirement.
- 10.12.4.2 be three-pole type, with faulty phase identification/indication. The operating time of the relay shall not be greater than 30ms at 5 times the setting.
- 10.12.4.3 be stable for magnetizing inrush currents and shall be stable under normal over-fluxing conditions. Magnetizing inrush stability shall not be achieved through the use of an intentional time delay.
- 10.12.4.4 have an internal feature in the relay to take care of the angle and ratio correction.
- 10.12.4.5 the disturbance recording feature for transformer shall record the analogue form of instantaneous values of the current in all three windings (i.e. nine analog channels) during faults and disturbances for the pre-fault and post-fault periods.

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The disturbance recorder shall have the facility to record the following external digital signals in addition to the digital signals pertaining to the differential relay itself. HV breaker (main and tie) status ,LV breaker status, Buchholtz alarm/trip, On-load tap-changer, Winding temperature/Oil temperature/Pressure relief alarm/trip of transformer, Group-A, Group-B lock-out relay trip and any other signals of transformer field protection devices.

- 10.12.4.6 Further, Transformer auxiliary protections contacts (Buchholz, PRD, SPRD, Oil Temperature, Winding Temperature, OLTC Buchholz etc. can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.
- 10.12.4.7 The necessary hardware and software for downloading the data captured by the disturbance recording function to a personal computer available in the substation shall be included in the scope.
- 10.12.4.8 be acceptable with built-in features of definite time overload protection (alarm) relay provided the technical requirements of these relays specified under the relevant clauses are met.
  - a) Restricted Earth Fault Protection shall:
  - b) be single pole type.
  - c) be of current/voltage operated high impedance type.
  - d) have a suitable non-linear resistor to limit the peak voltage
  - e) shall have setting range from 5-80%
- 10.12.5 Transformer over fluxing Protection shall
  - a) Operate on the principle of voltage to frequency ratio
  - b) Have inverse time characteristics compatible to transformer over fluxing withstand capability and also a separate high set feature.
  - c) Provide an independent alarm with continuously adjustable time delay.
  - d) Tripping time shall be governed by V/ F versus Time characteristic of the relay
  - e) Have a set of characteristics for various multiplier settings.
  - f) Have a resetting ratio of 98% or better.
- 10.12.6 Transformer Backup Over Current Protection (51) shall
  - a) Be triple pole type
  - b) Be of both definite time over current and IDMT type

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- c) Have an adjustable setting range of 20-80% or 150-600% of rated current (as applicable) and 0.3 to 3.0 sec time delay.
- d) Be provided with operation indicator

**10.12.7 Transformer Backup Earth Fault Protection (51N) shall**

- a) Be single pole type
- b) Be of both definite time over current and IDMT type
- c) have an adjustable setting range of 10-80% of rated current as applicable and 0.3 to 3.0 sec. Time delay
- d) Be provided with operation indicator

**10.12.8 Directional Back up Over Current and E/F Protection (67/67N)**

- a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s) and shall have built-in timer with suitable range.
- b) shall be of numerical type.
- c) the scheme shall include the necessary VT fuse failure relays for alarm purposes.
- d) the over current function shall:
  - have a low transient, overreach high-set instantaneous unit
  - include hand-reset indication.
- e) the earth fault function shall:
  - have a low transient, over-reach high set instantaneous unit
  - include hand reset indication
  - Include the necessary separate interposing voltage transformers or have an internal feature in the relay for open delta voltage to the relay


The ranges mentioned above are only indicative only and the final ranges shall be finalized during detailed engineering.

**10.13 HV AND EHV Circuit-breaker Protection**

**10.13.1** Each circuit breaker in the HV AND EHV switchyard shall be provided with following protection functions:

**10.13.2** Numerical Local Breaker Back up Protection Function: LBB protection function shall be provided for each circuit breaker in the HV AND EHV switchyard. The LBB protection function for each circuit-breaker shall be interfaced with the Bus




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bar protection by hard-wired signals between the Bay Protection Unit and the Bus bar protection panels. The intent of providing the hard-wired logic as a backup to the software logic is to ensure that in the event of failure of Substation LAN, the bay level functionality is not hampered. The LBB function is acceptable as built-in protection function of Distributed Bus Bar protection scheme only provided it meets all the requirements specified for the LBB function. For Tie LBB protection, standalone units are to be provided. In addition, the LBB protection function shall meet following criteria:

- i) Be three pole type having three single phase units
- ii) Shall operate for stuck breaker conditions
- iii) Have an operating/resetting time each of less than 15 ms.
- iv) The LBB function shall be initiated by external trip contacts from the Bay Protection Units and after a set time delay shall energize the trip bus in the bus bar protection scheme on which the stuck breaker is connected for tripping of all breakers connected to the particular bus. For all CBs, a repeat trip command from LBB shall be given to both trip coils of the primary breaker through self-reset high speed trip relay on reliable both DC source.
- v) Have a setting range of 5 to 80% of rated current
- vi) Have a continuous thermal withstand of 2 times rated current irrespective of the setting.
- vii) Have time delay feature with a continuously adjustable setting range of 0.1 to 1 s.
- viii) Shall be an individual phase comprehensive scheme.
- ix) Shall not operate during the single-phase auto-reclosing period.
- x) Shall provide end-fault protection that initiates a direct transfer trip to the remote end.

#### 10.13.3 Trip Coil Supervision:

A Trip Coil supervision function shall be provided for each lockout trip relay and each of the circuit-breaker trip coils. It shall incorporate both the pre-close and post-close supervision of trip coils and associated trip circuits. An audible alarm shall be given in the event of operation of trip coil supervision function. It shall have a time delay on drop off of not less than 200ms. Trip coil supervision function as a built-in feature of the BCUs / Bay Protection Units is also acceptable, provided it meets all other requirements specified here, including loss of DC supply.

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10.13.4 High Speed Trip Relays supplied under this package shall be:


- a) With operating time of less than 10ms.
- b) With reset time of less than 20ms.
- c) Provided with operation indicator for each element/coil.
- d) Have adequate contacts to meet the scheme requirements of trip, interlock, LBB, auto-reclose, DR, fault locator, etc.
- e) Hand reset or self-reset, depending on the application. Further, the trip relays shall be provided with a feature to receive manual reset command from engineering workstation located in remote.

10.13.5 Bus bar (BB) Protection

10.13.5.1 Each HV AND EHV bus bar shall be covered with a duplicated low-impedance high-speed busbar protection scheme connected to two different CT cores. Bus bar protection of each bus shall operate in a two-out-of-two mode so as to achieve better security.

10.13.5.2 Each bus bar protection scheme shall:

- i) Be numerical having modular construction and three pole type.
- ii) Main I and Main II shall be connected to different DC source such that even under the failure of either Main I or Main II relays AND/OR failure of the associated DC, the bus bar protection will operate in one out of two mode.
- iii) Have a maximum operating time for all types of faults of 20ms at five times the setting value.
- iv) Operate selectively for each bus bar.
- v) Give 100% security up to a HV AND EHV bus bar fault level as per SLD.
- vi) Incorporate continuous supervision for the CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection in-operative. The zone protection contact shall be bypassed automatically, and the affected zone shall be protected by the appropriate healthy zone only.
- vii) Not give any false operation during normal load flow in bus bars.
- viii) Shall not mal-operate for an out-of-zone fault, particularly with current transformer saturation under maximum through fault current with maximum DC offset.
- ix) Shall provide independent zones of protection and incorporate clear zone indication.


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- x) Include individual dedicated high speed tripping relays for each feeder, including future ones, as identified in single line diagram.
- xi) Be transient free in operation.
- xii) Incorporate protection "In-Out" function for each zone & the same shall be implemented by using external switch/from OWS.
- xiii) Be a biased differential type, have operate and restraint characteristics and self-monitoring facilities.
- xiv) Shall be of phase segregated type with three-pole tripping.
- xv) Shall include continuous DC supply supervision.
- xvi) shall include trip relays as well as additional Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays
- xvii) In case of distributed Bus bar Protection, the bay units for future bays shall be included.
- xviii) Shall include dedicated individual high-speed hand reset tripping relays for each bay including Future bays.


The Bus bar protection relay shall be connected to the Inter bay communication bus. Use of external CT-switching relays and CT ratio correction relays is not acceptable. The bus bar relay settings and analysis of bus bar fault data shall be possible from the Substation Level.

#### **10.14 Time Synchronization Equipment**


- 10.14.1 Two dedicated time Synchronization equipment shall be provided for SAS system. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SAS.
- 10.14.2 Shall be complete in all respects including antenna, all cables, processing equipment, etc.
- 10.14.3 All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.
- 10.14.4 Shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long-life lithium batteries.
- 10.14.5 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.

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- 10.14.6 The system shall be fully tested to the relevant international standards such as IEC: 61000-4, IEC: 60255 and IEC: 60068. One copy of all the test reports shall be enclosed with the bid.
- 10.14.7 All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric relays shall be synchronized with an accuracy of 1 mili second or better.
- 10.14.8 The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.
- 10.14.9 The system shall have provisions for combination of any of the following output signals:
- NTP (network time protocol) 100Mbps Ethernet port
  - IRIG-B00x (TTL, pulse width modulated signal)
  - 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
  - Any other output port as may be required for the offered system.
  - Alarm status contact indicating healthy status of system
- 10.14.9.1 These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. IEDs. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.
- 10.14.9.2 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, having display size of approx. 144mm height.
- 10.14.9.3 Where Time Synchronisation Equipment is out of service, time of line protection IED's shall be taken as master clock and all equipment in that station shall be synchronised to follow the master.
- 10.15 Panels**
- 10.15.1 All panels shall be free standing, floor mounting type and completely metal enclosed. Cable entries shall be from the bottom. Indoor Panels shall be of IP 5X class or better and Outdoor Panels shall be of IP 55 Class or better as per IS/IEC 60529.
- 10.15.2 Panels shall have removable gland plates with glands made of brass and shall be suitable for armored cables.

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- 10.15.3 The thickness of panel sides shall be 2mm for Cold Rolled Sheet Steel, 2.5mm for Hot Rolled Sheet Steel.
- 10.15.4 Panels shall be painted. The color of paint for exterior of the panel shall be as follows:
- a) Ends: Color-Blue, Shade-RAL5012
  - b) Front and Rear: Color-Grey, Shade-RAL9002
- 10.15.4.1 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.
- 10.15.4.2 Shall be supplied complete with interconnecting wiring between all devices mounted therein.
- 10.15.4.3 All equipment mounted on the panel (front/rear/inside) shall have individual name plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.
- 10.15.4.4 Each panel shall be provided with a 240V AC lighting fixture controlled by door switch as well as a 5A, 240V AC switch-socket unit.
- 10.15.4.5 Shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of AC & DC supplies for various circuits for control, signaling, lighting, interlocking, etc. Selection of main and sub-circuit fuse rating shall ensure selective clearance of the sub-circuit faults.
- 10.15.4.6 Voltage circuits for protection and metering shall be protected by fuses. Suitable fuse failure relays (Stand alone or Built in numerical relay) 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.
- 10.15.4.7 The DC supplies at the individual relay and protection panels shall be monitored and failure of DC supplies shall be annunciated.
- 10.15.5 Earthing
- 10.15.5.1 The panels shall be equipped with an earth bus of at least 50x6mm<sup>2</sup> galvanized steel flat bar or equivalent copper.
- 10.15.5.2 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.
- 10.15.5.3 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.

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10.15.5.4 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.

10.15.5.5 An independent Electronic Earth System shall be provided as per contractor's standard. The electronic earth shall be connected to the substation earth mat through a dedicated riser.

#### 10.15.6 Wiring

10.15.6.1 Internal wiring to be connected to external equipment shall terminate on terminal blocks.

10.15.6.2 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.

10.15.6.3 Shall have 20% terminals as spare terminals in each panel.

10.15.6.4 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.

10.15.6.5 All wiring shall be with 1100V grade, FRLS, single core, PVC insulated stranded copper conductor. 1100V grade Terminal Blocks shall be provided.

10.15.6.6 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.

10.15.6.7 Contractor shall be solely responsible for completeness and correctness of all the wiring, and for proper functioning of the connected equipment.

#### 10.16 Control Cabling Philosophy in Switchyard


10.16.1 Each secondary core of all the phase CT/CVT shall be brought to the equipment marshalling box through independent cables.

10.16.2 Each three-phase secondary core of each CT/CVT shall be brought to the associated control/relay/metering panel from the equipment marshalling box through independent cables.


10.16.3 Duplicated cores with at least 2 x 2.5 sq.mm<sup>2</sup> CU/equivalent core cross sectional area per connection shall be used for connection of all CT/CVT circuits.

10.16.4 VT leads used for tariff metering shall have an equivalent core cross-sectional area of at least 2.5 mm<sup>2</sup> CU/equivalent per phase/neutral connection.



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- 10.16.5 Cable for CT to panel shall be atleast 4 sq.mm Cu (for 1A CT Sec) and 10 sq.mm Cu (for 5A CT).
- 10.16.6 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, such as interfacing between SWYD and SWGR.
- 10.16.7 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:
- DC supply to Bay Marshalling box
  - DC supply to circuit-breaker cubicle
  - DC looping for closing and tripping circuits of circuit-breaker
- 10.16.8 All the interconnections (both AC/DC) within the switchyard and between switchyard and other systems required for the successful implementation of the control, interlocks and protection schemes under present shall be in the scope of the Contractor. Such interconnections between switchyard and other system shall include but not limited to the following:
- 10.16.8.1 CT connections 33kV switchgear / transformer MB to Control Room for transformer protections.
- 10.16.8.2 CT connections from SWYD to control room.
- 10.16.8.3 Necessary interconnections for the Inter tripping / closing interlocking between upstream and downstream systems for transformer.
- 10.16.8.4 Necessary interconnections from transformer MB to BCU for OLTC control & monitoring.
- 10.16.8.5 Any screened cable required for connecting 4-20 mA analog signals.
- 10.16.8.6 Necessary cabling between Transformer MB and SWYD Control Room for various Transformer monitoring system and fire protection system.
- 10.16.8.7 Necessary interconnections for signal exchange between SWYD / SWYD CR to interfacing panels of RLDC etc wherever applicable.
- 10.16.9 Spare cores shall be provided as per following norms:

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- a) Up to 3-core cable - Nil
- b) 5 Core Cable - Min. 1 core
- c) 7 to 14 core cables - Min. 2 cores
- d) More than 14 core - Min. 3 cores

#### **10.17 Factory Acceptance Tests (FAT)**

10.17.1 All equipment furnished under this specification shall be subject to test by authorized quality assurance personnel of the contractor and Owner's representatives during manufacture, erection and on completion. The approval of the Owner or passing such inspections or tests will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specifications when erected or fails to give complete satisfaction in service. The detailed requirement of operational and pre-FAT tests as well as FAT test (Integrated Test) is given in this Section.

10.17.2 The FAT shall be mutually agreed upon and approved by Owner during detailed engineering.


#### **10.17.3 Operational and Pre-FAT Tests**

10.17.3.1 The authorized quality assurance personnel of the contractor shall conduct all tests as per the requirements and fully satisfy themselves regarding completeness of hardware, software and full compliance with specification requirements by all equipment/sub-systems and the system as a whole before sending notification for FAT to the Owner. Contractor shall maintain accurate records for all pre-FAT tests which shall be properly documented, and duly certified documents shall be furnished to Owner at least two weeks prior to FAT tests, while giving inspection call.

10.17.3.2 Each individual item of equipment/ sub-system/ software package furnished by the Contractor as well as the complete system as per this specification shall be inspected and tested by the Contractor in his works for full compliance with specification requirements, completeness, proper assembly, proper operation, cleanliness and state of physical condition as applicable.

10.17.3.3 The Contractor shall conduct a point-by-point wiring continuity check to every input and output and verify that the wiring connections agree with the documentation.

10.17.3.4 Contractor shall conduct all tests as per requirements to fully satisfy himself regarding completeness of the system and full compliance with specification requirements for SAS as a whole as well as for individual components/ software module. This test will be done for 100% samples, even if the FAT requires tests for only some smaller percentages.

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10.17.3.5 The pre-FAT report shall be in the format of FAT procedure as approved by the Owner. It shall be accompanied by a very detailed report, in a log form, of the performance of all pre-FAT Tests. These records shall list not only the successfully completed tests, but shall detail all system, test and component failures.

#### 10.17.4 Notification for FAT


10.17.4.1 Contractor shall send notification regarding readiness for FAT and indicate the proposed date for commencement of FAT to enable the Owner to depute representatives for participating in these tests. The notification shall be sent to the Owner not less than one week prior to commencement of the FAT along with the copies of documents covering pre-FAT results.

10.17.4.2 The Contractor shall ensure that all hardware and software required for fully implementing the system as per requirements of this specification is available and the adequacy of hardware, software, system configuration, etc., is fully established during the pre-FAT Tests conducted by the Contractor. In case any deficiencies in hardware and/or software are noticed by the Contractor during the pre-FAT Tests, the Contractor shall make good all such deficiencies and re-conduct the required tests to fully satisfy him regarding completeness of the system and full compliance with specification requirements before sending notification to the Owner regarding FAT Tests.

#### 10.17.5 Factory Acceptance Tests (FAT)

10.17.5.1 Factory Acceptance Tests (FAT) shall include all tests required to fully demonstrate to Owner's satisfaction that each equipment/sub-system/system as well as software modules furnished as per this specification as well as SAS as a whole, fully meets the functional, parametric and other requirements of this specification and Owner's approved drawings/documents under all operating regimes. The testing shall be conducted with the all the SAS components fully interconnected as per the final system configuration, including BCU, BPU and other protection relays. The Owner shall witness all FAT tests. If the complete system consists of parts from various suppliers, then the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together as part of Site Acceptance Test.

10.17.5.2 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:

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- a) Pre power on checks
- b) Power on checks
- c) Hardware tests
- d) Functional tests
- e) Parametric tests
- f) Specific tests on electronic hardware
- g) Power failure auto-restart tests
- h) Testing of interlocking


10.17.5.3 The Contractor shall submit a detailed FAT procedure for Owner's approval during detailed engineering stage based on the above guidelines. The FAT procedure to be submitted by the Contractor shall be detailed and exhaustive enough such that Owner is satisfied that all the SAS System specification requirements and features are being tested and the system meets these requirements. The test results obtained shall be properly documented by the Contractor and furnished in the Owner approved format as decided during detailed engineering and submitted in the requisite number of copies with all annexes irrespective of the fact that Owner's representative was present during the tests.

10.17.5.4 For integrated testing of the total SAS system, the Contractor shall provide an I/O generator/simulator, which will be connected, to the BCUs simulating the plant status and plant operation. This will help in generating desired rate and sequence of I/O to test various BCU and HMI functionality under worst case loading conditions. With the I/O generator/simulator, all possible interlocking conditions shall be simulated, and controls tested.

10.17.5.5 Following the tests, if in the opinion of the Owner, the system has not been adequately manufactured, programmed, tested or debugged the Contractor shall make good all deficiencies including system parametric specifications of display response time, processor duty cycle, SOE resolution, etc., and re-run the test to fully satisfy the Owner regarding full compliance with specification requirements and requisite quality standards. The Contractor shall be responsible for all travel and accommodation costs of the Owner related to re visits and/or re-testing required.

10.17.5.6 The system shall not be shipped without approval of Owner in writing. Upon successful completion of FAT, the Owner will provide the Contractor with a written authorization for shipment of the system equipment to the project site.

10.17.5.7 Contractor shall note that no payments towards dispatch of equipment and subsequent activities shall be due and payable to the Contractor till the

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Contractor is able to successfully demonstrate to Owner's satisfaction that the SAS and parts thereof fully meet the FAT requirements.

10.17.5.8 The tests shall include the verification of all I/O functions at all Control Levels. The interface to the control center(s), interface to the HV AND EHV SAS, interface to the Solar SCADA shall be tested with the use of a protocol simulator.

10.17.5.9 Performance test: The duty cycle time shall be checked under the worst loading conditions.

#### **10.18 Site / Commissioning Tests**

10.18.1 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 pre-commissioning trials start up tests, trial operation and performance and guarantee tests. The Contractor shall be responsible for all site / commissioning tests.

10.18.2 The Contractor shall maintain all tests, calibration records in Owner approved formats, and these shall be countersigned by authorized quality assurance personnel of the Contractor supervising these works.

10.18.3 The Contractor 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 Contractor.

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


- a) Start-up tests
- b) Calibration and configuration checks
- c) Pre-commissioning tests
- d) Trial Operation
- e) Availability Tests

10.18.5 Point-to-point testing of all the I/O signals in the HV AND EHV network shall be done by the Contractor.

10.18.6 Point-to-point testing shall include:


- a) Verification of all status indications by operating the plant
- b) Verification of event / alarm indications by simulating alarm conditions
- c) Verification of all analogue indications by injection testing
- d) Verification of all controls by operating the plant

10.18.7 Availability Tests


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- 10.18.7.1 The Contractor shall guarantee 99.9 percent availability for a continuous period of 180 days. Availability guarantee test shall be conducted to assure this level of availability. If the accrued down time exceeds 0.1% of 180 days, during availability test run, a new 180 days test run shall start at the time when the system becomes available again. Loss of availability (unavailable system) shall be defined as the loss of the systems guaranteed accuracy and repeatability or of any system function, except however, that the loss of a function for not more than five percent of the points shall not be considered loss of availability. Loss of function for not more than 5% of the points shall be treated as partial unavailability and the corresponding outage time shall be weighted with respect to the function and the percentage of the points for which the function is unavailable. Loss of each function shall have one weighing factor and unavailability of each equipment, peripherals device or process I/O card etc. shall have another weighing factor. The guaranteed accuracy and repeatability and system parametric requirements specified in clauses on system parametric requirements shall be maintained for the entire 180 days run without any manual re-calibration or any other changes made to the SAS.
- 10.18.7.2 Downtime shall start upon loss of a system function and shall end upon full restoration of the affected system function. A minimum of one hour's down time shall be charged for each loss of availability in determining system availability.
- 10.18.7.3 The Contractor shall submit the Availability Test Procedure for Owner's approval. The details regarding outage time, weighing factors for various systems functions equipment to calculate the down time shall be discussed and finalized during detailed engineering.
- 10.18.7.4 The availability test shall start at a date, which will occur, between the commissioning date and 5 months after commissioning.
- 10.18.7.5 The availability test shall be expressed as percentage, which shall be calculated as  $(100\% \times (\text{test duration time} - \text{Accumulated test outage time} / \text{Test duration time}))$ .
- 10.18.7.6 System outage time will be accumulated over test duration and calculated as outage time x weighing factor. The contractor shall submit a list of weighing factors for all system components along with the bid and the same will be mutually finalized before contract award. Outage time shall be weighted by each function's weighing factor.
- 10.18.8 Conditions for Availability Tests



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- 10.18.8.1 Down time shall start with the notification to contractor about any loss of function. Downtime shall be exclusive of travel time required by the Contractor, but not in excess of 8 hours.
- 10.18.8.2 The contractor shall furnish in his bid recommended spare parts inventory, along with unit price, to be maintained at site during availability test run. If the spare parts required for maintenance as recommended by contractor are not available with Owner for fault repair the outage time necessary for obtaining spare will not be counted. If the required spare are not recommended by the Contractor and are required for repairs, then the time required to obtain the part by the Contractor shall be multiplied by weighting factor or 0.05 and counted as a accumulated outage time. The spare parts, which are used by the Contractor and not replaced by the contractor, shall accumulate outage time at the rate of time required to obtain the spare parts multiplied by the weighing factor of 0.05 if the part is required on a subsequent outage.
- 10.18.8.3 The contractor shall be responsible for replacing any of the Owner's spare parts which are used in the availability run free of cost to the Owner.
- 10.18.8.4 Failure of peripheral output devices shall be counted as outage time if failure of the device affects any for part of the system function.
- 10.18.8.5 Any degradation of function shall accrue outage time regardless of processor configuration.
- 10.18.8.6 During a period of system outage, the Owner shall use operable functions of the system provided that such use does not interfere with maintenance of the inoperable functions or hardware as determined by the Contractor.
- 10.18.8.7 Should the contractor determine that partial use of the system by the Owner will interfere with the contractor's maintenance procedures, system outage time shall accumulate with a weighing factor of 1.0 since no functions are available to the Owner. This shall include offline servicing.
- 10.18.8.8 Outage time for each function shall stop at the time the contractor returns each of the functions in full service and relinquishes full use of the system to the Owner.
- 10.18.8.9 The contractor shall prepare a detailed site / commissioning tests procedure based on the guidelines given here and submit to Owner for approval during detailed engineering stage.
- 10.18.9 System Hand-over and Final Acceptance
- 10.18.9.1 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.

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A hand-over certificate will be issued by the Owner. The Contractor will still be responsible for the Availability Tests.

10.18.9.2 Final acceptance of the system by the Owner will take place after the Availability Tests have been done to the satisfaction of the Owner.

#### **10.19 Type Test Requirements**

10.19.1 Test reports for following type tests shall be submitted for all BCUs / BPU's / DR / 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. Type Test Standards mentioned below are to be of latest revision in all cases.


##### **10.19.2 BCU/BPU**

- i) Insulation Tests: Dielectric Withstand Tests, High Voltage Impulse Test, class III
- ii) Electrical Environment Tests: DC Supply Interruption, AC Ripple on DC supply, AC voltage dips and short Interruptions, High Frequency Disturbance, Fast Transient Disturbance, Surge Withstand Capability, Electrostatic Discharge, Surge Immunity.
- iii) EMC tests: Radiated Immunity, Radiated Electromagnetic Field Disturbance Test, Disturbances Induced by Radio Frequency fields, Amplitude Modulated (Conducted Immunity), Power Frequency Magnetic Field, Interference Voltage, Aux. Voltage (Conducted Emission), Interference Field Strength (Radiated Emission).
- iv) Atmospheric environment test: Humidity, Temperature
- v) Mechanical Stress Tests: Vibration (during Operation and Transportation), Shock (during Operation and Transportation), Seismic Vibration (during Operation).

##### **10.19.3 DISTURBANCE RECORDER**

10.19.3.1 Type test reports for the following tests shall be submitted

- i) High Voltage Impulse Test, class III as per IEC 60255-27
- ii) High Frequency Disturbance as per IEC 60255-26, class III
- iii) Fast Transient Disturbance as per IEC 60255-26, class IV


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## 10.20 Functional Tests

All the numerical relays shall be tested for the functions specified in Owner technical specifications. In case of Numerical Differential and Distance Relays, test reports for dynamic tests clearly indicating the operating time under different system / fault conditions shall be submitted.

## 10.21 Settings

- 10.21.1 Fault levels will be provided to the Contractor by the Owner. The Contractor 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 Contractor.
- 10.21.2 The contractor shall provide the Owner with a philosophy document clearly setting out the philosophy the contractor 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 contractor 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 Contractor.
- 10.21.3 The setting document will be presented and discussed with the Owner prior to final issue of the document. Relay setting template (in editable document format) shall be provided by the contractor for each typical protection IEDs for relay setting purpose. The final accepted setting document should be made available to the Owner in PDF format.
- 10.21.4 It is the Contractor'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 contractor will issue three sets of setting documents once accepted by the client and consultant.

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#### 10.22 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:

SN	Item description	Required quantities
a)	Desk for Switchyard control room - Modular for workstations and printers covered under this package	As per system design
b)	Chairs	4
c)	Filing Cupboard	1
d)	Fireproof almirah	1


#### 10.23 Engineering/Operator workstation

##### 10.23.1 Minimum quantity requirement is specified below:

SN	Item description	Required quantities
a)	Engineering/DR cum Operator workstation (EWS cum OWS) (PC with Min 22" LED Monitor)	01 Set
b)	Operators workstation (OWS) (PC with Min 22" LED Monitor)	02 Set
c)	Portable (laptop) based EWS	01 no
d)	50 Inch LED display (connect with both OWS)	01 no
e)	Time Synchronization equipment	01 no
f)	Networked Color Laser Printer	01 no
g)	Digital display clock	01 no

The contractor shall provide the compatible Engineering, DR and Operator workstation and other components as per the offered SAS system complying with the following minimum specification requirement.


##### 10.23.2 Operator Workstation and Engineering/DR Workstation:

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SN	Features	Industrial Server Grade IEC 61850-3 certified Workstation One Operator Workstation One Engineering cum Operator Workstation
a)	Processor	64-bit Server Grade (Xeon or Equivalent)
b)	Memory	16 GB RAM upgradable to 32 GB
c)	Hard Disk	SSD 1 TB RAID1
d)	Monitor (color)	Min 22" TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz.
e)	Network Connectivity	Minimum 4 Nos. Built-in Ethernet Network Port
f)	Removable bulk storage drive (DVD / DAT)	6 GB (minimum) for each work station
g)	Portable Bulk Storage Media	2 TB (2 nos.)
h)	DVD R/W	16x or higher
i)	Keyboard	ASCII
j)	Pointing Device	Mouse
k)	Additional general purpose software (for using over network by servers/workstations/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.
l)	Software	MS Windows latest, MS Office, Adobe PDF Reader, PDF Editor professional, Anti-Virus, Network Security Etc.

10.23.3 LED display: 50 Inch LED Display, Display Resolution : 1920 x 1080, Wall Mounted, Reputed make

10.23.4 Printer

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SN	Features	Industrial Server Grade IEC 61850-3 certified Workstation One Operator Workstation One Engineering cum Operator Workstation
a)	Paper size	A4
b)	Printing Speed (min.)- in normal mode for A4 size paper	6 ppm (Color), 24 ppm (B&W)
c)	Type	Heavy duty, at least 50000 pages/month
d)	Resolution (black) (min.)	600 dpi
e)	First page out time (with full graphic display)	=<1 min for color, <45 Sec for BW
f)	Paper input capacity (min.)	500 sheets
g)	Additional features	Automatic Duplex Printing

#### 10.24 COMMUNICATION CABLE (Optic Fibre Cable)

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

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



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

10.24.3 Contractor 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.

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

**10.25 Specification for input output modules of RTU in 33 kV Switchgear**

10.25.1 Electrical isolation of 1.5kV with optical couplers between the plant input/output and RTU 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.

10.25.2 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.

10.25.3 The I/O Module shall have the following features:

- a) Power supply monitoring.
- b) Contact bounce filtering.
- c) Optical isolation between input and output signals with the internal circuits


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.

10.25.4 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.

10.25.5 In case of loss of I/O communication link with the main processing unit, the I/O shall be able to go to predetermined fail safe mode (to be finalized during detailed engineering) with proper annunciation.

10.25.6 Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) shall be calculated based on the Input/output signal list to be submitted by the contractor for approval during detail engineering.

10.25.7 10 % spare channels in input/output modules fully wired up to cabinets TB.

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

### **10.26.1 General Requirements:**

10.26.1.1 Contractor 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).


10.26.1.2 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.

10.26.1.3 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.

10.26.1.4 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.


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

- i) 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.
- ii) 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.
- iii) 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

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validated before using the OEM provided file/binary in the process of firmware up-gradation and security patching.

- iv) Firewall shall have Management Console port to configure remotely.
- v) Firewall shall be EMI/EMC compliant in Substation environment as per IEC 61850-3.
- vi) Firewall shall be rack mounted in existing standard equipment cabinets.
- vii) Firewall shall have support of SCADA applications (IEC-60870-5-104), ICCP, PMU (IEEE C37.118), Sub-Station Automation System (IEC 61850), Ethernet and other substation environment protocols.
- viii) Client based Encryption/ VPN must support different Operating System platforms e.g. Windows, Linux & Mac.
- ix) The solution must have content and comprehensive file detection policies, blocking the files as function of their types, protocols and directions.
- x) 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 able to export all logs/events for a period of last 90 days at any given time.
- xi) 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.
- xii) Firewall shall have the capability to configure sufficient number of VLANs.
- xiii) Firewall shall have the capability to support sufficient number of sessions.
- xiv) 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
- xv) Firewall shall be capable of SNMP v3 for monitoring from Network Management system. It shall also have SNMPv3 encrypted authentication and access security.
- xvi) 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.

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- xvii) Firewall should have integrated traffic shaping (bandwidth, allocation, prioritisation, etc.) functionality.
- xviii) Shall support simultaneous operation with both IPv4 and IPv6 traffic.
- xix) Firewall shall be compatible with SNTP/NTP or any other standards for clock synchronization.
- xx) Firewall shall have the features of port as well as MAC based security.
- xxi) Firewall shall support exporting of logs to a centralized log management system (e.g. syslog) for security event and information management.
- xxii) Firewall time shall be kept synchronised to official Indian Timekeeping agency, time.nplindia.org.
- xxiii) 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.


## **11 LT Equipment**

### **11.1 LT Cable**

#### **11.1.1 Quality Certifications**

- 11.1.1.1 Cables shall be compliant to most recent standards (and latest amendments if any) developed by the International/Indian Standards. Below Table presents a non-exhaustive list of standards to which the cables should conform.

IEC 60228	Conductors of insulated electric cables
IEC 60502	XLPE insulation and sheath of electric cables.
IEC-60332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).
IEC 60754-1	Test on gases evolved during combustion of materials from cables
IEC 60754 Part I	Test on gases evolved during combustion of electric cables.
IEC 60332 Part I & III	Smoke Compound
IEEE-383	Standard for type test of Class IE Electric Cables.

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ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
11-TMSS-10	SEC transmission material standard-LV Power and Control Cables

#### 11.1.2 Specific Design Requirements

11.1.2.1 Cables shall be 1.1kV grade, single core, extruded XLPE insulated with extruded PVC inner sheath (ST-2) and conductor shall be electrolytic grade aluminium / copper H4 grade (control cables).

11.1.2.2 The maximum conductor temperature shall not exceed 90 degree C during continuous operation at full rated current. The temperature after short circuit for 1.0 second shall not exceed 250 degree C with initial conductor temperature of 90 degree C.

11.1.2.3 Cables shall be armoured with Al wires or strips of H4 grade as required for underground and in trench installations.

11.1.2.4 Outer Sheath shall be of PVC (ST-2) grade. Colour of the outer sheath shall be in red, blue and yellow colour for easy identification.

11.1.2.5 The power cables for CT and PT circuits shall be of minimum size 4mm<sup>2</sup> Copper and for rest shall be 2.5mm<sup>2</sup> copper.

11.1.2.6 Cable sizing calculations shall be finalized during detailed engineering phase.

#### 11.1.3 Pre-dispatch Quality and Testing

11.1.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.

11.1.3.2 Indicative list of tests shall be performed on cables is as below:

##### i) Routine Test


a) Conductor Resistance test.

b) Insulation resistance test.

c) High voltage test.

##### ii) Factor Acceptance Test

a) Tests on conductor:


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- Conductor resistance.
  - Tensile strength (before & after stranding).
  - Wrapping test (before stranding).
- b) Thickness of Insulation and sheath.
- c) Hot set test on insulation.
- d) Tensile strength and elongation at break test for Insulation & sheath.
- e) Insulation resistance test.
- f) High voltage test.
- iii) 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.
- iv) During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- v) However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the Owner either at third party lab or in presence of Owner's/Owner appointed PMC's representative and submit the reports for approval.
- vi) The reports for type tests shall be furnished as per pre-dispatch quality and testing section of HT cables.

#### 11.1.3.3 Cable Drums

- i) Cable shall be supplied in non-returnable wooden/steel drum. The wood used for construction of the drum shall be properly seasoned and free from defects. Wood preservative shall be applied on the entire drum. Wooden drums shall comply with IS: 10418. All ferrous parts shall be treated with a suitable rust preventive coating to prevent rusting during transit or storage. Cable drums shall conform latest Indian standards. Cable ends shall be sealed with non - hygroscopic cap. Allowable tolerance on individual drum length is  $\pm 5\%$ .
- ii) The cable drums should carry the following details in printed form:
- a) Manufacturer's name or trade make.
  - b) Owner's name, address.
  - c) Type of cable & voltage grade.



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- d) Year of manufacture.
- e) Type of insulation.
- f) No. of core and size of cables.
- g) Cable code.
- h) Length of cable on drum.
- i) No. of length on drum, if more than one.
- j) Direction of rotation, by arrow.
- k) Handling Instructions.

#### 11.1.3.4 Cable Identification

Cable identification shall be provided by embossing on every meter on the outer sheath the following:

- a) Manufacturer's name or trademark.
- b) Voltage grade.
- c) Year of manufacture.
- d) Type of insulation.
- e) No. of core and size of cables.

#### 11.1.3.5 On Site test

Cables shall be tested on site prior into putting into service to ensure that all items are in required working condition, correctly installed and free from damage. An experienced and qualified testing Engineer shall be engaged by the contractor to perform the site testing and commissioning.


- a) Conductor Resistance test.
- b) Insulation resistance test.
- c) High voltage test.
- d) Jointing kit and Termination kit shall be inspected and tested as per the applicable standards and approved Quality Plan.

### 11.2 LT Control Cable

#### 11.2.1 Quality Certifications

- 11.2.1.1 Cables shall be compliant to most recent standards (and latest amendments if any) developed by the International/Indian Standards. Below Table presents a non-exhaustive list of standards to which the cables should conform.


IEC 60228	Conductors of insulated electric cables
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IEC 60502	XLPE insulation and sheath of electric cables.
IEC-60332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).
IEC 60754-1	Test on gases evolved during combustion of materials from cables
IEC 60754 Part I	Test on gases evolved during combustion of electric cables.
IEC 60332 Part I& III	Smoke Compound
IEEE-383	Standard for type test of Class IE Electric Cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
11-TMSS-10	SEC transmission material standard-LV Power and Control Cables


#### 11.2.2 Specific Design Requirements

- 11.2.2.1 Control Cables shall be 1.1kV grade, single core, extruded XLPE insulated with extruded PVC inner sheath (ST-2) and conductor shall be electrolytic grade aluminium / copper H4 grade (control cables).
- 11.2.2.2 Control cables shall be heavy duty, stranded copper conductor, PVC type A insulated, galvanized steel wire/ strip armoured. Flame retardant low smoke (FRLS) extruded PVC of Type-ST1 outer sheathed.
- 11.2.2.3 The Cables shall be brand new and in good condition. These shall be suitable for laying in trays, trenches, ducts, conduits and underground buried installation with uncontrolled backfill and possibility of flooding by water. The terminating and straight through joint kits for the cables shall be suitable for the type of cables offered and for storage without deterioration up to 50 Deg. C ambient temperature.
- 11.2.2.4 The maximum conductor temperature shall not exceed 90 degree C during continuous operation at full rated current. The temperature after short circuit for 1.0 second shall not exceed 250 degree C with initial conductor temperature of 90 degree C.
- 11.2.2.5 The type of the cable shall be Armoured Heavy Duty Type Insulated PVC Cable. The inner Sheath shall be PVC type and the outer Insulation shall be FR-PVC type.

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The conductors shall be 1100 V grade Copper Conductors with a minimum of 2.5 Sq. mm size.


- 11.2.2.6 The core insulation shall be with PVC compound applied over the conductor by extrusion and shall conform to the requirements of type 'A' compound of IS:5831. Control cables having 6 cores and above shall be identified with prominent and indelible Arabic numerals on the outer surface of the insulation. Colour of the numbers shall be white with a spacing of maximum 500 mm between two consecutive numbers.
- 11.2.2.7 The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of Type ST1 PVC compound of IS 5831. The extruded inner sheath shall be of uniform thickness of size not less than those mentioned in IS:1554
- 11.2.2.8 For multicore cables, the armouring shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and galvanized steel strips where this dimension is greater than 13mm
- 11.2.2.9 The outer sheath for the cables shall be applied by extrusion and shall be PVC compound conforming to the requirements of type ST1 Compound of IS:581. To protect the cables against rodent and termite attack suitable chemicals shall be added into PVC compound of the outer sheath.
- 11.2.2.10 Cable sizing calculations shall be finalized during detailed engineering phase.
- 11.2.3 Pre-dispatch Quality and Testing
  - 11.2.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.
  - 11.2.3.2 Indicative list of tests shall be performed on cables is as below:
    - i) Routine Test
      - a) Conductor Resistance test.
      - b) Insulation resistance test.
      - c) High voltage test.
    - ii) Factory Acceptance Test
      - a) Tests on conductor:
        - Conductor resistance.
        - Tensile strength (before & after stranding).
        - Wrapping test (before stranding).
      - b) Thickness of Insulation and sheath.
      - c) Hot set test on insulation.
      - d) Tensile strength and elongation at break test for Insulation & sheath.

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- e) Insulation resistance test.
- f) High voltage test.
- iii) 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.
- iv) During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- v) However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the Owner either at third party lab or in presence of Owner's/Owner appointed PMC's representative and submit the reports for approval.
- vi) The reports for type tests shall be furnished as per pre-dispatch quality and testing section of HT cables.

#### 11.2.3.3 Cable Drums

- i) Cable shall be supplied in non-returnable wooden/steel drum. The wood used for construction of the drum shall be properly seasoned and free from defects. Wood preservative shall be applied on the entire drum. Wooden drums shall comply with IS: 10418. All ferrous parts shall be treated with a suitable rust preventive coating to prevent rusting during transit or storage. Cable drums shall conform latest Indian standards. Cable ends shall be sealed with non - hygroscopic cap. Allowable tolerance on individual drum length is  $\pm 5\%$ .
- ii) The cable drums should carry the following details in printed form:
  - a) Manufacturer's name or trade make.
  - b) Owner's name, address.
  - c) Type of cable & voltage grade.
  - d) Year of manufacture.
  - e) Type of insulation.
  - f) No. of core and size of cables.
  - g) Cable code.
  - h) Length of cable on drum.
  - i) No. of length on drum, if more than one.

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j) Direction of rotation, by arrow.

k) Handling Instructions.

iii) Cable Identification

Cable identification shall be provided by embossing on every meter on the outer sheath the following:

a) Manufacturer's name or trademark.

b) Voltage grade.

c) Year of manufacture.

d) Type of insulation.

e) No. of core and size of cables.

### 11.3 Battery and Battery Charger


#### 11.3.1 Quality Certification

11.3.1.1 Battery charger shall be compliant to most recent standards (and latest amendments if any) developed by the International/Indian Standards. Below Table presents a non-exhaustive list of standards to which the battery & battery charger should conform.

IEC : 60529	Degrees of Protection Provided by Enclosures (IP Code)
EN61000-6-2	Electromagnetic compatibility (EMC)
EN61000-6-4	Electromagnetic compatibility (EMC): Generic standards. Emission standard for industrial environments
EN61000-3-3	Flicker Standards for Commercial Electronic Products
IEEE: 485	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE : 1188 and 1189	Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications
IEC : 60335-2-29	Household and similar electrical appliances - safety particular requirements for battery chargers

#### 11.3.2 Specific Design Requirements

##### 11.3.2.1 Batteries


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- i) The battery offered shall be stationary, sealed maintenance free, lead acid VRLA type with High Discharge Performance (HDP).
- ii) Batteries shall have low self-discharge. The battery used in this panel shall have excellent charge retention capability and high rate of discharge.
- iii) Cell containers shall be of unbreakable poly carbonate type and shall be sufficiently robust and free from flaws/manufacturing defects. The inter-cell and internal cell connectors shall be lead plated copper having minimum thickness of 4mm and sufficient cross section to carry the high currents. All cells shall be suitable numbered with number plates and fixing pins.
- iv) Noncorrosive steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.
- v) One DC voltmeter having scale of -3V to +3V with suitable leads for measuring cell voltages and one syringe type hydrometer for measuring specific gravity of electrolyte in steps of 0.002 shall be provided.
- vi) Battery capacity shall be as per sizing calculations finalized during detailed engineering.

#### 11.3.2.2 Battery Charger

- i) The charger shall be redundant type Dual Float cum Boost charger (DFCBC) and capacity shall be as per sizing calculations finalized during detailed engineering.
- ii) Charger shall be of 'Constant Potential' type with current limiting facility.
- iii) Charger shall have provision to change the charging voltage on the front panel. Normal charging voltage shall not exceed 2.25volts per cell.
- iv) MCCB of suitable rating shall be provided as incomer to charger. The rating shall be suitable for battery short circuit current.
- v) DC output voltage during float charging shall be stabilized within 1% of the set value of DC bus voltage for variation in parameters as follows:
  - a) Input AC voltage: 10%
  - b) Input Frequency: 5%
  - c) DC Load variation 0 to 100%
- vi) The ripple contents shall be within 3% of the nominal DC rated voltage.



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- vii) Load Limiting feature of charger shall be designed for short time overload to take care of intermittent loads coming on DC bus.
- viii) All PCBs shall be of plug in type, if more than one PCBs are to be provided in panel then the same shall be interlocked to prevent insertion in wrong slot.
- ix) Normal operating condition shall be indicated by LED mounted on PCB.
- x) The boost charging voltage shall be adjustable between 70% to 100% of maximum value of 2.45volts per cell. Boost charge current shall have provision for adjustment between 30% to 100% of its maximum value.
- xi) Battery charger panel shall be provided with one potential free contact for collective trouble in battery charger system. This contact shall be wired up to terminal block for interfacing with Master Control Panel.
- xii) Following minimum protections shall be provided in charger.
  - a) Charger shall go in current limiting mode if battery current or charger current exceeds the set value.
  - b) Dropping diode panel shall be part of battery and charger.
  - c) Charger shall trip in case input voltage decreases beyond set value.
  - d) Charger shall trip in case of DC voltage is increased beyond set value.
  - e) Charger shall trip in case DC current is increased beyond set value.

### 11.3.3 Pre-dispatch Quality and Testing

11.3.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.


11.3.3.2 Indicative list of tests shall be performed is as below:

- a) Insulation resistance
- b) Dielectric test.
- c) Automatic voltage regulation test at normal AC supply.
- d) Ripple content at rated input, output voltage and output currents.
- e) Efficiency and power factor test
- f) Checking of proper operation of annunciations system
- g) Temperature rise test
- h) Operational logic test

### 11.3.4 Specific Erection Requirement

#### 11.3.4.1 Batteries

- i) All batteries shall be mounted on stand / frame prior to putting into service. The frame shall be properly painted with the acid resistant paint.

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- ii) The suitable insulation shall be provided between stand and floor.
- iii) The contractor should ensure application of petroleum jelly on the terminals of batteries after making connections.

#### 11.3.4.2 Battery Charger

- i) Checking of name plate, physical damage, connections details according to specification
- ii) Functional check of auxiliary devices such as alarms, indicating lamps etc.
- iii) Insulation test of all circuits
- iv) Measurement of voltage regulation and ripple voltage.

#### 11.3.4.3 Onsite Testing

- i) After unpacking the panel, inspect the panel externally for any damage of components during transits (lamps, switches, meters, etc). If anything is found damaged replace it at the earliest. Open the panel and check all connections and the mounting conditions of relays and printed circuit boards.
- ii) Check the insulation of the charger input lines (marked R, Y & B) at the bottom of the back of the panel with a 500 Volts megger. The insulation resistance should be more than 2 M-ohms.
- iii) Check the input supply voltage. This should be within 415 Volts  $\pm 10\%$  (or as applicable). If found O.K. then connects the line at the input terminals after checking the phase sequence. The panel should be properly earthed through the earthing terminals provided at the back of the panel. Without connecting any load first switch on the input Isolation MCCB and check all the output voltages and indication lamps.
- iv) Keep the auto / manual selector switch provided on the front door of the panel to manual position. Connect light load. Switch on input isolation MCCB. Input and output indicating lamps should glow. Voltmeter and ammeter will show some voltage and current. If any adjustment in the output voltage/current is required, the setting of the potentiometer provided on the front door of the panel should be adjusted to set the voltage/current at the required value. Do not temper the setting of any other potentiometer, which may otherwise lead to serious malfunctioning of the charger. If the above tests are O.K. switch off the input isolation MCCB.
- v) Connect the same load as float mode to the terminals marked B+ & B-. Keep the auto / manual selector switch provided on the front door of the panel to manual position. Switch on input isolation MCCB and switch on the toggle switch. Input and output indicating lamps should glow. Voltmeter and ammeter will show some voltage and current. If any adjustment in the output voltage/current is required, the setting of the potentiometer provided on the front door of the panel should be adjusted to set the voltage/current at the required value. Do not temper the setting of any other potentiometer, which may otherwise lead to serious malfunctioning of the charger. If the above tests are O.K. switch off the input

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isolation MCCB. After checking the charger in manual mode, keep auto/manual selector switch in auto position for normal operation.

- vi) Please ensure constant manual supervision during manual operation by trained & knowledgeable personal (either in Float mode or in Boost mode) as system malfunction may occur due to mal operation. It is highly recommended to keep charger in Auto Mode under normal operating condition.

#### 11.4 Marshalling Kiosk

Marshalling Kiosk is used to provide convenient connection points for the various control, protection and instrumentation cables.


##### 11.4.1 Quality Certification

- 11.4.1.1 Kiosk shall comply with most recent standards (and latest amendments if any) developed by the International/Indian Standards. Below Table presents a non-exhaustive list of standards to which the Marshalling kiosk should conform.

IEC : 61850	Interoperability for Advanced Protection and Control Applications
IEC : 60529	Degrees of Protection Provided by Enclosures (IP Code)

##### 11.4.2 Specific Design Requirements

- 11.4.2.1 The marshalling kiosk shall be of outdoor and free-standing type and made up of 2mm thick CRCA sheet steel. The kiosk shall be provided with separate base channel, removable undrilled gland plate of not less than 3mm thick sheet steel, canopy arrangement and double door with gasketing arrangements and lock.
- 11.4.2.2 Cable entry shall be at bottom. Degree of protection shall be of IP55 or better. The kiosk shall be sized suitably for housing terminal block strips, MCBs, cabling troughs and illumination arrangement with CFL lamp, Fuses, links, door switch and 5pin 16A Industrial grade socket with individual ON-OFF switches.
- 11.4.2.3 Space heater and thermostat shall be provided in inside the cubicle to prevent condensation.
- 11.4.2.4 Marshalling Kiosk's shall be furnished for all 220kV bays of switchyard. It is intended to have AC distribution in each bay through this cubicle. The terminal blocks shall be installed at least at a height of 200mm from bottom gland plate and gap between two terminal blocks shall be at least 150mm.
- 11.4.2.5 The Marshalling Kiosk shall have distinct compartments for the following purpose:
  - i) To receive incoming 415V, 3phase, 32A, AC supply MCB unit and distribute suitable number of 415V, 6A, AC supplies controlled by MCB.
  - ii) To distribute suitable number of 240V, 6A, single phase supplies to be controlled by MCB and drawn from above 3 phase incomers.

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- iii) Collecting all control terminal from Isolator and SF6 circuit breaker for onward termination at BCU type control metering and relay panel.

#### **11.5 Cable Laying Methodology**

Cable installation shall be carried out as per IS:1255 and other applicable standards.

##### **11.5.1 HT cable Trench:**

11.5.1.1 The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 grade.

11.5.1.2 Cables shall be laid in accordance with relevant Indian standards. For underground installation cables shall be laid at depth not less than 1.05m below ground level. Prior to cable laying, bottom of the trench shall be well compacted and bedded with fine sand. Subsequently second layer of fine sand shall be spread over the cable and then covered by compacted soil.

11.5.1.3 Cable laying should be done by digging trench in ground. Minimum bedding of 100mm riddle soil or sand at the bottom of the trench and covering it with the additional soil or sand of minimum 100mm and should be protected it by means of tiles, bricks or slabs.

11.5.1.4 Power cable route indicators should be provided at an interval not exceeding 50m and also at turning points of the power cable route wherever practicable. PVC warning tape of minimum 200mm (width) X 150 microns (thick) shall be laid along the cable route at depth not less than 300mm. This tape shall be printed with warning in black letters in English and local language.

11.5.1.5 The diameter of the cable conduit or pipe or duct should be at least 1.5 times the outer diameter of cable. The ducts/pipes should be mechanically strong to withstand forces due to heavy traffic when they are laid across road.


11.5.1.6 All metal parts inside the trench shall be connected to the earthing system and cables from trench to equipment's shall run in hard conduit pipes.

11.5.1.7 Cable trench design shall be finalized during detailed design engineering with the approval of Owner.


##### **11.5.2 LT cable Trench:**

11.5.2.1 The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 grade.

11.5.2.2 For underground installation cables shall be laid at depth not less than 0.75m below ground level. Prior to cable laying, bottom of the trench shall be well compacted and bedded with 150mm thick layer of sand. Subsequently second layer of minimum 150mm fine sand shall be spread over and below the cable and then covered by compacted soil. Landscape post cabling shall be restored to the original condition.

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- 11.5.2.3 PVC warning tape of minimum 300mm (width) X 150 microns (thick) shall be laid along the cable route at depth not less than 300mm. This tape shall be printed with warning in black letters in English.
- 11.5.2.4 Wherever more than one cable is laid in the same trench, adequate interspacing shall be maintained for reducing mutual heating and cable safety. While laying power cables, interference with control and monitoring cables should be avoided. Communication cables shall be laid at least 300mm away from power cable. Communication cables shall be laid through double wall corrugated HDPE pipe.
- 11.5.2.5 The relative position of the cables laid in the same trench shall be preserved and the cables shall not cross each other as far as possible. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius of bend not less than 15 times the diameter of the cable. Minimum 3 meters long loop shall be provided at both sides of every straight joint and 5 meters at each end of the cable.
- 11.5.2.6 All metal parts inside the trench shall be connected to the earthing system and cables from trench to equipment's shall run in hard conduit pipes.
- 11.5.2.7 Cable trench design shall be finalized during detailed design engineering with the approval of Owner.
- 11.5.2.8 All cable trenches should be constructed in such a way that there will not be water logging in the trenches and depending on the contour and gradient of the yard as per actual site conditions.
- 11.5.3 Cable Trays, Fittings and Accessories:
- 11.5.3.1 Cable trays shall be ladder type for power and electrical control cables, while perforated type cable trays shall be used for instrumentation cables. The fabrication of cable trays shall be done with 2.5mm thick sheet. Cable trays shall be hot dip galvanized as per relevant IS.
- 11.5.3.2 Cable trays shall be bolted to tray mounting supports with a minimum clearance of 300mm between cable tray tiers and cable shall be fixed minimum 25mm away from the wall. Cable trays shall be supported at an interval of minimum 1200mm for all horizontal runs. For vertical cable risers/shafts cables will be supported at every 1000mm interval.
- 11.5.3.3 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures. The supports shall be fabricated from standard structural steel members.
- 11.5.3.4 Insert plates will be provided at an interval of 750mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.
- 11.5.3.5 Designing of cable trays and support system shall be finalized during detailed engineering phase.
- 11.5.4 Pipes, Fittings and Accessories:

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Entry of cables from trenches into buildings shall be by means of RCC hume pipes. Hume pipes shall be NP3 type as per IS 458. All such entries shall be sealed against water ingress after completion of cable laying with advanced modular multi diameter cable sealing system shall be followed at the entries against water ingress. This system shall be tested for continuous pressure at minimum 0.3bar, anti-rodent and fire rating as per IS/IEC or equivalent standard.

#### 11.5.5 Terminations and Straight through joints:

11.5.5.1 The termination and connection of cables shall be done strictly in accordance with cable termination as per manufacturer's drawing with the approval of Owner. The termination schedule will be submitted by the contractor for the approval of Owner.

11.5.5.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.

11.5.5.3 Supply of all consumable material shall be in the scope of Contractor.

11.5.5.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

11.5.5.5 Control cable cores entering control panel/switchgear/MCCB/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

11.5.5.6 The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by OWNER. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

11.5.5.7 Spare cores shall be similarly tagged with cable numbers and coiled up.


11.5.5.8 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor without any extra cost, as directed by Owner.

11.5.5.9 Solderless crimping of terminals shall be done by using corrosion inhibitory compound.

11.5.5.10 Termination and jointing kits for XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, taped type or heat shrinkable type. Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard. Straight through joint and termination shall be capable of withstanding the fault level for the system.

#### 11.5.6 Cable Gland:



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Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer as required to complete installation. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm Al sheets. Cable glands shall be suitable for the sizes of cable supplied. Compression type tubular terminal ends for aluminium conductors of insulated cables shall be designed as per IEC.

**11.5.7 Cable lugs/ferrules:**

Cable lugs shall be of aluminium, tinned copper or may be of Bi-metallic type depends on the requirement. Thickness of tinning shall not be less than 10 microns. Type of cable lugs shall be as follows:

- a) Power cables with aluminium conductor: Aluminium crimping type.
- b) Power cables with aluminium conductor terminated on Cu Busbar: Bimetallic Lug.
- c) Power cables with copper conductor: Copper crimping type.
- d) Control Cable: Copper Pin Type / Copper Screw type.
- e) Special Cables: Pin Type / Maxi-Termi type.

**11.5.8 Cable clamps & straps:**


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

**11.5.9 Cable tags & markers:**

**11.5.9.1** The cable schedule shall be prepared by the contractor and submitted to Owner for approval. Each cable and conduit run shall be tagged with numbers that appear in the cable schedule.

**11.5.9.2** Cable tags shall be made out of 2mm thick aluminium sheets, each tag with appropriate holes shall be provided for clamping the same with cables. Control cable tag shall be of thick aluminium with number punched on it and securely attached to the cable by not less than two turns of 20SWG GI wire conforming to IEC 60446.

**11.5.9.3** All underground cables and cable joints shall be marked on the surface by markers generally manufactured and tested to the requirements of relevant IEC. CI cable markers shall be provided at every 30m along the route of the cables and at both ends of road crossing, indicating cable joints and cables as applicable. Cable markers shall be applied at every corner points.

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11.5.9.4 Special CI markers shall be provided at all buried cable joints indicating "Electrical Cable Joints".

## 11.6 Earthing System

11.6.1 Substation equipment shall be sufficiently earthed by suitable earth strip to provide the low resistance path during the faulty conditions.

### 11.6.2 Quality Certification

11.6.2.1 Earthing design shall comply with the latest IEC/IS standards along with below mentioned standards. Below Table presents a non-exhaustive list of standards to which the earthing system should conform.

IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 142	Grounding of Industrial & commercial power systems
IEC: 60364	Low voltage electrical installation
IS: 3043	Code of practice for earthing
IEC:61936	Power installations exceeding 1kV ac
Indian Electricity Rules 1910	


### 11.6.3 Specific Design Requirements

11.6.3.1 The system earthing grid sizing, earthing electrode sizing and equipment wise earthing strip/cable sizing shall be done as per relevant IEC/IS standard and shall be submitted for the approval of Owner during detailed engineering phase.

11.6.3.2 Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipment and extraneous metal works associated with electric system shall be connected to a single earthing system.

11.6.3.3 The earthing conductor shall be designed for a life expectancy of minimum 25 years and for maximum system fault current of time duration 1.0Sec. The minimum rate of corrosion of steel used for earthing conductor shall be considered as 0.12mm per year for designing its size.

11.6.3.4 Earthing and lightning protection system installation shall be in accordance with the latest editions of India Electricity Rules, relevant India Standards and Local codes of practice and the same shall be finalized during detailed engineering phase.

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#### 11.6.4 Earthing Conductor

11.6.4.1 Earthing conductors in outdoor areas shall be buried at least 600mm below finished ground level unless stated otherwise. Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, etc. it shall be laid minimum 300mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

11.6.4.2 Earthing conductors or leads along their run on cable trench, ladder, walls etc. shall be supported by suitable welding / cleating at intervals of 750mm. Wherever it passes through walls, floors etc., galvanized iron sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

11.6.4.3 Earthing conductor around the control room shall be buried at least 600mm below in earth at a minimum distance of 1500mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500mm away from such location.

11.6.4.4 Earthing conductors crossing the road shall be laid minimum 300mm below road or at greater depth to suit the site conditions. Earthing conductors embedded in the concrete shall have approximately 50mm concrete cover.

#### 11.6.5 Equipment and Structure Earthing

11.6.5.1 The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from bend and splice.

11.6.5.2 Steel/RCC columns, metallic stairs shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

11.6.5.3 Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.


11.6.5.4 Metallic conduits shall not be used as earth continuity conductor.

11.6.5.5 Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches shall be connected to the earthing conductor running along with the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points.


11.6.5.6 Flexible earthing connectors shall be provided for the moving parts.

11.6.5.7 MS/GI flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both ends and at an interval of 30meters. The MS/GI flat shall be finally painted with two coats of Red oxide primer and two coats of Post Office red enamel paint.

#### 11.6.6 Jointing

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- 11.6.6.1 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested shall be painted with anti-corrosive paint/compound.
- 11.6.6.2 Connection between equipment earthing lead and main earthing conductors shall be welded type. The welds should be treated with red lead and afterwards coated with two layers bitumen compound to prevent corrosion.
- 11.6.6.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingress. Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.
- 11.6.6.4 All ground connections shall be made by electric arc welding. Bending of earthing flats shall be done preferably by gas heating. All arc welding with large diameter conductors shall be done with low hydrogen content electrodes.
- 11.6.6.5 Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.
- 11.6.6.6 Each earthing lead from the neutral of the power transformer shall be directly connected to two pipe electrodes in treated earth pit (as per IEC:60364) which in turn, shall be buried in cement concrete pit with a cast iron cover hinged to a cast iron frame to have access to the joints.
- 11.6.6.7 Earthing terminal of each lightning arrester and capacitor voltage transformer shall be directly connected to pipe earth electrode shall be connected to station earthing grid.
- 11.6.7 Specific Erection Requirement
  - 11.6.7.1 The entire switchyard area shall be appropriately earthed with adequate number of earth stations. Earthing system shall comply with the latest edition of IEEE80/IS:3043 describing code of practice of earthing and following International/Indian standards.
    - i) The Step Potential, which is the maximum value of the potential difference possible of being shunted by a human body between two accessible points on the ground separated by the distance of one pace (which may be assumed to be one metre), should be within safe limits.
    - ii) Touch Potential, which is the maximum value of potential difference between a point on the ground and a point on an object likely to carry fault current such that the points can be touched by a person, should also be within safe limits.
    - iii) To meet these requirements, an earthed system comprising of an earthing mat buried at a suitable depth below ground and supplemented with ground rods at suitable points is provided in the Sub-stations.

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- iv) All the structures & equipment in the Sub-station are connected to the earthing mat so as to ensure that under fault conditions, none of these parts is at a potential higher than that of the earthing mat.
- v) The neutral points of different voltage levels of transformers/reactors are separately earthed at two different points. Each of these earthed points should be interconnected with the station earthing grid.
- vi) Neutral connection shall never be used for the equipment earthing. An earthing pad shall be provided under each operating handle of the isolator. Operating handles of the isolator and supporting structure shall be bonded together by a flexible connection and converted to the earthing grid.
- vii) A separate earth pit shall be provided adjacent to structures supporting lightning arrester and coupling capacitors. Separate earth connections for each unit shall be provided.
- viii) The earthing system shall have complete earthing network comprising of GI/GS earth electrodes and earth bonding of all relevant necessary non-current carrying metal parts of equipment's/ apparatus shall be connected as required.
  - a. Electrodes shall be made of 40mm dia MS rod or as per design requirements. The pipe electrode shall be as far as practicable embedded below permanent moisture level. The length of the pipe electrode shall not be less than 3m.
  - b. The pipe electrode shall be made from one unit. Earth leads to the electrode shall be laid in a heavy-duty GI pipe and connected to the pipe electrode with brass bolts, nuts and washers. GI pipe shall be terminated in a wire-meshed funnel.
  - c. The soil around the earthing electrode shall be treated to reduce the resistivity of the soil by filling the complete depth of electrode with alternative layers of charcoal and salt.
  - d. The funnel shall be enclosed in a masonry chamber of 600mm x 600mm dimensions. The chamber shall be provided with GI frame and CI inspection cover. The earth station shall also be provided with a suitable permanent identifications label tags.

#### 11.6.7.2 Onsite Testing

The earthing stations and the earthing network shall be tested for following on completion of the installation:

- a) Earth resistance of electrodes.
- b) Continuity of conductors and joints.

#### 11.7 High mast

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The specification defines the requirements for design, fabrication, testing at manufacture's work, supply, installation at site, testing and commissioning of High Mast lighting system, including supply and installation of associated cables and materials, design of civil and structural foundation and supply of all related materials.

#### 11.7.1 Quality certification

11.7.1.1 The design, manufacture, testing and performance of High Mast shall comply with all current statutes, regulations and safety codes in the locality where the equipment will be installed. Unless otherwise specified, the High Mast shall conform to the relevant Indian Standards. The relevant IS are:

IS: 2713	Tubular steel poles for overhead power lines
IS: 1944	Code of Practice for Lighting of public thoroughfare
IS: 875 Pt-3	Code of Practice for Design loads for Buildings & Structures (Other than Earthquake)
IS: 6665	Code of Practice for Industrial Lighting
IS: 3043	Code of Practice for Earthing
IS: 3961	Recommended current ratings for cables
IS: 2629	Code of Practice for galvanizing
IS: 325	Three- phase induction motors
IS: 2309	Code of practice for protection of building and allied structures against lightning
IS: 4691	Degree of protection provided by enclosure of rotating machines


#### 11.7.2 Specific design requirements

11.7.2.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.


11.7.2.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply.

11.7.2.3 Vendor shall give a notice for at least one year to the end user of equipment and tell before phasing out the product/ spares to enable the end user for placement of order for spares and services.




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- 11.7.2.4 The high mast lighting system shall have a minimum design life of 25 years unless otherwise specified.
- 11.7.3 Mast
- 11.7.3.1 The high mast shall be of continuously tapered, polygonal cross section atleast 16 sided, presenting a pleasing appearance and shall be based on proven In-Tension design conforming to the Standards referred to above, to give an assured performance and reliable service.
- 11.7.3.2 Minimum height of mast shall be 20 meters, unless otherwise specified, with minimum diameters of 152mm at the top and 612mm at the bottom. Minimum plate thickness of bottom section shall be 5mm and other sections 4mm. The structure shall be suitable for wind loading as per IS:875, Pt-3 and suitable for fixing LED type flood light fittings.
- 11.7.3.3 The mast shall be capable of safely withstanding the strong winds prevailing at site. The deflection at the top during heavy monsoon periods shall therefore be considered in the design and the mast designed in such way that the above deflection during worst periods is kept to a minimum value.
- 11.7.3.4 The mast shall be fabricated from special steel plates, conforming to BS-EN10-025, cut and folded to form a polygonal section as stated above and shall be telescopically jointed and fillets welded. The welding shall be in accordance with BS:5135.
- 11.7.3.5 The procedural weld geometry and the workmanship shall be exhaustively tested on the completed welds. The mast shall be delivered in two/three sections, and shall be jointed together by slip-stressed-fit method at site. No site welding or bolted joint shall be done on the mast. The minimum over lap distance shall be 1.5 times the diameter at penetration.
- 11.7.3.6 The mast shall be provided with full penetrated flange which shall be free from any lamination or incursion. The welded connection of the base flange shall be fully developed to the strength of the entire section. The base flange shall be provided with supplementary gussets between the bolt holes to ensure elimination of helical stress concentration. For the environmental protection of the mast, the entire fabricated mast shall be hot dip galvanised, internally and externally, having a uniform thickness of 65 microns.
- 11.7.3.7 The base flange shall be provided with gaskets and high tensile anchor bolts.
- 11.7.3.8 The bottom section shall have adequate sized opening approximately 1000mm x 300mm with a hinged door to accommodate electric drive for winch, cable, plug socket, etc. The opening shall be such as to permit clear access to the above components inside the mast. The opening shall be complete with a close fitting, dust and vermin proof door, weather protected with gaskets of durable material and provided with a heavy-duty double locking arrangement. The door opening shall be carefully designed and reinforced with welded steel section, so that the mast section at the base shall be unaffected and undue buckling of the cut portion is prevented.

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- 11.7.3.9 The means for natural ventilation of the mast shall be provided.
- 11.7.3.10 The whole head frame assembly shall be covered and protected by an aluminium canopy secured to the frame by stainless steel bolts and nuts. The canopy shall have suitable prevention arrangement against entry of birds etc.
- 11.7.3.11 The mast shall have integral power tool for winch drive unless otherwise specified in the data sheet.
- 11.7.3.12 The mast shall have stainless steel earthing terminal at convenient location in the base compartment and these shall be suitable for connection with 50x6mm GI strip to the plant-earthing network unless otherwise specified. Minimum two number earth pit shall be provided for each high mast.
- 11.7.3.13 One number heavy duty, hot dip galvanised lightning finial shall be provided for each mast as per standard IS-2309. The finial shall be minimum 1.2 M in length and shall be provided at the centre of the head-frame. It shall be bolted solidly to the head frame to get a direct conducting path to the earth through the Mast body. The lightning finial shall, under no circumstances, be provided on the lantern carriage, in view of the safety of the system.
- 11.7.3.14 The complete design of the mast and associated foundation shall be such that mast is structurally and mechanically safe.
- 11.7.4 LANTERN CARRIAGE
- 11.7.4.1 The Lantern carriage shall be of steel tubular ring type construction designed to accommodate the specified number of lighting fixtures and balance counter weights shall be provided wherever required. The carriage shall be fabricated in two halves jointed by bolted flanges to enable easy removal from the erected mast for replacement and maintenance purpose.
- 11.7.4.2 The complete lantern carriage assembly shall be hot dip galvanized after fabrication. It shall have perfect self-balance arrangement so as to avoid swing and to prevent damage to mast surface or other installed parts, during lowering/ raising operation of carriage.
- 11.7.4.3 All hardware used shall have necessary corrosion protection. The carriage shall have weather protected IP-55 cast aluminum junction box with required number of terminals (phase, neutral and earth) for connection to the designed number of flood light fittings and associated control gears fixed on the carriage. 2.3.4 Unless otherwise specified, Lantern carriage shall be suitable for accommodating a minimum of 12 numbers of flood light fixtures. The number, wattage and type of lighting fixture of the high mast shall be as specified in job specification/ data sheet.
- 11.7.4.4 The flood light fixtures shall have die cast aluminum body with facility for lamp centering and focusing and shall be provided with angle indicator for aiming, and also with anodized and polished aluminum reflector with control gearbox.

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- 11.7.4.5 Twin cluster LED type medium intensity flashing lamps, maintenance-free aviation obstruction lighting fixtures for mast height 30meters and above shall be provided.
- 11.7.4.6 Provision shall also be available to test the luminaries while lantern carriage is in lower position by connecting the plug to the receptacle
- 11.7.5 WINCH ASSEMBLY
- 11.7.5.1 For lowering and raising of lantern carriage assembly, a winch arrangement shall be fixed at the bottom of the mast. This shall have provision to operate both manually and electrically.
- 11.7.5.2 The winch shall be suitable to handle the weight of the lantern carriage assembly with lighting fixtures and all other accessories, with factor of safety not less than two unless otherwise specified.
- 11.7.5.3 Minimum two number of winch drum shall be provided for the winch assembly. The winch shall be of self-sustaining type with positive locking arrangement without the need for brake shoe, springs or clutches. The winch drums shall be grooved to ensure perfect seat for stable and tidy rope lay, with no chances of rope slippage. The rope termination in the winch shall be such that distortion or twisting is eliminated and atleast 5 to 6 runs of rope remains on the drum even when lantern carriage is fully lowered and rested on the rest pads.
- 11.7.5.4 The winch shall be self-lubricating type by means of an oil bath.
- 11.7.5.5 The mast shall be fitted with flexible stranded high tensile strength stainless steel wire ropes, which shall have a factor of safety not less than five times the safe working load of winch.
- 11.7.5.6 Particular care shall be exercised in all aspects of design, manufacture, testing and installation arrangements of the system to ensure safety under all operating conditions.
- 11.7.5.7 The material of construction for top pulley block shall be non-corrosive and preferably made up of die cast LM-6 aluminum alloy, with self-lubricating bearing. The design shall ensure that the operation of pulley is maintenance-free.
- 11.7.5.8 The capacity, operating speed, safe working load of the recommended lubrication and serial number of the winch shall be clearly marked on each winch. The gear ratio may be according to manufacturer's standard.
- 11.7.5.9 The winch shall be type tested in presence of reputed Institution and the test certificate shall be furnished before supply of material. A test certificate shall be furnished by the vendor from the original equipment manufacturer, for each winch in support of the maximum load operated by the winch.
- 11.7.6 POWER TOOL FOR WINCH DRIVE (1 No. to be supplied for all high masts put together)


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- 11.7.6.1 A suitable, high powered, electrically driven, externally mounted, power tool, with manual operating handle, together with an operating stand shall be supplied for raising and lowering of the lantern carriage for maintenance purpose.
- 11.7.6.2 The speed of power tool may preferably be of slow speed, of 1.5 to 1.8 mtr/minute, so that vibrations associated with high speed are avoided.
- 11.7.6.3 The power tool shall be single speed, provided with a motor of required rating, suitable for trolley mounting. The power tool shall be supplied complete with push button type remote control switch, together with 6 (six) meters of power cable, so that the operation can be carried out from a safe distance of 5 (five) meters. The capacity and speed of the electric motor used in the power tool shall be suitable for lifting of the designed load installed on the lantern carriage.
- 11.7.6.4 The power tool trolley shall be so designed that it will not only be self supporting but also align the power tool perfectly with respect to the winch spindle during the operations. Also, a handle for the manual operation of the winches, in case of problems with electrically operated tool, shall be provided and shall incorporate a torque limiting device.
- 11.7.6.5 There shall be a separate torque limiting device to protect the wire ropes from over stretching. It shall be mechanical with suitable load adjusting device. The torque limiter shall trip the load when it exceeds the adjusted limits. There shall be suitable provision for warning the operator once the load is tripped off. The torque limiter is a requirement as per the relevant standards in view of the overall safety of the system. Internal built-in type power tools shall not be acceptable.
- 11.7.6.6 It is utmost importance that the complete power tool, including trolley, motor, PB station and lead etc. shall be designed, assembled / built and supplied as one unit by the original equipment manufacturer (OEM). Locally assembled / built makeshift contraption, in lieu of the above, to be called as power tool by the Contractor, shall under no circumstances be accepted.
- 11.7.7 FEEDER PILLAR BOX
- 11.7.7.1 Each high mast shall be supplied with one power supply feeder pillar distribution box, which shall be located near it. The feeder pillar-box shall be metal enclosed, free-standing type made out of 2mm thick mild sheet steel, epoxy painted and IP-55 weather protected. Additional canopy for rain protection shall be provided as an integral part of feeder pillar distribution box. 2.6.2 The feeder box shall be complete with incomer MCCB, ELCB, motor starters for winch drive, MCB for lighting control and a 3 pin 5/15A socket along with 15A MCB. MCCB and ELCB shall be separate unit.
- 11.7.7.2 Motor starter shall be complete with MCCB/MPCB, contactor, and bimetal relay with single phasing prevention feature.

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- 11.7.7.3 LEDs for indication of incoming power supply healthy for feeder pillar incomer shall be provided. Feeder pillar shall also have provision to receive emergency power supply for aviation fixtures in case specified in the data sheet.
- 11.7.7.4 Adequately rated space heater with MCB, thermostat shall be provided for the feeder pillars.
- 11.7.7.5 Feeder pillar shall have adequate space to receive incoming and outgoing cable terminations for 415V, TPN supply loop-in and loop-out arrangement. The feeder pillar-box shall be complete with double compression nickel-plated brass cable glands and tinned copper lugs. The gland plate shall be of 3mm thickness.
- 11.7.7.6 The feeder pillar shall have two numbers external earthing terminal.
- 11.7.7.7 The feeder pillar-box shall have required wiring interface for taking signals from hand held external control push button station for raising and lowering of lantern carriage. The feeder pillar-box shall be installed on a raised concrete foundation block and foundation shall be up to the level of minimum 300mm above ground level.
- 11.7.8 LOCAL CONTROL STATION
  - 11.7.8.1 Local control station shall be hand held type. This control station shall have necessary raise/lower pushbuttons, emergency stop push button etc.
  - 11.7.8.2 The hand held control Push button station shall be supplied with minimum of 5 meters length of 5Cx2.5 sq mm flexible cable and cable type shall be with copper conductor, EPR insulation, metal braiding and overall PVC sheath. The hand held control station and associated cable shall be kept inside feeder pillar-box when not in use and suitable arrangement shall be provided for the same.
- 11.7.9 LIGHT FIXTURE
  - 11.7.9.1 LED type of flood light fittings of reputed makes are only to be used. The spectral distribution of LED type lights shall be such that, all colors used for plant can be correctly identified. The LED chip shall be suitable for universal burning conditions/ positions.
  - 11.7.9.2 The Minimum Power factor required for light fixtures is 0.9.
  - 11.7.9.3 The illumination design should be such that, an average horizontal illuminance of 20 lux is obtained on the plant area with uniformity ratio of 4:1 (average to minimum). The arrangements and aiming of flood light should be such that, plant receives light from different directions to minimize shadow. The open area earmarked clearly as "open space" in the drawing to be illuminated with an average 1 lux illumination.
  - 11.7.9.4 OVER VOLTAGE RELAY & TIMER: The mast should be suitably provided with a timer for switching the lights on & off (preferably with adjustment for seasonal changes in day-light). Also an over/ under voltage relay to be provided for each mast.
- 11.7.10 Cable and cable connections



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- 11.7.10.1 All power and control cables including flexible trailing cables shall be supplied, laid and terminated by the high mast vendor.
- 11.7.10.2 The electrical connections from base compartment to the junction box on the lantern carriage shall be made through special multi-core trailing cable of minimum size 4sq.mm copper conductor, EPR insulated and sheathed in heavy duty polychloroprene.
- 11.7.10.3 Minimum 8 cores shall be provided unless otherwise specified. Separate cores shall be used for lighting fixtures; aviation fixtures and one dedicated core shall be kept for earthing. Suitable chemicals shall be added to outer sheath of cable to protect cable against birds, rodent and termite attack.
- 11.7.10.4 All power and control cables shall be 1100V grade and shall conform to IS-1554 and all flexible-trailing cables shall also comply with requirement of IS-9968.
- 11.7.10.5 The trailing cable shall be terminated by means of metal cased plug and socket, which shall be provided at the base compartment to enable easy disconnection.
- 11.7.10.6 The cable for connection to flood lighting fixtures /aviation lighting fixtures from junction box provided on lantern carriage shall be through 2.5 sq.mm flexible copper conductor, PVC insulated cable as per IS:694. The trailing cable at the lantern carriage shall be taken in flexible metal conduit.
- 11.7.10.7 Connection to the power tool motor inside mast at the bottom shall be through metal cased plug and socket arrangement to enable easy disconnection. All cabling from feeder pillars to high mast shall be laid in directly buried trenches.
- 11.7.11 CIVIL AND STRUCTURAL WORK
- 11.7.11.1 The scope of work under this specification includes design, detailing, supply and construction of foundations for high light mast works. The work shall in general be executed as per IS: 456 and all referred codes therein.
- 11.7.11.2 Materials:
- i) Cement: The cement used shall be any one of the following:
    - a) 33 Grade ordinary Portland cement conforming to IS: 269
    - b) 43 Grade ordinary Portland cement conforming to IS: 8112
    - c) Sulphate resisting Portland cement conforming to IS: 12330
  - ii) Aggregates
    - a) Only natural existing aggregates conforming to IS: 383 shall be used.
    - b) Coarse aggregate shall be 20mm downgraded as per IS: 383
    - c) Fine aggregate shall be graded evenly from fine to coarse as per Zones II and III of IS: 383. Zone IV aggregate shall not be used.
  - iii) Water



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Water used for manufacture and curing of concrete shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel as specified in IS: 456. Potable water shall be considered satisfactory.

iv) Chemical Admixtures

- a) Chemical admixtures, if used, shall conform to IS: 9103.
- b) Criteria of use of chemical admixtures shall be as per IS: 456

v) Reinforcing Steel

- a) Only high strength deformed steel bars of grade Fe-415 conforming to 1786 shall be used.
- b) Minimum diameter of main reinforcing bars in foundation and pedestal shall be 12mm. Links shall be of minimum 8mm diameter

vi) Anchor / Foundation Bolts

Mild steel bars for black hexagon bolts shall conform to IS: 432 Grade 1. Precision hexagon bolts, screws & Nuts shall conform to IS: 1363 and IS: 3138.

vii) Grout

Premix free-flow non-shrink cementations grout, with a minimum compressive strength of 40N/mm<sup>2</sup> at 28 days, shall be used.

viii) Concrete

The concrete shall be design mix of grade and other requirements as mentioned in project data sheet. 75mm thick lean concrete shall be provided under the structural foundation of proportion 1:5:10 using 40mm down aggregates. The mud mat of lean concrete shall project 50mm beyond all sides of the structural foundation slab.

11.7.12 Design of Foundation

11.7.12.1 The foundation shall be placed minimum 1.5 meters below Finished Grade Level (FGL) or Existing Ground Level (EGL), whichever is lower.


11.7.12.2 Ground water table shall be considered at FGL/EGL, whichever is higher

11.7.12.3 Factor of safety against overturning and sliding shall be considered as 2.0 and 1.5, respectively. Only 50% of the overburden weight of backfilled soil over base slab of the foundation shall be accounted for checking of over-turning and sliding. All design parameters for foundation shall be as per IS: 456 and referred BIS codes. Limit state method shall be used.

11.7.12.4 Safe Bearing of Soil (SBC) shall be as per the Soil Investigation Report.

11.7.13 Loadings Loading in general shall be as per IS: 875. The basic wind speed shall be as per the Project/site location and as called for in IS: 875. K1 and K2 factors shall be unity. K3 shall be appropriate to topography but not less than 1.0.

11.7.14 Review of foundation design/drawing

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Design and drawing shall be prepared on standard size sheets and submitted for review/approval prior to execution of works. Construction shall not be taken up prior to documents/drawings reviewed and approved.

#### 11.7.15 Construction Requirements

Construction shall be done following all safe practices required as per IS: 456 and other referred codes.


#### 11.7.16 INSPECTION, TESTING AND ACCEPTANCE AT WORKS

11.7.16.1 During fabrication, the High mast lighting system equipment and materials shall be subject to inspection by Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only proven raw material is used. The manufacturer shall furnish all necessary information /data concerning the supply to Owner's inspectors. The vendor shall give at least 30 days notice to the purchaser regarding the date of testing to enable him or his representative to witness the tests

11.7.16.2 Tests shall be carried out at the manufacturer's works under his care and expense. All routine tests as specified by the applicable standard codes shall be conducted. Type test certificates for the high mast lighting system equipment shall be furnished from a recognized testing organization.

11.7.16.3 In addition, acceptance and functional tests shall be conducted on mast as per Owner approved vendor's QAP to check mechanical and electrical operation.

- a) Mechanical operation of the lantern carriage
- b) Load carrying capacity test
- c) Operation of winch for over speeding/time to raise and lower
- d) Visual check of positive locking arrangement of winch system
- e) Visual and breaking test of the steel wire rope
- f) Test of remote control function and manual operation
- g) Test on the power tool as per relevant standards
- h) Component / Auxiliary Component Failure
- i) Test of all protection, alarm and trip functions
- j) Check degree of protection of cubicles
- k) Check simulation facility control signals for testing purposes
- l) Check space available for cable termination size and number of terminals, cable supporting devices
- m) Check accessibility of components Check earthing of cubicles and cubicle doors  
Check the quality of galvanization of mast structure.

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- n) In addition to above, all functional and electrical tests shall also be conducted on feeder pillars/control cubicles.

11.7.16.4 All tests shall be conducted as per relevant applicable standards

11.7.16.5 Pre-commissioning tests shall be carried out but not limited to the following:

- a) Insulation resistance tests
- b) Continuity test
- c) Earth continuity check and measurement
- d) Load current in all phases shall be measured in each mast
- e) All safety interlock
- f) Feeder pillar wiring schematics and functional requirements

## 11.8 Lightning Protection System

Lightning protection system is used to protect the equipment from direct lightning surges.

### 11.8.1 Quality Certification

11.8.1.1 Lightning protection system shall comply with the latest IEC/IS standards along with below mentioned standards. Below Table presents a non-exhaustive list of standards to which the lightning protection system should conform.


IEEE: 998 - 1996 IEC 62305 1-4 IS 2309	Direct Lightning Stroke Shielding of Substations
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### 11.8.2 Specific Design Requirements

11.8.2.1 The main purposes of lightning protection system are to provide protection to structures from lightning strokes and to provide low resistance conducting path to lightning discharge. Lightning protection will also be provided for building / structures where the calculated risk index exceeds 40.

11.8.2.2 The system design for lightning protection shall be based on the following. However, same shall be finalized during detailed engineering with the approval of Owner.

- i) Air termination network with down conductors and earthing electrodes will be provided on the basis of IEC / IEEE/IS Code of Practice.
- ii) Horizontal air termination shall be so laid out in such a way that no part of the MCR building roof should be more than 9 meters from the nearest horizontal protective conductor.
- iii) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.

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- iv) Down conductors will run along the outer surfaces of the building and shall have a test joint about 1 meter above ground.
- v) An earth electrode will be provided at the connection point of the down conductor with the station ground.
- vi) Galvanized steel rods and flats will be generally used for air termination and connections. All connections will be welded type.

#### 11.8.2.3 Air Terminations


- i) The vertical air terminals rods shall be installed at the roof of buildings or at the suitable locations to be finalized during detailed engineering so as to protect the structures/equipment from lightning strokes.
- ii) The vertical air terminal shall be made of 20mm diameter galvanized steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- iii) The air terminal rod shall be properly fixed on the top of the building / structure to withstand wind pressure at site. In case, the air terminal rod is embedded at the top of roof of building. The portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- iv) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 50 x 6mm galvanized steel flats.

#### 11.8.2.4 Down Conductor

- i) The down conductors shall be 50 x 6mm galvanized steel flats. The sizes of down conductors and horizontal conductor provided for lightning protection shall be 25 x 3mm galvanized steel flats. One end of this shall be connected with air terminal rod/horizontal conductor at the top of roof / structure and other end connected to the nearest 40mm diameter mild steel rod riser from ground electrode.
- ii) Each down conductor shall have an independent earth termination. In no case, conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- iii) The connection between each down conductor and rod electrode (by means of 40mm mild steel rod riser) shall be made via test link located at approximately 1500mm above ground level.
- iv) Down conductor shall be cleated on outside of the building wall and column/structure at about 750mm interval unless stated otherwise in the drawing to be finalized during detailed engineering.
- v) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.

#### 11.8.2.5 Electrodes

- i) The electrodes shall be 40mm diameter 3000mm long MS steel rod

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- ii) All the electrodes shall be interconnected by means of one 40mm diameter MS rod, which will be laid underground at a minimum depth of 600mm below finished grade level unless stated otherwise. This ground mats / electrode in turn shall be connected to main grounding grid.

11.8.2.6 Riser: All risers connected to grounding mat shall be 50x10mm GS flat.

#### 11.8.2.7 Jointing and Connection

- i) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- ii) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1mm after connection.
- iii) All the joints shall be connected by arc welding process overlapping of the conductors at straight joints and overlapping shall not be less than 150mm. The contact surfaces shall be cleaned properly before jointing.
- iv) The portion of galvanized steel flats shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding. The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- v) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- vi) The steel to copper connection shall be brazed type.

#### 11.8.3 Specific Erection Requirement

11.8.3.1 The Lightning protection system shall be tested for following on completion of the installation:

- a) Earth resistance of electrodes.
- b) Continuity of conductors and joints.


#### 11.9 Availability Based Tariff (ABT) Meter

##### 11.9.1 Quality Certification

11.9.1.1 Availability based tariff metering through check and main energy meters shall be installed within the solar plant premises. Meters shall have an accuracy class of 0.2S and shall be microprocessor based conforming to IEC-60687 & Latest CEA metering regulation.

11.9.1.2 ABT meters shall comply with the latest IEC/IS standards along with below mentioned standards. Below Table presents a non-exhaustive list of standards to which the meter should conform.

IEC : 60687	Static Watt hour meter for class 0.2s with the latest amendments
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IEC : 62053 - 22	Static meters for active energy (class 0.2S and 0.5S)
IEC : 62056	Electricity metering - Data exchange for meter reading, tariff and load control
IEC : 62053 - 23	Static meters for reactive energy
IS 15959	Data Exchange for electricity metering (DLMS/COSEM)- Critical for remote AMR (Automatic Meter Reading)

#### 11.9.2 Specific Design Requirements

11.9.2.1 Utility main and check energy meters shall be provided by contractors; consequently, contractors are expected to coordinate with the utility and provide the meters. Installation of meters complying PGCIL's/Utility requirement shall be done by the contractor. Location of meter, metering CT & PT shall be as per PGCIL/Utility requirement. Metering CT & PT specification shall be as per PGCIL/Utility requirement.

#### 11.10 Auxiliary Power Supply


IS 8623	Low-Voltage Switchgear & Control Assemblies
IS 13947/IS 60529	Degree of Protection (IP Code)
IS/IEC 60947-2	Circuit Breaker (MCCBs)
IS/IEC 60947-4	Air Break Switches/Fuse units
IS 16227/IEC 61869	Instrument Transformers (CT/VTs)
IS 1248/IEC 60051	Measuring Instruments (Digital Meters)
IS/IEC 60947-7-1	Terminal Blocks

#### 11.10.1 Auxiliary supply distribution Panel


##### 11.10.1.1 General requirements

- i) Switchboards shall be of metal enclosed, indoor, floor-mounted, free- standing type.
- ii) All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non- magnetic material.




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- iii) All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/bend by the weight of maintenance personnel working on it.
- iv) The switchboards shall be of bolted design. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cut outs shall be true in shape and devoid of sharp edges.
- v) All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60529. All cutouts shall be provided with EPDM / Neoprene gaskets.
- vi) All switchboards shall be of uniform height not exceeding 2450 mm.
- vii) Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates.
- viii) All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/ component shall be possible without switching off or isolating the other equipments/components.
- ix) Each switchboard shall be provided with undrilled, removable type gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.
- x) The minimum clearance in air between phases and between phases and earth for the entire busbars shall be 25mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be at least ten 10 mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / fuses/MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminium alloy / copper of adequate size.
- xi) All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- xii) The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.
- xiii) All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet molded compound or

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equivalent type polyester fiber glass molded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.

- xiv) All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All copper to aluminium joints shall be provided with suitable bimetallic washers.
- xv) All busbars shall be colour coded as per IS: 375.
- xvi) Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.
- xvii) The Contractor shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.
- xviii) Panel space heaters shall be provided and the supply for this shall be tapped from incomer, before the isolating switch/circuit breaker. Incoming circuit to space- heater shall have an isolating switch, HRC fuse and neutral link of suitable rating.
- xix) Panel illumination and plug-socket shall also be tapped from the space heater supply.
- xx) A galvanized steel / Copper / Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.
- xxi) The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth without exceeding the allowable temperature rise.
- xxii) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.
- xxiii) All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable

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clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable. However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.

- xxiv) VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.
- xxv) All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.
- xxvi) All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.
- xxvii) All auxiliary wiring shall be carried out with 650V grade, single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm<sup>2</sup> (min.) for control circuit wiring and 2.5 mm<sup>2</sup> (min) for CT and space heater circuits.
- xxviii) Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.
- xxix) All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.
- xxx) All internal wiring terminations shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method.
- xxxi) Similar lugs shall also be provided at both ends of component to component wiring.
- xxxii) Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.
- xxxiii) Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.
- xxxiv) Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC/ XLPE insulated, armoured / unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the contractor, to suit the final cable sizes.


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- xxxv) All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.
- xxxvi) All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local push- button stations etc. shall be provided with prominent, engraved identification plates.
- xxxvii) All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Owner's approval.
- xxxviii) Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.
- xxxix) ON/OFF status and protection trip status of incomers and bus coupler to be provided for SCADA/SAS system.
- xl) Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler.
- xli) It shall be the responsibility of the contractor to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type ii class of co-ordination as per IS: 8544.
- xl ii) Potential-free contacts (dry contacts) and MFM\_-RS-485 ports must be provided to send all status/alarms to the Substation Automation System
- xl iii) Type Tests: Short-circuit withstand strength, Temperature rise test, and Degree of Protection (IP) verification.
- xl iv) Routine Tests: High Voltage (HV) power frequency test, Insulation Resistance (IR) measurement, and Operational/Functional checks.

## 11.10.2 MCCB

### 11.10.2.1 General requirement

- i) MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.
- ii) MCCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc).
- iii) MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher

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size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked. The MCCBs being offered shall have common/interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

#### 11.10.3 Specific requirements for AC main Distribution board

11.10.3.1 The scope of work shall include the design, engineering, manufacture, assembly, inspection, testing at manufacturer's work, supply, packing, transportation, unloading, installation, testing, commissioning, and satisfactory operation of floor-mounted, metal-enclosed AC Distribution Board (LT-ACDB) complete in all respects

11.10.3.2 The LT-ACDB shall be suitable for operation on a 415 V, 3-phase, 4-wire, 50 Hz AC system. The panel shall be provided with following incomers:


- i) Incomer- 1&2: Incoming supply from normal AC mains source through 2 No's of transformers with change over switch.
- ii) Incomer-3: Incoming supply from Diesel Generator (DG) source derived from a 250 kVA DG set.

11.10.3.3 The LT-ACDB shall be designed to ensure safe, reliable, and uninterrupted power distribution, with provision for automatic and manual changeover between the normal AC mains and DG supply sources, as specified elsewhere in this specification.

11.10.3.4 Selection, sizing, adequacy, coordination, and suitability of all equipment, components, and accessories furnished under this specification shall be entirely the responsibility of the Vendor. The Vendor's scope shall include all items necessary for complete, safe, efficient, and reliable operation of the LT-ACDB, including but not limited to:


- i) SFU, Circuit breakers, contactors, relays, meters, and indicating instruments
- ii) Busbars, internal wiring, terminal blocks, and cable alleys
- iii) Protection, control, metering, and annunciation systems
- iv) Mechanical and electrical interlocks
- v) Space heaters, illumination, and panel accessories
- vi) Mounting hardware, support structures, and foundation bolts
- vii) Nameplates, labels, danger notices, and mimic diagrams



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- viii) Remote supervision, status monitoring, alarm annunciation, and data acquisition through the Owner's RTU/SCADA system considering the Potential-free contacts for status, alarm, and trip indications, Analog output signals for electrical parameters, Suitable communication interface modules, if specified
  - ix) All auxiliary devices, fittings, and consumables required for installation and commissioning
- 11.10.3.5 Any item or accessory not specifically mentioned herein but required for the proper and satisfactory performance of the equipment, shall be deemed to be included in the Vendor's scope of supply without any additional cost.
- 11.10.3.6 The LT-ACDB shall be provided with the following minimum outgoing feeders. The final quantities and ratings of feeders will be finalized after detailed engineering:
- i) Two (2) nos. outgoing feeders, each rated at 125 A
  - ii) Two (2) nos. outgoing feeders, each rated at 100 A
  - iii) Three (2) nos. outgoing feeders, each rated at 63 A
  - iv) Three (3) nos. outgoing feeders, each rated at 32 A
  - v) One (1) no. 63 A outgoing feeder for Lighting Distribution Board (LDB), complete with timer-controlled contactor arrangement for automatic lighting control
- 11.10.3.7 In addition to the above, one (1) fully equipped spare outgoing feeder of each rating/type specified above shall be provided for future use. And provide the 10% spare item of each rating which are installed in the subject panel.
- 11.10.3.8 Complete data sheet of LT ACDB as mentioned in technical specifications should be submitted and must be duly filled and signed & sealed otherwise offer shall be liable for rejection. Vendor must take GA, BOM & Scheme drawing approval before manufacturing.
- 11.10.3.9 Supervision during installation, testing and Commissioning of the Panel shall be under Vendor's scope, and it is required to quote accordingly. No separate charges shall be paid. Responsibility of the Vendor also includes supply of any items/material not specifically mentioned but required to complete the system in all respects without any extra price implication to IOCL.
- 11.10.3.10 During fabrication, switchgear shall be subject to inspection by Owner or by third party agency authorized by the Owner. Manufacturer shall furnish all necessary information concerning the supply to Owner's inspectors.
- 11.10.3.11 The complete LT-ACDB shall conform to the requirements stipulated in this specification. All equipment and materials supplied shall be suitable for the intended application, site conditions, and operating environment
- 11.10.4 Power Distribution Board/AC Distribution Board
- 11.10.4.1 The scope of work shall include the design, engineering, manufacture, routine and type testing, inspection, supply, installation, testing, commissioning, and



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satisfactory operation of 100 A PDB (6-way) and high mast including busbar and incoming & outgoing MCB's, suitable for wall, concrete column, or steel structure mounting, for industrial applications.

11.10.4.2 Scope of Supply: The supply scope shall include, but not be limited to, the following:

- i) LV Lighting / Power Panels complete with all accessories, suitable for outdoor industrial service, with minimum IP55 degree of protection, in weatherproof and/or flameproof construction as specified.
- ii) Routine and type testing of the panels in accordance with the applicable standards and technical specifications.
- iii) Packing, forwarding, transit insurance, and transportation up to the project site.
- iv) Recommended commissioning spares.
- v) Mandatory spares, commissioning spares, and a list of operational spares for two (2) years, as specified in the technical specification.

11.10.4.3 Scope of Installation: The installation scope shall include, but not be limited to, the following:


- i) Installation of the panels on wall, concrete column, or steel structure, as applicable.
- ii) Supply and installation of all mounting arrangements, support structures, brackets, clamps, anchor fasteners, and associated hardware.
- iii) Construction of concrete foundations/pedestals for support, wherever required.
- iv) Provision and installation of protective canopies, wherever specified.
- v) Supply and installation of all interconnection and termination hardware, including glands, lugs, ferrules, nuts, bolts, washers, and accessories.
- vi) Equipment identification tags, nameplates, stenciling, and touch-up painting after installation.

11.10.4.4 Handling and Erection

- i) Loading, transportation from storage area to installation location, unloading, shifting, lifting, and erection of the panels using the Contractor's own tools, tackles, lifting equipment, and transportation arrangements.
- ii) Unpacking, inspection, assembly, alignment, and complete erection as per approved drawings and manufacturer's recommendations

11.10.5 Emergency lighting distribution board (ELDB)

11.10.5.1 Feeding from 10KVA UPS , 230V, 1 Ph, 50Hz, floor mounted, Fully Draw out, Double front, conventional type, metal clad, medium voltage IP55, suitable for

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2 incomers and one bus coupler provision along with CT / PT/ relays / multi-function meters / indications & other component, accessories as required.

11.10.5.2 The MLDB shall be designed to ensure safe, reliable, and uninterrupted power distribution, with provision for automatic and manual changeover between the normal AC mains, as specified elsewhere in this specification.

11.10.5.3 Selection, sizing, adequacy, coordination, and suitability of all equipment, components, and accessories furnished under this specification shall be entirely the responsibility of the Vendor. The Vendor's scope shall include all items necessary for complete, safe, efficient, and reliable operation of the ELDB, including but not limited to:

- i) Circuit breakers, SFU units, contactors, relays, meters, and indicating instruments
- ii) Busbars, internal wiring, terminal blocks, and cable alleys
- iii) Protection, control, metering, and annunciation systems
- iv) Mechanical and electrical interlocks
- v) Space heaters, illumination, and panel accessories
- vi) Mounting hardware, support structures, and foundation bolts
- vii) Nameplates, labels, danger notices, and mimic diagrams
- viii) All auxiliary devices, fittings, and consumables required for installation and commissioning

11.10.5.4 Any item or accessory not specifically mentioned herein but required for the proper and satisfactory performance of the equipment, shall be deemed to be included in the Vendor's scope of supply without any additional cost.


11.10.5.5 The ELDB shall be provided with the following minimum outgoing feeders. The final quantities and ratings of feeders will be finalized after detailed engineering:

- i) Three (2) nos. outgoing feeders, each rated at 32 A
- ii) Three (3) nos. outgoing feeders, each rated at 16 A

11.10.5.6 In addition to the above, one (1) fully equipped spare outgoing feeder of each rating/type specified above shall be provided for future use. And provide the 10% spare item of each rating which is installed in the subject panel.

11.10.5.7 Complete data sheet of ELDB as mentioned in technical specifications should be submitted and must be duly filled and signed & sealed otherwise offer shall be liable for rejection. Vendor must take GA, BOM & Scheme drawing approval before manufacturing.

11.10.5.8 Supervision during installation, testing and Commissioning of the Panel shall be under Vendor's scope, and it is required to quote accordingly. No separate charges shall be paid. Responsibility of the Vendor also includes supply of any

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items/material not specifically mentioned but required to complete the system in all respects without any extra price implication to Owner.

11.10.5.9 The complete ELDB shall conform to the requirements stipulated in this specification. All equipment and materials supplied shall be suitable for the intended application, site conditions, and operating environment.

- i) Potential-free contacts (dry contacts) and MFM\_-RS-485 ports must be provided to send all status/alarms to the Substation Automation System

11.10.6 Main Lighting distribution board (MLDB)

11.10.6.1 415V, 160 A, 3 Ph, 4W, 50Hz, 25 kA for 1 sec, Indoor floor mounted, Fully Draw out, Double front, conventional type, metal clad, medium voltage IP55, suitable for 2 incomers and one bus coupler provision along with CT / PT/ relays / multi-function meters / indications & other component, accessories as required.

11.10.6.2 The MLDB shall be designed to ensure safe, reliable, and uninterrupted power distribution, with provision for automatic and manual changeover between the normal AC mains, as specified elsewhere in this specification.


11.10.6.3 Selection, sizing, adequacy, coordination, and suitability of all equipment, components, and accessories furnished under this specification shall be entirely the responsibility of the Vendor. The Vendor's scope shall include all items necessary for complete, safe, efficient, and reliable operation of the MLDB, including but not limited to:

- i) Circuit breakers, SFU units, contactors, relays, meters, and indicating instruments
- ii) Busbars, internal wiring, terminal blocks, and cable alleys
- iii) Protection, control, metering, and annunciation systems
- iv) Mechanical and electrical interlocks
- v) Space heaters, illumination, and panel accessories
- vi) Mounting hardware, support structures, and foundation bolts
- vii) Nameplates, labels, danger notices, and mimic diagrams
- viii) All auxiliary devices, fittings, and consumables required for installation and commissioning


11.10.6.4 Any item or accessory not specifically mentioned herein but required for the proper and satisfactory performance of the equipment, shall be deemed to be included in the Vendor's scope of supply without any additional cost.

11.10.6.5 The MLDB shall be provided with the following minimum outgoing feeders. The final quantities and ratings of feeders will be finalized after detailed engineering:

- i) Three (3) nos. outgoing feeders, each rated at 32 A
- ii) Three (3) nos. outgoing feeders, each rated at 16 A

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- 11.10.6.6 In addition to the above, one (1) fully equipped spare outgoing feeder of each rating/type specified above shall be provided for future use. And provide the 10% spare item of each rating which is installed in the subject panel.
- 11.10.6.7 Complete data sheet of MLDB as mentioned in technical specifications should be submitted and must be duly filled and signed & sealed otherwise offer shall be liable for rejection. Vendor must take GA, BOM & Scheme drawing approval before manufacturing.
- 11.10.6.8 Supervision during installation, testing and Commissioning of the Panel shall be under Vendor's scope, and it is required to quote accordingly. No separate charges shall be paid. Responsibility of the Vendor also includes supply of any items/material not specifically mentioned but required to complete the system in all respects without any extra price implication to IOCL.
- 11.10.6.9 The complete MLDB shall conform to the requirements stipulated in this specification. All equipment and materials supplied shall be suitable for the intended application, site conditions, and operating environment.
- 11.10.7 LT DB (External DB)
- 11.10.7.1 The scope of work shall include the design, engineering, manufacture, routine and type testing, inspection, supply, installation, testing, commissioning, and satisfactory operation of 63 A LV Lighting (12-way) including busbar and incoming and outgoing MCB's, suitable for wall, concrete column, or steel structure mounting, for industrial applications.
- 11.10.7.2 Scope of Supply: The supply scope shall include, but not be limited to, the following:
- i) LV Lighting / Power Panels complete with all accessories, suitable for outdoor industrial service, with minimum IP55 degree of protection, in weatherproof and/or flameproof construction as specified.
  - ii) Routine and type testing of the panels in accordance with the applicable standards and technical specifications.
  - iii) Third-Party Inspection (TPI), as specified.
  - iv) Packing, forwarding, transit insurance, and transportation up to the project site.
  - v) Recommended commissioning spares.
  - vi) Mandatory spares, commissioning spares, and a list of operational spares for two (2) years, as specified in the technical specification.
- 11.10.7.3 Scope of Installation: The installation scope shall include, but not be limited to, the following:
- i) Installation of the panels on wall, concrete column, or steel structure, as applicable.

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- ii) Supply and installation of all mounting arrangements, support structures, brackets, clamps, anchor fasteners, and associated hardware.
- iii) Construction of concrete foundations/pedestals for support, wherever required.
- iv) Provision and installation of protective canopies, wherever specified.
- v) Supply and installation of all interconnection and termination hardware, including glands, lugs, ferrules, nuts, bolts, washers, and accessories.
- vi) Equipment identification tags, nameplates, stenciling, and touch-up painting after installation.

#### 11.10.7.4 Handling and Erection

- i) Loading, transportation from storage area to installation location, unloading, shifting, lifting, and erection of the panels using the Contractor's own tools, tackles, lifting equipment, and transportation arrangements.
- ii) Unpacking, inspection, assembly, alignment, and complete erection as per approved drawings and manufacturer's recommendations

#### 11.10.8 Pre-dispatch Quality and Testing


11.10.8.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.

11.10.8.2 **Routine Test:** All acceptance and routine tests as per the specification and relevant IEC/IS standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. Test certificates shall be submitted for the approval of Owner.

#### 11.11 Diesel Generator

11.11.1 Design requirement: Silent Type Diesel Generating set as per CPCB IV + or better norms along with having Prime Power Rating of KVA as mentioned in respective BoQ/SoR, 415 volts at 1500 RPM, 0.8 lagging power factor at 415 V suitable for 50 Hz, 3 phase system & for 0.85 Load Factor, including testing at factory and site with fuel, load for test and other necessary arrangements Complete as per CPWD specifications, should have QR code which should contain drawing, test report OEM manual, Geo- Tag of manufacturing location, rating plate as per relevant IS Code etc. and consisting of the followings:

11.11.1.1 Diesel Engine:

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Turbocharged Diesel engine 4 stroke water cooled, multi cylinder, dynamically balanced fly wheel, electric start of suitable BHP at 1500 RPM suitable for above output of alternator at 40 OC, 50% RH & at 1000 Meter MSL , capable of taking 10% over loading for one hour after 12 hours of continuous operation. The engine will be with Electronic governor, Dry type Air filter with service indicator, first filling of engine fuel (after commissioning) lubricating Oil, Coolant and other consumables complete with all the required accessories, the Electronic governor shall be as per ISO 8528. The engine shall comply to the latest CPCB norms (CPCB IV + or better) and Conforming to BS 5514, BS 649, IS 10000, IS 10002, IS 13018 and as per CPWD specifications.

11.11.1.2 Engine mounted Instrument Panel fitted with and having digital dis Plate for following:

- i) Start-stop switch with key
- ii) Water temperature indication
- iii) Lubrication oil pressure indication
- iv) Lubrication oil temperature indication
- v) Battery charging indication and Voltage indication
- vi) RPM indication
- vii) Over speed indication
- viii) Low lubrication Oil trip indication
- ix) Engine Running Hours indication
- x) Fuel Level

11.11.1.3 Alternator


Synchronous alternator rated of appropriate KVA, 415 volts at 1500 RPM, 3 phase 50 Hz, AC supply with 0.8 lagging power factor at 40 OC, 50% RH & at 1000 Meter MSL. The alternator shall be having Screen Protected Drip Proof (SPDP) enclosure IP23, brushless, continuous duty, dynamically balanced rotor, capable of taking 10% over loading for one hour after 12 hours of continuous operation, self cooled, self-excited and self-regulated through AVR conforming to IS13364(Part 2)/IS: 4722/BS 2613 suitable for tropical conditions and with class- H insulation.

11.11.1.4 Base Frame & Foundation

Both the engine and alternator shall be mounted on suitable base frame made of MS channel with necessary reinforcement which shall be installed on suitable cement concrete foundation and vibration isolation arrangement as per recommendations of manufacturer.

11.11.1.5 FUEL TANK



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Daily service fuel tank of suitable liters capacity as per CPWD Specifications, fabricated out of 3 mm thick M.S. sheet complete with all standard accessories and fuel piping between fuel tank and diesel engine with MS class 'C' pipes of suitable dia. Complete with valves, level indications & accessories as required as per specifications.

#### 11.11.1.6 Exhaust System

Dry exhaust manifold with hospital type exhaust silencer and catalytic convertor.

#### 11.11.1.7 Starting System


12V/24V DC starting system comprising of starter motors: voltage regulator and arrangement for initial excitation complete with suitable numbers of batteries (180 AH capacity lead acid SMF type) as required as per specifications. The battery shall be housed inside the acoustic enclosure of DG Set.

#### 11.11.1.8 Acoustic and weather proof enclosure with arrangement for fresh air intake for cooling of the engine & alternator, extraction, discharging hot air in to the atmosphere and the temperature rise inside the enclosure, noise level outside enclosure. The acoustic enclosure should be suitable for cable connection/connection through bus-trunking. Such arrangements on acoustic enclosure should be water proof & dust-proof conforming to IP-65 protection. The enclosure shall be as per CPCB IV + or better norms etc. and as per CPWD specifications.

#### 11.11.1.9 AMF Panel

Free standing floor mounted IP 42 automatic mains failure control panel including auto by-pass, suitable for KVA as below for silent type DG set complete with relays, timers, set of CTs for metering & protection and energy analyser to indicate currents, phase and line voltages, frequency, power factor, KWH, Kilo Volt Ampere Reactive Hour (KVARH), KVA (Phase & Total), KW & provision for overload, short circuit, restricted earth fault, under frequency, power (aluminium) and control (copper ) cabling of suitable size upto 15 meter between AMF panel, LT Panel and DG Set including connection interconnection etc. as required, all complete and inter locking and communication/ Ethernet /RS485/SNMP port open protocol for BMS integration including suitable software, the panel shall be of DG Set OEM make etc. as per approved by Engineering in charge and including the following:

- i) Suitable numbers and appropriate capacity 4 pole motorised electrically operated draw out with cradle type 3 position ACB/ MCCB with electronic release for O/C & E/F and shunt trip.
- ii) Auto/Manual/Test/Off selector switch
- iii) Protection for under and over voltage phase reversal (2 nos Over voltage relay, 2 Nos. reverse power relay and 2 Nos. under voltage relay).
- iv) 3 Sets of current transformers 15 P 10 accuracy for protection and 15 VA class-I for metering


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- v) Energy analyser unit to indicate current, Voltage( L N & L\_L), kW, kVA (Phase & Total), Frequency, KWH, PF.
- vi) LED Indicating lamps for load on mains and load on set
- vii) Fuse/ MCB for instruments
- viii) Battery charger, complete with transformer/ rectifier, D.C. voltmeter and ammeter, selector switch for trickle, off and boost and current adjustment.
- ix) Main supply failure monitor
- x) Supply failure timer
- xi) Restoration timer
- xii) Control unit with three impulse automatic engine start/stop and failure to start lockout.
- xiii) Impulse counter with locking and reset facility.
- xiv) ON/OFF/Control circuit switch with indicator
- xv) Audio/Video annunciation for:
  - a) High water temperature
  - b) Low lubricating oil pressure
  - c) Engine over speed
  - d) Engine fails to start
  - e) Full load/maximum load warning
- xvi) Protection for over/under Frequency, Loss of AC sensing, Over Current, Unbalancing load with suitable number of relays and accessories
- xvii) Maintenance notification based on Engine Run Hour & due date
- xviii) Load Management through PLC to achieve auto opening and closing of incomer breakers, bus coupler switching of essential panel , interlocking providing signal to AMF Panel for load status and AMF shall give command to DG Set to auto start / auto stop depending upon load status and requirement etc. and necessary hardware and software required to perform the operation shall be provided by the contractor including all control wiring

#### 11.11.2 Specific Erection Requirement

11.11.2.1 Diesel engine, alternator, AMF panel, Batteries and Chargers shall be installed in a suitable weather-proof enclosure which shall be provided for protection from rain, sun, dust etc. Further, in addition to the weather proofing, acoustic enclosures shall also be provided such that the noise level of acoustic enclosure DG set shall meet the requirement of MOEF.

11.11.2.2 The diesel generator sets should also conform to Environment (Protection) Rules, 1986 as amended. An exhaust fan with louvers shall be installed in the enclosure

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for temperature control inside the enclosure. The enclosure shall allow sufficient ventilation to the enclosed D.G. Set so that the body temperature is limit to 50° C. The airflow of the exhaust fan shall be from inside to the outside the shelter. The exhaust fan shall be powered from the DG set supply output so that it starts with the starting of the DG set and stops with the stopping of the DG set. The enclosure shall have suitable viewing glass to view the local parameters on the engine.

11.11.2.3 Fresh air intake for the Engine shall be available abundantly; without making the Engine to gasp for air intake. A chicken mess shall be provided for air inlet at suitable location in enclosure which shall be finalised during detailed engineering.

11.11.2.4 The Enclosure shall be designed and the layout of the equipment inside it shall be such that there is easy access to all the serviceable parts.

11.11.2.5 Engine and Alternator used inside the Enclosure shall carry their manufacturer's Warranty for their respective Models and this shall not degrade their performance.

11.11.2.6 Exhaust from the Engine shall be let off through Silencer arrangement to keep the noise level within desired limits. Interconnection between silencer and engine should be through stainless steel flexible hose/ pipe. DG set enclosed in enclosure shall be installed on Concrete Pedestal 300 mm above FGL.


11.11.3 Pre-dispatch Quality and Testing

11.11.3.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.

11.11.3.2 In addition to the checks and test recommended by the manufacturer, the Contractor shall carryout the following commissioning tests at site:

11.11.3.3 Load Test

- a) Ambient temperature.
- b) Exhaust temperature if exhaust thermometer is fitted
- c) Cooling water temperature at a convenient point adjacent to the water output from the engine jacket.
- d) Lubricating oil temperature where oil cooler fitted.
- e) Lubricating oil pressure.
- f) Colour of exhaust gas
- g) Speed
- h) Voltage, wattage and current output.
- i) Oil tank level

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#### 11.11.3.4 Insulation Resistance Test for Alternator

- Insulation resistance in mega-ohms between the coils and the frame of the alternator when tested with a 500V megger shall not be less than  $IR=2x$  (rated voltage in KV)+1
- Check of Fuel Consumption
- A check of the fuel consumption shall be made during the load run test. This test shall be conducted for the purpose of proper tuning of the engine.
- Insulation Resistance of Wiring
- Insulation resistance of control panel wiring shall be checked by 500V Megger. The IR shall not be less than one mega ohm.


#### 11.11.3.5 Functional Tests

- Functional tests on AMF/control panel.
- Functional test on starting provision on the engine.
- Functional tests on all Field devices.
- Functional tests on AVR and speed governor.


11.11.3.6 Potential-free contacts (dry contacts) and MFM\_-RS-485 ports must be provided to send all status/alarms to the Substation Automation System

### 12 Preferred make

SN	ITEM	MAKE
1.	FLOOR MOUNTED FIXED TYPE INDOOR/OUTDOOR LT SWITCHGEAR PANEL (ACDB/DCDB)	SWITCHING CIRCUITS
		JAKSON & COMPANY
		VIDYUT CONTROL
		PYROTECH
		VOLTECH MANUFACTURING COMPANY
2.	FLOOR MOUNTED FIXED TYPE INDOOR/OUTDOOR LT SWITCHGEAR PANEL (Bay Marshalling Kiosk)	BCH ELECTRIC LIMITED
		SWITCHING CIRCUITS
		JAKSON & COMPANY
		VIDYUT CONTROL
		PYROTECH
3.	1.1KV LT Power Cable	VOLTECH MANUFACTURING COMPANY
		BCH ELECTRIC LIMITED
		ULTIMA SWITCHGEAR LIMITED
		KEI INDUSTRIES
		POLYCAB
		RPG CABLES
		KEC INTERNATIONAL
		HAVELLS INDIA
		FINOLEX


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SN	ITEM	MAKE
		CABLE CORPORATION OF INDIA
		UNIFLEX CABLE
		CORDS CABLE
4.	1.1 KV CONTROL CABLE	THERMO CABLES
		KEI INDUSTRIES
		POLYCAB WIRES
		UNIVERSAL CABLES
		RPG CABLES
		KEC INTERNATIONAL
		DELTON CABLES
		FINOLEX
		ORIENT CABLE
		V-GUARD CABLES
		HAVELLS INDIA
		ANCHOR
5.	HT CABLE UP TO 33KV	UNIFLEX CABLE
		POLYCAB WIRES
		TORRENT CABLES
		UNIVERSAL CABLES
		CABLE CORPORATION OF INDIA
		RPG CABLES
		KEC INTERNATIONAL
		HAVELLS
		CRYSTAL CABLES
6.	HT CABLE TERMINATION KIT & STRAIGHT THROUGH JOINTING KIT (HEAT SHRINKABLE TYPE)	RAYCHEM RPG
		3M
7.	LAMP (FILAMENT TYPE & LED TYPE)	SIGNIFY
		OSRAM
		SYLVANIA
		SYSKA
		HAVELLS
		SURYA ROSHINI
		WIPRO
		BAJAJ Electricals
8.	LIGHTING FIXTURES WITH ACCESSORIES INCLUDING	BAJAJ ELECTRICALS
		CROMPTON GREAVES
		PHILIPS INDIA
		WIPRO


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SN	ITEM	MAKE
		HAVELLS
		SYSKA
		GE
		SURYA ROSHINI
		OSRAM
		C&S ELECTRIC
		Orient Electric Ltd
9.	33KV SWITCHGEAR PANEL	BHEL
		MEGAWIN
		L&T
		SIEMENS
		JYOTI
		ABB
		SCHNEIDER
		TRISQUARE
		POPULAR SWITCHGEARS PVT. LTD.
10.	33KV CIRCUIT BREAKER	SIEMENS
		Lauritz Knudsen Electrical & Automation (Formerly M/s L&T Electrical & Automation)
		ABB
		SCHNEIDER ELECTRIC
11.	PROTECTION RELAYS (EM)	ABB
		GE Vernova
		SCHNEIDER ELECTRIC
		SIEMENS
		ALSTOM
		Lauritz Knudsen Electrical & Automation(Formerly M/s L&T Electrical Automation)
12.	CABLE LUG	DOWELL
		COMET
13.	CABLE GLAND	BALIGA
		FLEXPRO
		COSMOS
		R-STAHl
		BRACO
		JAINSON
		COMET
14.	GI CABLE TRAY, FITTING, ACCESSORIES INCLUDING BENDS.	INDIANA
		JENCO
		PENTAX FERRO INCORPORATE
		PATNY
		PROFAB




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SN	ITEM	MAKE
		RELIANCE Eloectro Systems
		SADHANA
		STERLITE
		R K ENGINEERING WORKS
		PREMIER POWER PRODUCTS (CAL ) PVT. LTD
15.	33kV ISOLATOR (OUTDOOR TYPE)	A-BOND STRANDS
		SIEMENS
		ABB
		CGL
		DRESCHER & PANICKER
		SCHNEIDER
16.	33kV Potential Transformer (METERING/ PROTECTION)	ABB
		JYOTI
		PRAYOG
		PRAGATI
		INTRAVIDYUT
17.	33kV CURRENT TRANSFORMER (METERING/ PROTECTION)	ABB
		PRAYOG
		PRAGATI
		INTRAVIDYUT
		INSTRANS
		INSUTECH INDUSTRIES
		ELPRO
18.	33kV SURGE ARRESTOR/LA	SIEMENS
		TOSHIBA
		OBLUM
		WS-INDUSTRIES
19.	AB TARIFF ENERGY METER	SECURE
		ELSTER
		L&T
20.	CONDUCTOR	SMITA
		GUPTA POWER INFRA
		SARAVATHY
		GALAXY
		HINDUSTAN VIDYUT PRODUCTS
		APAR INDUSTRIES
		HIRA CABLES
		JSK
		DIAMOND
		HIREN ALUMINIUM
		CABCON INDIA LIMITED
		STERLITE POWER TRANSMISSION LIMITED
		DYNAMIC CABLES

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SN	ITEM	MAKE
		LUMINO
21.	DISC INSULATOR/PIN INSULATOR/ LONG ROD INSULATOR	ADITYA BIRLA
		IEC
		WS INDUSTRIES
		BHEL
		IMPERIAL CERAMICS
		SHREE RADHE INDUSTRIES
		SARAVANA GLOBAL ENERGY
22.	BUS POST INSULATOR	ADITYA BIRLA
		IEC
		WS INDUSTRIES
		MODERN INSULATOR
		SARAVANA GLOBAL ENERGY
23.	ALUMINIUM TUBE	HINDALCO
		INDALCO
		CENTURY EXTRUSIONS
		JINDAL ALUMINUM TUBE
		ALOM EXTRUSIONS
		BALCO
		SUDAL
24.	CONTROL & RELAY PANEL / SAS (INCLUDING GPS AND NETWORK COMPONENTS)	GE VERNOVAVernova
		SIEMENS
		ABB
		Danish Private Limited
		SCHNEIDER
		Easun Reyrolle Ltd
		Enpro Industrial Automation Pvt Ltd
		Toshiba Transmission & Distribution Systems
25.	NUMERICAL RELAYS	GE VERNOVAVernova
		SIEMENS
		SCHNEIDER ELECTRIC
		Easun Reyrolle Ltd
		Schweitzer Engineering Laboratories
		Toshiba Transmission & Distribution Systems
		ABB
26.	220kV CAPACITIVE VOLTAGE TRANSFORMER	ABB
		GE VERNOVAVernova
		BHEL
		CGL
		MEHRU
		SIEMENS
27.	WAVE TRAP	GE VERNOVAVernova

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SN	ITEM	MAKE
		BPL
28.	NIFPS FOR POWER TRANSFORMER	CTR
		EASUN-MR TAP CHANGERS (P) LTD
		TRIL
		TECTONICUS SERVICE
29.	BATTERY (LEAD ACID - PLANTE)	AMARA RAJA
		HBL POWER SYSTEMS
		EXIDE INDIA
		AMCO BATTERIES
30.	BATTERY (NI - CD) FOR UPS	Exide Battery
		Amarraja
		AMCO SAFT
		HBL POWER SYSTEM
31.	BATTERY CHARGER	AMARA RAJA
		AUTOMATIC ELECTRIC
		CHHABI ELECTRICALS
		HBL POWER SYSTEMS
		MASS-TECH CONTROLS
32.	CONTROL DESK	PYROTECH WORKSPACE SOLUTIONS PVT LTD
		COSMOS MEDIA PRODUCTS PVT LTD
		ADARSHA CONTROL SYSTEM PVT LTD
33.	FIBER OPTIC CABLE	FINOLEX CABLE LTD
		ABB
		CORNING CABLES
		DNALINK
		OM OPTEL INDUSTRIES
		R & M
		SIEMON
		TYCO CABLES (TE CONNECTIVITY)
		SIEMENS
34.	FIRE ALARM PANEL	TYCO
		RAVEL
		SIEMENS
35.	INSTRUMENT CABLES	TEMPSENS INSTRUMENTS (I) PVT LTD
		HAVELLS INDIA
		PARAMOUNT COMMUNICATION LTD
		POLYCAB
		DELTON
		KEI
		CORDS
		UNIVERSAL CABLE
		THERMOCABLES
		CMI

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SN	ITEM	MAKE
		ADVANCE CABLES PVT LTD
		GEMSCAB INDUSTRIES LTD
		APAR INDUSTRIES LIMITED
		SUYOG ELECTRICALS LTD
		SPECIAL CABLES PVT LTD
		HABIA CABLES
		KERPEN CABLES
		LAPP CABLES
		GOYOLENE FIBERS (INDIA) PVT LTD
		KEC INTERNATIONAL
		THERMO ELECRTA BV
36.	UPS	VERTIV ENERGY PVT LTD
		HITACHI HIREL POWER ELECTRONICS PVT LTD
		FUJI ELECTRIC
		SIEMENS
		AMARAJA
		APLAB
		SCHNEIDER
37.	STRUCTURAL STEEL	SAIL
		TATA STEEL
		RINL
		ARCELOR MITTAL NIPPON
		JINDAL
		JSW
38.	CEMENT	ACC
		AMBUJA
		BIRLA
		JSW
		JK
		RAMCO CEMENT
		ULTRA TECH
		SHREE CEMENT
		DALMIA
		BHARAT
		BINANI
		INDIA CEMENTS
		JP
		MADRAS CEMENTS
		SANGHI
		ZUARI
		WONDER
39.	REINFORCEMENT STEEL	ARCELOR MITTAL NIPPON STEEL IND LTD
		JSW STEELS LIMITED


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SN	ITEM	MAKE
		RINL
		SAIL
		TATA Steel
40.	PAINT	ICI
		BERGER
		ASIAN PAINTS
		JOTUN
		SHALIMAR
		KANSAI NEROLAC
		SURFA COATS
		JOHNSON & NICOLSON
		DULUX
41.	FIREPROOF DOORS	SHAKTIMET SHIRKE
		VIPER (NAVAIR
		INTERNATIONAL) RADIANT(RDG ENGG)
		PROMAT GODREJ ADHUNIK SIGNUM
		FENESTA REHAU PROMINANCE ASSA
		ABLOY
42.	DG	KIRLOSKAR OIL ENGINES CATERPILLAR
		POWERICA
		JACKSON STERLING WILSON ESCORT
		KUBOTA
		MAHINDRA & MAHINDRA EICHER
43.	220kV Potential Transformer (METERING/ PROTECTION)	MEHRU
		GE VERNOVA
		ABB
		CGL
		BHEL
		VISHAL TRANSFORMER
44.	220kV CURRENT TRANSFORMER (METERING/ PROTECTION)	HEPTACARE
		MEHRU
		GE VERNOVA
		ABB
		CGL
		BHEL
45.	220kV ISOLATOR	VISHAL TRANSFORMER
		HEPTACARE
		SIEMENS
		ABB
		CG POWER
		DRESCHER & PANICKER
46.	198kV LA	SCHNEIDER
		GE VERNOVA
		ABB

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SN	ITEM	MAKE
		CG POWER
		ELPRO
		OBLUM
		SIEMENS
		INSULATIONS INDIA
47.	CIRCUIT BREAKER SF- 6 /OUT DOOR EHV	ABB INDIA LIMITED
		BHARAT HEAVY ELECTRICALS LIMITED
		CG Power and Industrial Solutions Ltd
		GE VERNOVA India Ltd
		Siemens Ltd
		Toshiba Transmission & Distribution Systems (India) Private Limited
		Bharat Bijlee Limited
48.	Admixtures	BASF
		SIKA
		CICO
		PIDILITE
		CHRYSO
		ALCHIMICA
		BOSTIK
		MC BAUCHEMIE
		ACC
		FOSROC
		MYK ARMENT
49.	WATER-PROOFING COMPOUNDS	ACC
		BASF
		SIKA
		CICO
		PIDILITE
		FOSROC
		ROFF
		MYK ARMENT
		BOSTIK
		CHRYSO
		XYPEX
		IMPERMO
		PENETRON
		ALCHIMICA
		MC BAUCHEMIE
		SURFACOATS
50.	CONSTRUCTION CHEMICAL	BASF
		SIKA
		CICO
		PIDILITE



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SN	ITEM	MAKE
		CHRYSO
		BOSTIK
		MC BAUCHEMIE
		ACC
		MYK ARMENT
51.	Tiles	MARBO GRANIT
		GRANAMITE
		BOSS
		NITCO
		ASIAN PAINTS
		RAK
		EURO
		SOMANY
		KAJARIA
		REGENCY
		ORIENT
		JOHNSON
		PELICAN
		VARMORA
		CERA
52.	ACID / ALKALI RESISTANT TILES	SIMPOLO
		REGENCY
		JOHNSON ENDURA
		KOTHARI
		RUSTILE
		PEREFECT ACID WARES
		MAHAKOSHAL POTTERIES
		CHAMPION CERAMICS

### 13 220 kV Power Evacuation system


#### 13.1 Scope of Works

13.1.1 Scope of Supply & Work includes detailed route survey,

13.1.2 Spotting, optimization of tower location, soil resistivity measurements and geo-technical investigation, design & engineering, procurement & supply of all equipment, materials & accessories, testing at manufacturers works, inspections, packing and forwarding, receipt, unloading and storage at site, associated civil works, services, permits, licenses, installation and incidentals, insurance at all stages, erection, testing and commissioning of 220 kV transmission line from Pooling substation to Grid substation for 300 MW capacity Solar projects, complete in all respect, and performance demonstration with associated equipment and materials along with 5 (Five) years of comprehensive operation and maintenance of the Pooling Substation, 220 kV Transmission system and 220 kV bays at ISTS substation from the date of commissioning.

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- 13.1.3 Contractor to provide single circuit 220 kV transmission line on Double circuit tower as per CEA/utility/statutory guidelines and to be finalized during detailed engineering.
- 13.1.4 Scope shall also include design and construction of terminal bay(s), complete in all respect, at ISTS Grid Substation end as per requirement of CTU/PGCIL. It includes but not limited to interconnecting power & control cables, structures, metering CT & PT, Circuit Breaker, SAS panel, main & check meter with metring cubicle, Isolator with earthing switch etc. Liasoning for the work including equipment testing, statutory approvals etc shall be in Contractor's scope.
- 13.1.5 The transmission lines used to evacuate the power generated by the Solar power plant shall confirm in all respects to highest standards of engineering, design, workmanship, this specification, latest revisions of relevant Indian or IEC standards at the time of offer, Indian Statutory Regulations and Acts in force and shall in compliance with respective state/central statutory requirements.
- 13.1.6 Design, selection, supply and installation of foundations for all types of towers and other structures required for the transmission line shall be in the scope of contractor.
- 13.1.7 Further for type tested towers, Contractor shall furnish documentary evidence from OEM for transmission line tower structures along with foundation design and drawing meeting the requirements of the technical specification.
- 13.1.8 All the raw materials such as steel, zinc for galvanising, reinforcement steel and cement for foundation, coke and salt for earthing, bird guards, anti-climbing devices, bolts, nuts, washers, D-shackles, hangers, links, danger plates, phase plate, number plate etc. required for tower manufacturing and erection shall be in the scope of supply of contractor.
- 13.1.9 The tree-cutting shall be responsibility of the Contractor. The Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut. Contractor may note that Owner shall not pay any compensation for any loss or damage to the properties or for tree cutting due to Contractor's work. The cost of cutting the trees, stacking of cut trees, logging of tress, clearing debris and transportation of cut trees (if required) shall be borne by the contractor. Tree Enumeration and obtaining tree felling permission are included in the scope of contractor.
- 13.1.10 The entire stringing work of conductor and earth wire shall be carried out by the contractor as per standard stringing practice.
- 13.1.11 The design, testing, supply and erection of towers, and stringing of conductors, insulators (polymeric type), hardware, optical ground wire (OPGW), earth-wire, joints, splicing, connectors, Joint box, earth-wire clamps, identification plate, danger plate, anticlimbing and earthing devices and all accessories & hardware, which may be required but not specifically mentioned in the specification and are essential for completion and satisfactory operation of the 220 kV transmission system shall be in the scope of contractor.

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13.1.12 Required approvals from relevant agencies for the successful completion of 220 kV transmission system shall be in the scope of the Contractor.


### **13.2 Design and Engineering**

13.2.1 The Contractor shall prepare the detailed design basis report (DBR), Master Drawing List (MDL), Route profile, Tower schedule and abstract, all the design drawings and calculations and shall submit the same to Owner/Owner's appointed PMC for approval during detailed engineering phase.


13.2.2 The Contractor has flexibility to use the standard drawings of Central utility after getting project specific adoption approval from the relevant utility and the Owner, instead of designing the entire transmission system.

13.2.3 In case of design calculations done in spread sheet, editable (working) soft copy of the spread sheet shall also be submitted along with 'pdf' copies during every submission. The Owner shall return the document / drawing to the Contractor with category of approval marked thereon. Two nos. of hard copies of approved documents and drawings shall be submitted to the Owner at its office at New Delhi and one copy at the site. The contractor shall submit basic design data, design documents, drawings and engineering information including Guaranteed Technical Particulars (GTP) and test reports to Owner/Owner's appointed PMC for review and approval from time to time as per project schedule. The documents typically include, but not limited to, the following:

- i) Detailed technical specifications of all the equipment for transmission line works
- ii) Route profile in 'dwg' format.
- iii) Tower abstract in 'Excel' and 'pdf' format.
- iv) Tower schedule in 'Excel' and 'pdf' format.
- v) Foundation and structure drawings of all type of towers in 'word & pdf' format.
- vi) Test reports for type, routine and acceptance tests for all components for transmission line works.
- vii) Design calculations and sheets (civil, mechanical, structural and electrical designs)
- viii) Geo technical investigation data and Topographical survey report including topographical survey data in digital format and Contour plan of the area.
- ix) Transmission line drawings and erection plans as per CTU guidelines
- x) Quality assurance plans for manufacturing (QAP), Standard Operating procedure (SOP) and field quality assurance plan (FQAP).
- xi) Detailed site Environmental, Health and Safety (EHS) plan, fire safety & evacuation plan and disaster management plan.
- xii) Detailed risk assessment and mitigation plan.

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- xiii) O&M Instruction's and maintenance manuals for major equipment.
  - xiv) As-built drawings / documents
  - xv) Project specific adoption approval, in case of Standard design and drawing used.
- 13.2.4 All drawings shall be fully corrected to match with the actual "As - Built" site conditions and submitted to Owner (three sets of hard copies and one set of soft copy) after commissioning of the project for record purpose. All as-built drawings must include the Good for Construction deviation list.
- 13.2.5 The contractor shall ensure that the transmission line comply with all the applicable regulations, codes and standards.
- 13.3 Route survey**
- 13.3.1 To evaluate and tabulate the trees and bushes coming within applicable perimeter of the offered RoW, as per statutory requirement on either side of the central line alignment, the trees will be numbered and marked with quality paint serially from angle point 1 onwards and the corresponding number will be painted on the stem of trees at a height of one meter from ground level. The trees list should contain the following:
- i) Girth (circumference) measured at a height of 1 meter from ground level.
  - ii) Approximate height of the tree with an accuracy of + 2 meters.
  - iii) Name of the type of the species/tree.
  - iv) The bushy and under growth encountered in the 1.5 meters belt should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.
- 13.3.2 The Preliminary Survey and walk-over survey shall be conducted by contractor and the best suitable route shall be proposed from minimum three (3) routes considering minimum number of towers with higher deviation angles and avoiding forest, ecological sensitive zone, gas & fuel pipelines, Great Indian Bustard (GIB) zone, difficult and unsafe approaches.
- 13.3.3 All obligatory details including Power line crossings, road crossing, river crossing, railway crossing, petroleum pipeline crossings, telecommunication line crossing, canal crossing, forest areas or any other important crossings encountered in the line route shall be plotted in the drawing.
- 13.3.4 After approval of line route as determined by the preliminary survey, the contractor shall conduct detailed survey and submit a line schedule along with route, profile, sag template, tower spotting, etc., for the approval of the Owner. To facilitate checking of the alignment, suitable reference marks shall be provided.
- 13.3.5 Detailed Survey
- 13.3.5.1 The Contractor shall take care of the following points while doing the detailed route survey.

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- i) The route of power evacuation through transmission lines from PSS up to point of connection shall be as per approval from Owner and relevant CTU.
- ii) The route must be straight and short as far as possible and most economical from the point of view of construction and maintenance.
- iii) Good farming areas, religious places, forest, civil and defense installations, aerodromes, public and private premises, lakes, gardens, and plantations may be avoided as far as practicable.
- iv) Crossing with permanent objects shall be minimum but where unavoidable, preferably at right angles and shall be with required approvals and clearances.
- v) Difficult and unsafe approaches should be avoided.
- vi) The line should be away from the buildings containing explosives, bulk storage oil tanks, oil or gas pipelines.
- vii) Contractor to ensure all statutory clearances, permissions, NOC and approvals from statutory bodies / Government departments like Transmission utility, Airport Authority, State Highway authority, National Highway authority, Railway Authority, Gram panchayat, individual / farmer, etc.


#### 13.3.5.2 Route Marking

At the starting point of the commencement of route survey, an Indian Standard Angle of 65x 65 x 6 mm section and 1000 mm long shall be driven firmly into the ground to project only 150 mm above the ground level. A punch mark on the top section of the angle iron shall be made to indicate location of the survey instrument. Wooden peg of 50 x 50 x 650 mm size shall be driven at prominent position at intervals of not more than 750 meters along the transmission line to be surveyed up to the next angle point. Nails of 100 mm length should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to project 100 mm only above ground level.

#### 13.3.5.3 Profile Plotting

From the field book entries, the route plan with route details and level profile shall be plotted and prepared as per approved procedure. Reference levels at every 20 meters along the profile are also to be indicated on the profile besides R/Ls at undulations. Areas along the profile, which in the view of the Contractor are not suitable for tower spotting, shall also be clearly marked on the profile plots. If the difference in levels is too high, the chart may be broken up according to requirement. A 10m overlap shall be shown on each following sheet. The chart shall progress from left to right. Sheet shall be in accordance with the IS Standard. For 'as built' profile these shall be A1 size.

#### 13.3.5.4 Sag Template

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Necessary data in respect of conductor, earth wire and insulator have been given in specifications. On the basis of these, the Contractor shall prepare the sag template drawing and tower spotting data and submit the same along with sag tension calculations for the approval of the Owner. Sag template prepared based on the approved sag-template curve drawing shall only be used for tower spotting on the profiles. Two numbers of the approved template, prepared on rigid transparent plastic sheets, shall be provided by the Contractor to the Owner for the purpose of checking the tower spotting. The templates shall be on the same scale as that of the profile.

#### 13.3.5.5 Tower Spotting

With the help of approved sag template and tower spotting data, tower locations shall be marked on the profiles. While locating the towers on the profile sheet, the following shall be considered:

#### 13.3.5.6 Span

The number of consecutive spans between the section points shall not exceed 15 spans or 5 km in plain terrain and 3 km in hilly terrain. Section point shall comprise of tension point with B type, C type or D Type towers (as defined at Clause no 3.5 (c)) as applicable. For all crossing spans such as major road crossings, railway crossings, power line crossings, etc. the span shall not exceed 80% of design span. The normal span shall be considered as per the respective voltage levels and clearances as per IS 5613.

#### 13.3.5.7 Extension

An individual span shall be as near to the normal design span as far as possible. In case an individual span becomes too short with normal supports on account of undulations in ground profile, one or both the supports of the span may be extended by inserting standard body extension designed for the purpose according to technical specification.


#### 13.3.5.8 Road Crossing

At all important road crossings, the towers shall be fitted with double tension insulator strings depending on the type of towers but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces shall be in line with Indian Electricity rules. At all national highway crossings, tensions towers shall be used.

#### 13.3.5.9 Railways Crossings

At the time of detail survey all the railway crossings coming enroute the transmission line shall be finalised as per the regulation laid down by the Railway Authorities. The following are the important features of the prevailing regulations (revised in 1987):



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- a) The crossing shall be supported on D type tower on either side of railway line with double tension insulator strings.
- b) The crossing shall normally be at right angle to the railway rack. The crossing span shall be limited to 80% of design span.
- c) The minimum distance of the crossing tower shall be at least equal to the height of the tower plus 6 meters away measured from the centre of the nearest railway track.
- d) No crossing shall be located over a booster transformer, traction switching station, traction sub-station or a track cabin location in an electrified area.
- e) Minimum ground clearance above rail level of the lowest portion of any conductor under condition of maximum sag shall be maintained as per Indian Electricity rules.
- f) The approval for crossing railway track shall be obtained by the Owner from the Railway Authority. However, six copies of profile and plan, tower and foundation design and drawings, required for the approval from the Railway Authority shall be supplied by the Contractor to the Owner. All the support/liasing in this regard to be given by the contractor.

#### 13.3.5.10 River Crossings

In case of major river crossing, towers shall be of suspension type and the anchor towers on either side of the main river crossing shall be C type tower. Clearance required by navigation authority shall be obtained. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL).


#### 13.3.5.11 Power Line Crossing

Where this line is to cross over another line of the same voltage or lower voltage, towers with suitable extension shall be used. Provisions to prevent the possibility of its coming into contact with other overhead lines shall be made in accordance with the Indian Electricity Rules. The Contractor may be required to under-cross higher voltage lines by erecting gantry structures.

#### 13.3.5.12 Telecommunication Line Crossing

The angle of crossing shall be as near 90 degrees as possible. However, deviation to the extent of 30 degree may be permitted under exceptionally difficult situations. When the angle of crossing has to be below 60 degrees, the matter will be referred to the authority in-charge of the telecommunication system. Permission of the telecommunication authority may be obtained by the Contractor. Also, in the crossing span power line support will be as near the telecommunication line as possible, to obtain increased vertical clearance between the wires.

#### 13.3.5.13 Details Enroute

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All topographical details, permanent features, such as trees, building etc., within 75m distance, on either side of the alignment shall be detailed on the profile plan.

#### 13.3.5.14 Existing Petroleum Pipelines

Adequate clearances shall be maintained from existing pipelines as per Indian Electricity Rules, if any and adjacent road.

13.3.5.15 Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the Indian Electricity Rules, 1956 as amended up to date.

### 13.4 Preliminary Line Schedule


13.4.1 The profile sheets, duly spotted, along with preliminary schedules indicating type of towers, wind span, weight span, angle of deviation, river, power line, petroleum pipelines, railway or road crossing and other details shall be submitted for the approval of the Owner. After approval, the Contractor shall submit three more sets of the hard copy of approved reports along with one set in soft copy of final profile drawings to the Owner for record purpose.

13.4.2 The Contractor shall undertake the check survey during execution on the basis of the alignment profile arrived after the detailed survey. During check survey, if there are minor changes due to unavoidable constraints, the Contractor may have to change the said alignment after obtaining prior approval from the Owner.

### 13.5 Electrical System Data

13.5.1 The design parameters of the transmission lines for altitude up to 1000 m above mean sea level (MSL) shall be as indicated in Table below. Same shall be finalized during detailed engineering phase with the approval of Owner.

Parameter	220kV/ 230 kV AC
Nominal voltage (kV)	220/ 230
Highest system voltage (kV)	245
Lightning impulse withstand voltage (1.2/50 micro sec) (kV peak)	1050
Power frequency withstand voltage under dry condition (kV rms)	460
Switching surge withstand voltage under wet condition (kV peak)	NA
Minimum corona extinction voltage under dry condition (kV rms phase to earth)	156


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Maximum radio interference voltage under dry condition (micro volts)	1000 (at 156 kV rms)
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### 13.6 Applicable Regulations, Codes & Standards

- 13.6.1 All codes referred to shall be the latest revision. Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable


Standard	Description
IS: 802 Parts 1, 2 and 3	Use of Structural Steel in Overhead Transmission Line Tower - Code of Practice
IS 5613 Parts 2 & 3. Section 1 & 2	Code of practice for design, installation and maintenance of overhead power lines
IS 3043	Code of practice for Earthing
IS: 2486	Insulator fittings for Overhead Power Lines
IS: 1498	Classification and identification of Soil for General Engineering Purposes.
IS: 2141	Galvanized steel wire
IS: 2629	Hot dip galvanizing of steel and iron
IS: 398/ SS4240814	Aluminum Conductors for overhead transmission purpose
IS: 808	Dimensions of Hot Rolled Steel Beam, Column, Channel and Angle sections
IS: 4826	Specification for Hot-dipped galvanized coatings on round steel wires
IS: 1367	Threaded steel fasteners: General requirements for bolts, Screws and Studs

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Standard	Description
IS: 6639	Specification for Hexagon bolts for Steel structures
IS: 13134/ IEC 60815	Guide for selection of insulators in respect of pollution conditions
IS: 5561	Specification for Electric Power connectors
IS: 2551	Danger notice plates
IEC: 61109	Composite Insulator
IS: 2121	Conductor & earth wire accessories
IS:3961	Recommended current ratings for cables
IS:5216	Guide for safety procedures and practices in electrical work
IS: 4091 (1979)	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles
IS: 1498	Classification & identification of soil for general Engineering purposes
IS 10262	Guidelines for design mix of concrete
IS 456	Plain and reinforced concrete - Code of practice
IS 383	Specification for aggregates used in concrete
IS 269	Specification for Ordinary Portland Cement
IS 1489	Specification for Portland Pozzolana Cement
IS 455	Specification for Portland Slag Cement
IS 9103	Specification for Admixtures
IS 9013	Method of making, curing and determining compressive strength of accelerated cured concrete

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Standard	Description
	test
IS 1786	Specification for HYSD Reinforcement bars for concrete
IS 2386	Methods of tests for Aggregates for concrete
IS 4031	Methods of tests for physical properties of cement
IS 4032	Methods of tests for chemical properties of cement
IS 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
IS 2062	Hot rolled medium and high tensile Structural steel – specification
IS 12427	Fasteners - Threaded Steel Fasteners - Hexagon Head Transmission Tower Bolts - Specification (Grade 5.6)
IS 10238	Fasteners - Threaded Steel Fastener - Step Bolts for Steel Structures (Grade 5.6)
IS 1363	Hexagon Head Bolts, Screws and Nuts of Product Grade `C`
IS: 4759	Hot dipped zinc coatings on Structural steels
IS : 6005	Phosphating of iron and steel
IS: 2633	Tests on galvanized steel
IS 9708	Vibration dampers
CEA Regulations, 2010 (as amended)	Measures relating to Safety and Electric Supply
CEA Regulations, 2010 (as amended)	Technical Standards for Construction of Electrical Plants and Electric Lines
CEA Regulations, 2011	Safety requirements for construction, operation and maintenance of electrical plants and electric

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Standard	Description
(as amended)	lines
CEA Regulations, 2007 (as amended)	Technical Standard for Connectivity to the Grid
CEA Regulations, 2020 (as amended)	Technical Standards for Communication System in Power System Operation
CEA Manual, 2013 (as amended)	Manual on Transmission Planning Criteria
Indian Electricity Rules	1956 (as amended)
Indian Electricity Act 2003	And subsequent amendments
CERC Regulations, 2013 (as amended)	Communication System for inter-State transmission of electricity
CERC Regulations, 2023 (as amended)	Indian Electricity Grid Code
CEA Guidelines, 2021 (as amended)	Cyber Security in Power Sector

### 13.7 Transmission Towers

#### 13.7.1 Design, Engineering and Fabrication

The scope encompasses the design, engineering, fabrication, galvanizing, and supply of 220kV Double Circuit (D/C) lattice-type transmission towers. Design shall be as per following parameters in line with IS standards but not exhaustive in nature and including civil works of tower foundation:


#### 13.7.2 Supply of 220kV Double Circuit (D/C) lattice-type transmission towers would include

##### 13.7.2.1 Structural Supply: Tower types DA, DB, DC, and DD including stubs, cleats, and extensions (+3m, +6m, +9m).

##### 13.7.2.2 Special Structures: Design and supply of River Crossing and Transposition towers wherever required.

##### 13.7.2.3 Fasteners & Accessories: Anti-theft bolts for lower panels, standard hexagonal bolts, washers, step-bolts, and all requisite identification plates.



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13.7.2.4 Civil Works: Detailed soil investigation, RCC foundation design/construction, and tower earthing.

#### 13.7.3 DESIGN AND ENGINEERING PARAMETERS

13.7.3.1 The towers shall be designed to withstand the specific environmental conditions of the Morena/Sheopur region:


- a) Reliability Level: Level 1 (as per IS 802).
- b) Wind Zone: Wind zone of Madhya Pradesh (as applicable to Sheopur region)
- c) Factors of Safety (FOS): 2.0 for Normal Conditions; 1.5 for Broken Wire Conditions.
- d) Conductor & earth wire configuration
- e) Seismic loads (Zone as applicable)
- f) Configuration: Double Circuit
- g) Conductor: AL-59 Moose
- h) Earth wire / OPGW: As per system requirement
- i) Temperature Range: 5°C to 48°C
- j) Altitude: ~180 m
- k) Terrain Category: As per IS 875
- l) Limit state / working stress as per applicable code

#### 13.7.3.2 Loading Conditions

- a) The following load cases shall be considered:
- b) Normal condition (full load)
- c) Broken conductor condition
- d) Broken earth wire condition
- e) Wind load condition
- f) Temperature variation condition
- g) Erection condition

#### 13.7.3.3 Design Deliverables

- a) Contractor shall submit for approval:
- b) Tower geometry and configuration drawings
- c) Member forces and design calculations
- d) Bill of materials (BOM)
- e) Foundation reactions

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- f) 3D structural model (PLS Tower or equivalent)
- g) Fabrication shall commence only after approval.

#### 13.7.3.4 Tower Types

- a) DA (Tangent): 0-2 degree deviation.
- b) DB (Small Angle): 2-15degree deviation.
- c) DC (Medium Angle): 15-30 degree deviation.
- d) DD (Large Angle/Dead End): 30-60 degree / Terminal tower.
- e) Digital Validation: Contractors must provide a 3D structural model (PLS-Tower or equivalent). The model must confirm zero-interference at joints and compatibility with bolt clearances.

#### 13.7.3.5 Codes and Standards

IS:209-1992	Specification for zinc
CEA regulation 2022	Technical standards for construction of Electrical plant and Lines
IS:800-1991	Code of practice for use of structural steeling general Building Construction.
IS 802	Code of practice for designing and building structural steel overhead transmission line towers
IS 875	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures
IS:1363-1992(Part 3)	Hexagon head bolts, screws and nuts of product grade C
IS:1367-1979	Technical supply conditions for threaded fasteners (First Revision)
IS:2016-1992	Plain washers
IS:2062-1999	Hot Rolled Medium and High Tensile Structural Steel
IS:2629-1990	Recommended practice for hot-dip galvanizing of iron and steel.
IS:2633-1992	Methods of testing weight thickness and uniformity of coating on hot- dip galvanised articles.


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IS:2063-1972	Single Coil Rectangular Section spring washers for bolts, nuts, screws.
IS:4759-1990	Specification for hot-dip zinc containing on structural steel and other allied products.
IS:5358-1969	Specification for hot-dip galvanised coating on fasteners.
IS:5613-1976	Code of practice for design, installation and maintenance of overhead power lines.
IS:6610-1991	Heavy washers for steel structures.
IS:6639-1972	Hexagonal bolts for steel structures.
IS:6745-1972	Methods for determination of weight of zinc coating of zinc coated iron and steel articles.
IS:12427-1992	Transmission Tower bolts of property class 5.6.


*Note: In case of conflict, the more stringent requirement shall prevail.*

#### 13.7.4 PROCUREMENT OF EQUIPMENT'S, TOOLS-TACKLES AND MATERIALS

- 13.7.4.1 All the materials, tools, equipment in sufficient quantity, required for straightening, cutting, drilling, punching, bending, welding, galvanizing etc. activities shall be procured/arranged by the successful Contractor before the work is to be taken up on hand and shall not link the delivery period with procurement / arrangement of these items/tools/equipment. List of equipment and size of galvanized bath shall be submitted along with technical bid.
- 13.7.4.2 The Contractor shall make his own arrangement for procurement of steel conforming to IS: 2062 Grade- A before commencement of work-in sufficient quantity.
- 13.7.4.3 In case of non-availability of any required steel section, Contractor at his own cost shall procure and utilize next higher section to complete the work. However, from design point of view, such alternate higher section shall be got approved from Owner before the use. The total payable weight will be limited to A/T Guaranteed weight only. The Contractor shall make his own arrangement for procurement of required Bolt-Nuts, accessories, attachments like 'D' shackles, 'U' bolts, anchor bolts, step bolts etc. from the preferred makes given in this document well in advance and supply as per scheduled completion period along with the inspection at sub vendor's premises.
- 13.7.4.4 Bolt nuts shall be procured from the manufacturer which is approved by Owner. Contractor have to take prior approval of proposed manufacturer before ordering Bolts & nuts.

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- 13.7.4.5 For any other make of bolt nuts, the Contractor will have to take prior approval of the Owner. For such approval the Contractor has to submit the following in respect of prospective bolt-nut supplier. Plant Capacity per annum. Type test reports for bolt nuts to be supplied (not older than 5 years). List of orders executed / under execution. However, Owner reserves right to test the samples of Bolts & nuts of the proposed Bolt-nut supplier before approving the make. The Owner is at liberty to have samples of steel, zinc etc. to be used, test, check in any Laboratory recognized by the Government at the cost of Contractor and refuse the material if found below standard. The zinc used for galvanizing of fabricated materials shall be electrolytic high-grade zinc (99.95% Purity.)
- 13.7.4.6 All tower members shall be joined together with Bolts and nuts. The redundant members of first two (2) panels from ground level shall be connected with Anti-theft bolts and nuts along with spring washers whereas the balance joints shall be connected with hexagonal bolts and nuts.
- 13.7.5 DRAWINGS AND BILLS OF MATERIALS
- 13.7.5.1 The successful Contractor has to design and submit the drawings and bills of material for Owner approval before commencing the production along with manufacturing QAP (Quality Assurance plan) Proto-Model (if required) shall be prepared and got inspected for the approval along with fabrication sketches, tower drawings and bills of material at no extra cost to the OWNER. Soft copy of approved bill of material must be submitted along with drawings of tower in AUTOCAD format to concern Engineer In Charge, OWNER.
- 13.7.5.2 The approved copies of structural drawings and bills of materials for (4) four sets shall be submitted to the Engineer-in-Charge OWNER.
- 13.7.5.3 The approved copies of fabrication sketches shall be submitted in duplicate only to the Engineer-in- Charge, OWNER.
- 13.7.5.4 Sag tension calculation based on approved check survey and actual river crossing parameter, design of special tower structure and special cross arm(Transposition Tower) shall be approved from Owner and shall test the design before physical assembly. The Contractor shall submit a 3D structural model (in software like PLS-Tower or equivalent) for all tower types and extensions. The model must demonstrate zero-interference at all joints and joints' compatibility with the specified bolt sizes and clearance requirements and subsequently the fabrication sketches, structural drawings and bill of material of respective structure will be approved by Owner.
- 13.7.5.5 The quantity indicated in the schedule are provisional. These quantities may increase / decrease as per the site condition. The actual quantities of tower structures shall be according to approved design and bill of materials.
- 13.7.5.6 Contractor has to provide all data sheets and approved fabrication sketches without any extra cost to Owner. Owner will have right to use such designs, drawings, bill of materials, fabrication sketches etc. for any other project under any other contractor through any other agency / contractor. The Contractor has to pass on design right to Owner.

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13.7.5.7 All the structures shall be fully galvanized mild steel/high tensile steel as per relevant IS standards.. Hexagonal head bolts with nuts and spring washers shall be used for connections.

13.7.5.8 Special type of tower/ higher voltage class towers, wherever required shall also be provided by the Contractor under the contract at no additional cost to the Owner.

#### 13.7.6 MATERIAL

13.7.6.1 Steel required for fabrication of structure member shall conform to IS: 2062 - 1999 Grade A. Only structural mild steel sections shall be used. The zinc required for galvanizing shall be of Zn-99.95% and shall conform to IS: 209-1992.

13.7.6.2 All fasteners and accessories shall conform to the latest revisions of the following Indian Standards:

IS 12427 - High strength structural bolts

IS 1367 (Part 1 to 14) - Technical supply conditions for threaded fasteners

Part 3 - Mechanical properties of bolts (Property Class 5.6)

Part 6 - Mechanical properties of nuts

Part 13 - Hot dip galvanizing

IS 1363 (Part 1, 2 & 3) - Hexagonal head bolts, screws and nuts (product grade C)

IS 2016 - Plain washers

IS 6610 - Heavy washers

IS 3063 - Spring washers

IS 1573 - Electroplating of zinc

IS 2629 - Hot-dip galvanizing process

IS 10238 - Step bolts for transmission line towers

IS 14000 Series - Quality Management Systems (QMS)

13.7.6.3 General Requirements for Bolts and Nuts


##### i) Material and Mechanical Properties

Bolts and nuts shall be of minimum Property Class 5.6 as per IS 1367 (Part 3 & 6).

Minimum shear strength of bolts shall be 310 MPa as per IS 12427. Only partially threaded bolts shall be used; fully threaded bolts are not permitted.

##### ii) Dimensions and Manufacturing

Bolt diameters shall be 12 mm, 16 mm, 20 mm, and 24 mm, as per approved BOM.

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Bolts up to M16 and length  $\leq 10d$  shall be manufactured by cold forging and thread rolling. Bolt heads shall be: Hexagonal/Forged from solid/Concentric and square with shank. Nuts shall be: Hexagonal/Double chamfered as per IS 1363

Not over-tapped beyond 0.4 mm oversize ( $\leq$  M16)

iii) Threading Requirements

Threads shall conform to IS 1363. Thread engagement shall ensure:

Full nut depth engagement. Projection of threaded portion 3 mm to 8 mm beyond nut after tightening. Threads shall permit hand-tight engagement and full strength development.

iv) Length and Assembly Criteria

Bolt length shall ensure: Threaded portion does not lie within clamped member thickness.

v) Maximum connected thickness:

Shall not exceed 3 times bolt diameter (3d)

Bolt arrangement shall allow tightening without interference and be staggered at joints where necessary

vi) Washers

Types and Standards

Plain washers - IS 2016

Heavy washers - IS 6610

Spring washers - IS 3063

Spring washers shall be positive lock type, Electro-galvanized as per Grade IV of IS 1573

Thickness: M12 - 2.5 mm, M16 - 3.5 mm, M20/M24 - 4.0-4.5 mm

Flat/tapered washers shall be used wherever required to ensure proper bearing.

vii) Anti-Theft Fasteners

Shall have Round tapered heads, Hexagonal shear nuts


Shear nuts shall Break at specified torque and Prevent dismantling after installation. It shall conform to IS 12427 and IS 1367 (Property Class 5.6)

viii) Installation and Assembly Requirements

Nuts shall fit tightly against bolt heads without gap. Spring washers shall be provided under all nuts. Bolt positioning shall follow approved structural drawings

Tack welding is applicable for bottom two panels. Exposed areas shall be treated with Zinc-rich primer and two coats of enamel paint



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ix) Step Bolts

It shall conform to IS 10238. It shall withstand minimum 1.5 kN vertical load. Each step bolt shall have 2 nuts and 1 washer.

Diameter: Minimum 16 mm, Length: 150 mm to 175 mm. Head: Button head with 50 mm diameter. Spacing: Maximum 450 mm vertical spacing

Location: Provided from 2.5 m above ground level to tower top

For double circuit towers: Installed on two diagonally opposite legs

x) Ladders and Platforms (for Special Towers)

Ladders shall be provided where specified with safety protection rings

Platforms shall include: 6 mm thick perforated chequered plates

Handrails for safety wherein access shall be provided from ladder to cross-arms and ground wire peaks which is fixed using counter-sunk bolts

xi) Quality Assurance and Testing

Manufacturer shall have in-house testing facilities for:

Zinc coating thickness, Mechanical properties (shear, tensile strength)

QA system shall comply with IS 14000 series

Fasteners shall undergo dimensional inspection, Thread gauge test and Coating inspection

13.7.7 FABRICATION WORKMANSHIP

The details of fabrication shall conform to IS: 802 (Part-II) - 1978.

13.7.7.1 All the structure members shall be accurately fabricated to bolt together easily at site without any undue strain on the bolts. The diameter of the bolt hole shall be equal to the diameter of bolt plus 1.5mm. All similar parts of structure shall be made strictly inter changeable. All steel sections before any work is done on them, shall be carefully, levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure. Fabrication shall be done in factory conditions only


a) No reaming or cutting at site permitted (except approved cases)

b) Tolerances: As per IS 802

c) Identification: Each member shall be stamped/marked

13.7.8 Tower Foundation

13.7.8.1 Reinforced concrete footing shall be used for all types of tower as per the specifications laid herein. All the four footings of the tower and their extension shall be similar, irrespective of down thrust and uplift on each leg of tower.

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13.7.8.2 Foundation includes supply of materials such as cement, sand, coarse aggregates, reinforcement steel, etc., and all works related to construction of foundations including excavation and backfilling, form work, stub setting, placing of reinforcement, Concreting, etc.

13.7.8.3 Foundations: RCC foundations (Grade M25 minimum) based on site-specific soil reports. Tolerances: Verticality (plumb) must be maintained within 1 in 1000 of the tower height.

#### 13.7.9 Tower Earthing


13.7.9.1 Each tower shall be earthed. the tower footing resistance shall not exceed 10 ohms. The Contractor shall measure the tower footing resistance (TFR) of each tower during dry weather after it has been erected and before the stringing of the earth wire. Pipe type earthing and counter poise type earthing shall be done as required in accordance with the following standards:

IS: 3043	Code of practice for Earthing
IS:5613	Code of practice for Design, Installation and maintenance (Part-II/Section-2) of overhead power lines

13.7.9.2 For counterpoise type earthing the earthing will vary depending on soil resistivity. For soil resistivity less than 1500 ohms-meter, earthing shall be established by providing 4 lengths of 30m counterpoise wire. Otherwise, for soil resistivity greater than 1500 ohms meter earthing shall be established by providing 4 length of 70m counterpoise wire.

13.7.9.3 The provisional quantities for pipe type earthings and counterpoise earthing are indicated in the BPS. The Contractors are required to quote unit rates for the same in appropriate schedule of BPS. The quoted price shall include fabrication, supply and installation of earthing material including supply of coke, salt etc. In case of counterpoise type earthing, the unit rates shall correspond to 120 meters of counterpoise wire per tower. Earthing for River Crossing Towers /Pile foundation would entail Galvanised earthing strip of flat 50 x 6 mm is to be provided in two legs of tower for each location with proper arrangement of connecting these strips by 16mm bolts shall be provided in the stubs. For pile foundation, the strip has to be taken up to scour level along the concrete of pile foundations. Only bolted connections are allowed for connecting this strip to achieve desired length. Contractor shall submit the detailed drawing for approval of Employer before installations.

#### 13.7.10 DRILLING AND PUNCHING

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Before any cutting work is started, all steel sections shall be carefully straightened and treated by pressure and not by hammering. They shall again be trued after being punched and drilled. Holes for bolts shall be drilled or punched with a jig but drilled holes shall be preferred. The following maximum tolerance of accuracy of punched holes is permissible. Holes must be perfectly circular and no tolerance in this respect is permissible. The maximum allowable difference in diameter of the holes on the two sides of plates or angles is 0.8 mm i.e. the allowable taper in a punched hole should not exceed 0.8mm of diameter. Holes must be square with the plates or angles and have their walls parallel. Drills or punches shall remove all burrs left completely. When the structure members are in position, the holes shall be truly opposite to each other. Drilling or ramming to enlarge defective holes shall not be permitted.

#### 13.7.11 TOWER ACCESSORIES

The following shall be supplied and installed

- a) Danger plates (Min 2 No's in each tower)
- b) Number plates
- c) Phase plates (RYB set)
- d) Circuit plates
- e) Anti-climbing devices with barbed wire
- f) Bird guards (Min 3 no's per tower)
- g) Earth bonds (Min 2 No's per tower)
- h) Bird flight diverters (as required)
- i) Line information board (as required)

All accessories shall be suitable for outdoor installation in transmission environment, weather-resistant and corrosion-proof as per zone applicable, Compatible with tower structure and Supplied complete with clamps, fasteners and fixing arrangements. All items shall be securely fixed and shall not loosen during service.

#### 13.7.12 ERECTION MARK


- 13.7.12.1 Each individual structure member shall carry a code number conforming to the component number given to it in the bills of material and fabrication drawing. This code number shall be marked with marking dies, having 16 mm size-letter before galvanising and shall be legible after galvanising. The letters indicated for different types of structure shall only be used.

Erection mark shall be "AA - BBB - CC - DDD", where

AA = Contractor's code Alphabet

BBB = Contractor's project number Numerical

CC = Structure type Alphabet

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DDD = Member number Numerical.

This mark shall be got approved from the Owner.

13.7.12.2 Each structure member shall also be marked with indelible ink through stencil of 16 mm size alphabet/numerical.

#### 13.7.13 BENDING

A Mild steel angle sections up to 75 x 75 mm (up to 6 mm thick) shall be bent cold up to and including bend angle of 10 Deg. angles above 75x75 mm (thickness up to 6 mm) and up to and including 100x 100mm (thickness up to 8 mm) may also be bent cold up to the bend angle of 5 Deg. All other angle sections and bend angles not covered above shall be bent hot. All plates up to 12 mm thickness shall be bent cold up to a maximum bend angle of 15 Deg. Greater bends and other thicknesses shall be bent hot. All hot bent material shall be air-cooled. The bends shall be of even profile and free from any surface damages.

#### 13.7.14 GALVANISING

13.7.14.1 The galvanizing shall be done to all the structure members after the fabrication work is completed. The nuts may be tapped or re-run after galvanizing. Threads of bolts and nuts shall have neat fit and can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of bolts.

13.7.14.2 The zinc deposition should not be less than specified, per-galvanized surface area of the fabricated structure member.


13.7.14.3 The galvanizing of the structure members shall conform to IS: 2629-1985 & IS: 4759-1984. All galvanized members shall withstand tests as per IS: 2633-1986. The weight of zinc coating shall be determined as per the method stipulated in IS:2633-1986. Spring washers shall be electrogalvanized as per IS:1573-1970.

13.7.14.4 All the stubs, cleats and stub-setting templates shall be fully galvanized.

13.7.14.5 Unless otherwise specified the fabricated tower parts & stub shall have a minimum overall zinc coating of 610 Gram per Sq. meter of surface except for plates below 5 mm which shall have zinc coating of 460 Gram per sq. meter of surface. The average zinc coating for section 5 mm & above shall be maintained as 87 Micron & that for section below 5 mm shall be maintained as 65 Micron.

#### 13.7.15 CONFORMITY

13.7.15.1 The Contractor shall ensure that the specified materials and workmanship of all structures actually supplied strictly conform to drawings/data supplied/approved by the Owner. In case any deviation is detected during the process of supply or even after erection, the Contractor shall replace such defective structure free of cost to the Owner. All expenditure or losses incurred in erection, Back And Forth transportation and any other expenditure or losses incurred by the Owner on this account shall be borne by the Contractor. No extensions in delivery period shall be allowed on this account.

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### 13.7.16 QUALITY ASSURANCE PLAN


13.7.16.1 The Contractor shall invariably furnish following information along with his offer.

13.7.16.2 Statement providing a list of key raw materials that are proposed to be used in the fabrication in accordance with this specification, names of sub suppliers for the raw materials, a list of standards that govern the testing of the raw materials, a list of tests that are typically performed on raw materials in front of the Contractor's representative as part of routine and/or accepted production, and copies of test certificates for finished goods

- i) Raw material inspection
- ii) Fabrication checks
- iii) Galvanization inspection
- iv) List of manufacturing process sections where quality control stage inspections are typically conducted, along with specifics of the tests and inspections that are performed In accordance with the relevant IS stated, the Contractor's list of testing equipment is provided for final testing. The same tests will be conducted at a third-party lab that has been approved by the government if the Contractor does not have access to the entire acceptance testing facilities. The buyer retains the right to inspect the factory in order to confirm the information stated in the offer. The Contractor's offer will be rightfully refused and he may be placed on a blacklist if any of the details are discovered to be false or deceptive. Special features provided to make it maintenance free. The Employer reserves the right to sample and test steel, zinc, and fasteners at a government-recognized laboratory at the Contractor's expense. The Field Quality Plan (FQP) is to be submitted along with detail engineering phase.
- v) Along with the technical bid or during the detail-engineering phase, the Contractor must also provide the buyer with the following information.
- vi) List of raw materials as well as bought out accessories, and the name of suppliers of raw materials as well as bought out accessories.
- vii) Type test certificates of the raw material and bought out accessories.
- viii) Quality assurance plan (QAP) withhold points for purchaser's inspection.
- ix) The Contractors shall submit the routine test certificates of all the bought out items, accessories etc.

### 13.7.17 INSPECTION

The successful Contractor has to offer inspection of fabricated tower material every month as per scheduled bar chart giving minimum time of not less than 10 days. The inspection of fabricated tower material shall be carried out at manufacturer's works for Acceptance tests as per relevant Indian standard. The inspection of bolts-nuts, hanger, washers, step-bolts and other bought out items shall be carried out at Manufacturer's works as per relevant IS. The testing charges shall be borne by the Contractor. If the testing facilities are not available


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for the tests to be carried out, the same shall be carried out at third party laboratory at no extra cost to the Owner. Owner reserves right to pick-up sample of any material from the lot received at site and get the same tested as per ISS at third party Laboratory (preferably Government Laboratory or Educational Institution). The material should pass these and if the material fails they will be summarily rejected and Contractor should make immediate arrangements to replace them with standard materials and after getting, them duly inspected. Rejected/ defective material if found during inspection shall be destroyed in presence of OWNER representative. The Contractor shall replace the material if not found as per specific requirements, at no extra cost to the OWNER, including testing charges. The Contractor shall provide all the gauges and templates required for measurement of bend angles. The inspection shall be carried out as per guideline given hereunder.

#### 13.7.17.1 GENERAL GUIDELINE FOR INSPECTION

- i) Fabricated Structure Members:
  - a) Visual examination and quantity verification of offered lot.
  - b) Sample selection from the offered lot at a ratio of 50 MT (or part thereof) 1 no. for all tests.
  - c) Dimension, fabrication and trueness verification of structure member from fabrication sketch.
  - d) Galvanizing test of each sample i.e. dip test, hammer test and mass of zinc test.
  - e) Random verification Zinc coating over galvanized surface by Elco meter.
  - f) Tensile test and bend test on each sample.
  - g) Chemical composition test on at least one sample per lot offered for inspection.
  - h) Verification of manufacturer's test certificate for mild steel used in structure members and submission of copy of the same along with inspection report. Failing in which dispatch instruction will not be issued.
- ii) Bolts-Nuts, Washers, Accessories, Attachments etc.: (To be carried out at manufacture's works.)
  - a) Visual examination and quantity verification of offered lot.
  - b) Sample selection from the offered lot as per relevant IS for each item.
  - c) Dimension, fabrication and trueness verification from fabrication sketch.
  - d) Galvanizing test on each sample.
  - e) Other acceptance tests for respective item as per relevant Indian Standard and as per latest IS revision.
  - f) The inspection report shall be along with size and quantity shall be mentioned in each type of bolt-nut and attachment.



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- iii) Once declined a member cannot be resubmitted for review. Such a member will be eliminated in front of the inspector.
- iv) Accepting a lot does not absolve the Contractor of any need to fulfil all specifications, nor does it stop the subsequent refusal of any items from that lot that are later shown to be flawed.

#### 13.7.18 DISPATCH INSTRUCTIONS

On receipt and verification of test certificates, the Engineer In Charge will issue a clearance for dispatch of inspected material. No material shall be dispatched before receipt of such dispatch instruction in writing. The bolt Nuts and all other items procured from other manufacturer should be dispatched directly to the consignee to avoid double payment of Sales Tax / VAT.

according to sectional weight basis, as per approved bills of material only based on completion certificate issued by field office.


#### 13.7.19 WEIGHTS

The unit weights of each type of structure, including bolt nuts, accessories, and attachments shall be furnished and / or to be approved by the OWNER. The weight of structure shall mean the weight calculated by using the black sectional (i.e. un galvanised) weights of all steel members of the sizes indicated in the fabrication drawings and bills of materials without taking into consideration the reduction in weight due to drilling of bolts, holes, skew cuts, chamfering etc. or increase in weight due to galvanizing but taking into consideration the weight of the special fittings, bolts, nuts, washers and other accessories.

### 13.8 Conductors

#### 13.8.1 General requirements

- i) The conductor of appropriate size shall be selected considering power flow requirements and other system considerations. Same shall be finalized during detailed engineering phase. The conductors shall be All Aluminum Alloy Conductor (AAAC) conforming to IS:398 (Part-II) or relevant IEC/international standard.
- ii) Contractor shall submit the pulling and stringing methodology/ procedure for approval during detail engineering.
- iii) Joints shall be permitted in the individual Aluminium wires in all layers except the outer most layer of the finished conductor. These joints shall be made by cold pressure butt-welding and shall be such that no two such joints are within 15 metres of each other in the complete stranded conductor.
- iv) The standard length of the conductor shall be 1600 meters for conductor and 2x2000 metres for earth wire. A tolerance of  $\pm 5\%$  on the standard length offered by the contractor shall be permitted. All lengths outside this limit of tolerance shall be treated as random lengths. Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of random lengths shall not be more than 10% of the total quantity ordered.

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- v) Handling and transporting of the conductor and accessories shall be carried out in such a manner as to minimize the possibility of damages from abrasion through rough handling or dirt and grit.
- vi) The drums should always be transported in vertical position with the conductor ends fixed to prevent conductor from slackening.
- vii) The conductor crimping tool shall suit the selected conductor and crimping dimensions.
- viii) The crimping shall be inspected as per the approved QAP.

#### 13.8.2 Pre-dispatch Quality and Testing:

All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner.


13.8.2.1 Routine Test: All the routine tests shall be carried out as per the specification and relevant IEC/IS or Equivalent standard.

13.8.2.2 Type Test: Types tests shall be conducted as per the specification and relevant IEC/IS or Equivalent standard and the relevant test reports shall be submitted to Owner for review.

13.8.2.3 Factory Test to be offered for Inspection: Contractor shall offer the below listed test for Owner's witness.

- a) Visual and dimensional check
- b) Conductor by rewinding
- c) Measurement of diameter of individual steel & Aluminum strands
- d) Check for lay-ratios of various layers
- e) Galvanizing test on steel strands
- f) Torsion and Elongation tests on steel strands
- g) Breaking load test on steel and Aluminum strands
- h) Breaking load test & Elongation test on Aluminum Alloy strands
- i) Wrap test on Steel & Aluminum strands
- j) Wrap test on Aluminum Alloy strands
- k) DC resistance test on Aluminum strands
- l) DC resistance test on Aluminum alloy strands of AAAC conductor
- m) Resistivity Test on Aluminum Alloy strands of Al59 conductor
- n) Procedure qualification test on welded joint of Aluminum/ Aluminum
- o) Alloy strands
- p) Drum strength test (steel drum)
- q) Barrel Batten strength test (wooden drum)
- r) UTS test on stranded conductor
- s) DC Resistance test on stranded conductor

#### 13.8.3 Mid Span Compression Joint for Conductor

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The Mid Span Compression Joint for conductor shall meet the respective conductor finalized during detailed engineering and as per details given in IS:2121 Part-2.

#### 13.8.4 Repair Sleeve

13.8.4.1 Repair Sleeve Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface.

13.8.4.2 The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be of rounded that the conductor strands are not damaged during installation

13.8.4.3 The contractor shall clearly specify the before and after compression dimensions of the mid span compression joint and repair sleeve for Owner's review. The compression pressure shall also be indicated by the contractor.

#### 13.8.5 Vibration Damper for Conductor & Earth wire

13.8.5.1 Vibration dampers of 4 R-Stock bridge type with four (4) different resonance spread within the specified aeolian frequency bandwidth shall be used at all suspension and tension points on each span to damp out the Aeolian vibrations of the conductors to the specified level as mentioned hereinafter. Two dampers minimum on each side per conductor/earth wire shall be used at tension points and one damper minimum on each side per conductor at suspension points for ruling design span.


13.8.5.2 The clamp of the vibration damper shall be made of high strength aluminum alloy of type LM-6 or equivalent

13.8.5.3 The messenger cable shall be made of high strength galvanized steel/stainless steel with a minimum strength of 135 kg/mm<sup>2</sup>. It shall be of pre-formed and post-formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanized in accordance with the recommendations of IS:4826- 1979 for heavily coated wires.

13.8.5.4 The manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 KN and 5 KN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

13.8.5.5 The vibration damper for conductor shall not have magnetic power loss more than 0.5 watt at 350 amps at 50 Hz alternating current.

13.8.5.6 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper shall have to be submitted by the contractor.

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13.8.5.7 The damper placement chart shall be submitted by the contractor. All the placement charts should be duly supported by relevant technical documents and sample calculations.

### 13.9 Earth wire

13.9.1 The earth wire of appropriate size to cater to predicted and design fault currents and lightning shall be used. Same shall be finalized during detailed engineering. Single earth wire shall normally be used for transmission lines up to 220 kV. The earth wire used in 132 kV and above voltage class lines shall be OPGW. OPGW shall comply with provisions of Regulation as mentioned below.

13.9.2 The galvanised steel earth wire shall generally conform to the specification of ACSR core wire as mentioned in IS 398 (Part-II)-1976 except where otherwise specified herein.

13.9.3 The earth wire shall be pre-formed and post-formed to avoid opening of strands at the time of cutting or joining. The finished material shall have minimum brittleness, as it will be subject to appreciable vibration while in use. It shall withstand 3 and ½ number of one-minute dips in the Standard Preece test.


13.9.4 There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splicer in any length of the completed stranded earth wire.

#### 13.9.5 Optical Ground Wire (OPGW)

13.9.5.1 Dual-Window Single mode (DWSM), optical fibres (minimum 48 fibres) shall be provided in the fibre optic cables.

13.9.5.2 DWSM optical fibres shall meet the minimum requirements defined in table below:


Fibre Description:	Dual-Window Single-Mode
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength cc	≤ 1260 nm
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Polarization mode dispersion coefficient	≤ 0.2 ps/km <sup>½</sup>

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Temperature Dependence:	Induced attenuation $\leq 0.05$ dB (-60°C - +85°C)
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- 13.9.5.3 The OPGW cable is proposed to be installed on the EHV transmission lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines. The contractor shall design the OPGW requirements to suit each span in the system, based on the applicable drawings and field surveys. The contractor's proposal shall stipulate the characteristics of the OPGW required for each span in the system.
- 13.9.5.4 Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.
- 13.9.5.5 Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.
- 13.9.5.6 The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25 year cable creep.
- 13.9.5.7 Sag-tension charts for the OPGW cable shall be submitted by contractor for the approval of Owner.
- 13.9.5.8 The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.
- 13.9.5.9 OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose.
- 13.9.5.10 Below table provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable IS 802:1995 and IS 875: 1987 shall be applied.

Everyday Tension	$\leq 20\%$ of UTS of OPGW
D.C. Resistance at 20°C:	$< 1.0$ ohm/Km
Short Circuit Current	$\geq 6.32$ kA for 1.0 second

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13.9.5.11 Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

13.9.5.12 Supply and installation of all the OPGW assemblies and line accessories shall be under the scope of contractor.

13.9.5.13 Pre-dispatch Quality and Testing:


- i) All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner
- ii) Routine Test: All the routine tests shall be carried out as per the specification and relevant IEC/IS or Equivalent standard.
- iii) Type Test: Types tests shall be conducted as per the specification and relevant IEC/IS or Equivalent standard and the relevant test reports shall be submitted to Owner for review.
- iv) Factory Test to be offered for Inspection
  - a) Visual & Dimensional check
  - b) Attenuation Coefficient (1310nm,1550nm)
  - c) Point Discontinuities of attenuation
  - d) Ultimate Tensile Strength
  - e) Lay Length Measurements
- v) On Site Test to be offered for Inspection:
  - a) Optical Time Domain Reflectometer (OTDR) - Before Splicing
  - b) Optical Time Domain Reflectometer (OTDR) - After Splicing

13.9.6 Mid Span Compression Joint for Earth wire

13.9.6.1 It shall be used for joining two lengths of earth wire. The joint shall be made of mild steel. The steel sleeve should not crack or fail during compression in it or service period. The Brinell Hardness of steel should not exceed 200. The steel sleeve shall be hot dip galvanised. The joints shall not permit slipping off, damage to, or failure of the complete earth wire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earth wire.

13.9.6.2 The details of the joint shall be submitted for Owners' approval. Only Compression type tension clamp shall be used to hold galvanised steel earth wire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.



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13.9.6.3 The strain plates supplied with the towers will have a minimum thickness of 8 mm with a hole of 17.5 mm diameter. Suitable lugs for jumper connection shall also be supplied along with necessary bolts and nuts.

### **13.10 Insulators**

13.10.1 Composite long rod polymer insulator shall conform to IEC:61109. Composite long rod polymer insulators with creepage of 25 mm/kV (min) shall be used for both Tension and Suspension insulators.

13.10.2 Insulators shall have sheds of “open aerodynamic profile, without any under ribs”, with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

13.10.3 Tension Insulators: Composite polymer insulator, 120kN/160 kN as decided during DDE, Long rod, B&S type, as per IEC61109-2008.

13.10.4 Suspension Insulators: Composite polymer insulator, 70 kN/90 kN/120 KN as decided during DDE, Long rod, B&S type, as per IEC 61109-2008.

13.10.5 Core: It shall be a glass-fiber reinforced (FRP) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. The rod shall be of electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.


13.10.6 Housing & Weather Sheds: The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 5mm. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly moulded on the core.

13.10.7 End Fittings: End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron/ spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

### **13.10.8 Grading Rings:**

13.10.8.1 Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material. The insulator supplier shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona rings.

13.10.8.2 Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly. The design & supply of grading rings shall be in the scope of the composite insulator supplier.


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### 13.10.9 Pre-dispatch Quality and Testing:

13.10.9.1 All tests shall be carried out as per relevant IEC/IS standard. Tests to be carried out shall be finalized in the Quality assurance plan (QAP) with the approval of Owner:

13.10.9.2 Type Tests: The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for the approval of the Owner:

- i) On the complete composite Long Rod Polymer Insulator String with Hardware Fittings:
  - a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC:60383-1993.
  - b) Switching surge voltage withstand test under wet condition as per IEC:60383-1993.
  - c) Impulse voltage withstand test under dry condition as per IEC:60383- 1993
  - d) Corona and RIV test under dry condition. [132kV and above class only]
  - e) Mechanical Strength test: The test shall be carried out as per following procedure.
  - f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m<sup>3</sup> NaCl.
- ii) On Composite Polymer Insulator Units:
  - a) Tests on interfaces and connections of metal fittings as per IEC: 61109-2008.
  - b) Assembled core load time test as per IEC: 61109-2008.
  - c) Damage limit proof test and test of tightness of interface between end firings and insulator housing as per IEC: 61109-2008.
  - d) High Pressure washing test
  - e) Brittle fracture resistance test
  - f) Dye penetration test as per IEC: 61109-2008
  - g) Water diffusion test as per IEC: 61109-2008
  - h) Tracking and erosion test as per IEC: 61109-2008.
  - i) Hardness test as per IEC: 61109-2008.
  - j) Accelerated weathering test as per IEC: 61109-2008.
  - k) Flammability test as per IEC: 61109-2008.
  - l) Silicone content test
  - m) Recovery of Hydrophobicity test
  - n) Torsion test

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- o) Accelerated ageing test of 5000hrs as described in appendix-C of IEC 61109 or Test at multiple stresses of 5000 hrs as described in Annex- B of IEC - 62217

- iii) Acceptance & Routine Tests: Shall be done as per relevant IEC/IS standard and shall be finalized in the QAP with the approval of Owner.


#### 13.10.9.3 Visual Aids

- i) For the safety requirement of low flying military Aircrafts, all the transmission lines and transmission line structures falling within the safety zone of airfield and air to ground firing ranges shall meet the requirements of Directorate of flight Safety, Air Headquarters as per code of practice for Design, Installation and Maintenance of Overhead lines as per IS:5613 (Part-III) Section-1: 1989.
- ii) Within a radius of 10 Kms around aerodromes and air to ground firing ranges, all transmission lines and structures of height 45 meters or more shall be provided with day and night visual aids.
- iii) In all other areas, outside a radius of 10 Km from aerodromes, only those portions of transmission lines and structures of any height identified to pose a hazard to aircraft by the Directorate of Flight Safety shall be provided with day visual aids.
- iv) Suitable and sufficient day marking and night marking such as Coloured globules, low intensity obstacle lights, alternate bands of international orange and white colours paintings shall be provided.


13.10.9.4 Any other equipment / system / material not mentioned but required to comply with the relevant Procedures / Regulations issued by CEA/ CERC/ any other statutory body for connectivity to the Grid is included in the scope of contractor. All materials shall be supplied to site only after getting dispatch clearances from the Owner or Owner.

### 13.11 Installation

- 13.11.1 The Contractor shall construct, erect and install all material required for completion of the project. He shall be responsible for provision of all labour, tools and tackles.
- 13.11.2 The tools and tackles shall include, but not limited to, special hoisting equipment, cranes, slings, consumables and all other articles and supplies as required.
- 13.11.3 The tower should be erected on the foundations in not less than 14 days after concreting.
- 13.11.4 The Contractor shall ensure periodic cleaning of work site and removal of all waste material before moving on the next location.
- 13.11.5 The Contractor has to employ suitable manpower and supervision personnel. The Contractor is solely responsible for the safety of personnel and materials. Any damages to the existing facilities shall be made good by the Contractor at no extra cost to the Owner.

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- 13.11.6 No on-site fabrication of tower materials is allowed, Contractor has to plan the fabrication accordingly.
- 13.11.7 Manufacturer Test Certificates (MTC) for all materials shall be provided. In addition to that, all materials shall be tested in conformance to relevant applicable standards at approved NABL accredited third party laboratories. Sampling rate shall be finalized in QAP with the approval of Owner during detailed engineering phase.
- 13.11.8 Temporary bracing, whenever required, shall be provided to sustain forces due to erection loads, equipment etc. Erected parts of the structure shall remain stable during all stages of erection when subjected to action of wind, dead weight, erection forces etc. Specified sequence of erection of vertical and horizontal structural members shall be followed. After completion of all permanent member erection and alignment, the temporary bracing shall be removed.
- 13.11.9 After completion of the works, final checking of the line shall be done by the contractor to ensure that all the foundation works; tower erection and stringing have been done strictly in accordance with the specifications/IS/IEC/CEA/CERC guidelines and as approved by the CTU/Owner.
- 13.11.10 The transmission lines and transmission line structures of height 45 m and above shall be notified by the contractor to the Directorate of Flight Safety (DFS), Air Headquarters (Air HQ), New Delhi.
- 13.11.11 Transmission lines falling within a radius of 20 Kms around the Defence aerodromes and air to ground firing range, a No Objection Certificate (NOC) shall be obtained by the contractor from the concerned aerodromes authorities.
- 13.11.12 Ownership of packing materials shall be of the Contractor. Responsibility of removal and disposal of the packing material shall be in the scope of the Contractor.
- 13.12 Testing and Commissioning**
- 13.12.1 Pre-commissioning checks and tests for all equipment to be carried out by the contractor.
- 13.12.2 The line insulation for all phases to be tested by the contractor by using the suitable Insulation Resistance test.
- 13.12.3 Conductor continuity test to be carried out to verify that each conductor of the overhead line is properly connected electrically.
- 13.12.4 The line may be charged at low value of power, frequency and voltage for purpose of testing.
- 13.12.5 The proper line patrolling to be conducted before charging of the line.
- 13.12.6 Optical Time Domain Reflectometer (OTDR) test to be carried out to verify that each OPGW conductor of the overhead line is properly connected electrically.

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13.12.7 Any other works related to testing and commissioning of the power evacuation system.

### 13.13 Mono Pole Transmission Line

#### 13.13.1 Scope

13.13.1.1 The scope of work shall include design, engineering, manufacturing, supply, fabrication, galvanizing, testing, inspection prior to dispatch, transportation and delivery at site, construction, erection, and commissioning of 220 kV monopole transmission lines complete in all respects.


13.13.1.2 The required quantity of monopoles shall be finalized based on the detailed route survey. After finalization of quantities, the Contractor shall submit detailed design and engineering documents for the Owner's review and approval.

*Note: Monopole structures shall be considered at locations where Right of Way (ROW) constraints exist or where there is uncertainty in the construction of lattice tower structures subject to approval of Owner.*

#### 13.13.2 Applicable Standards


13.13.2.1 The design, manufacturing, fabrication, galvanizing, testing, erection procedure and materials used for manufacture and erection of monopoles, design and construction of foundations shall conform to the following Indian Standards (IS)/International Standards which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the specification. In the event of supply of material to Standards other than specified, the Contractor shall confirm in his bid that these Standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Business Associate and those specified in this document will be provided by the Business Associate to establish their equivalence. The material and services covered under these specifications shall be performed as per requirements of the relevant standards/codes (with latest revision) referred hereinafter against each set of equipment and services. Other Internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

SN	Standards	Details
1)	IS:209-1992	Specification for Zinc
2)	IS 278-1991	Galvanized Steel Barbed wire


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SN	Standards	Details
3)	IS 800-1991	Code of Practice for General Building Construction in Steel
4)	IS:802(Part 1)	Code of Practice for Transmission line System Design & General Building
5)	Sec 1-2015 Sec 2-2015	Construction in Steel in Overhead Transmission Line Tower: Materials, loads and Permissible Stress Section- 1: Materials and loads Section-2 : Permissible stresses.
6)	IS:802(Part 2)-1990	Code of Practice for use of structural steel in Overhead Transmission Line: Fabrication, Galvanizing, inspection & Packing
7)	IS:808-1991	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.
8)	IS:875-1992	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.
9)	IS:1363-1990	Hexagon Nuts (size range M5 to M36)
10)	IS:1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners
11)	IS:1477-1990	Code of practice for Painting Ferrous Metals in Buildings: Part-I: Pre-treatment Part-II: Painting.
12)	IS:1573-1991	Electro-Plated Coatings of iron on iron and Steel
13)	IS:1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products



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SN	Standards	Details
14)	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures
15)	IS:2016-1992	Plain Washers
16)	IS:2062-1992	Steel for general structural purposes
17)	IS:2074-1992	Ready Mixed Paint. Air Drying, Oxide. Zinc Chrome, Priming Specification.
18)	IS:2551-1990	Danger Notice Plates
19)	IS:2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel.
20)	IS:2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles
21)	IS:3043-1991	Code of Practice for Earthing
22)	IS:3063-1994	Single coil rectangular section Spring Washers for Bolts, Nuts Screws
23)	IS:3757-1992	High Strength Structural Bolts
24)	IS:4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products
25)	IS:5369-1991	General Requirements for Plain Washers
26)	IS:5613-1993	Code of Practice for Design installation and Maintenance of Overhead Power Lines Section-1: Design Part 2, Section-2: Installation and Maintenance

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SN	Standards	Details
27)	IS:6610-1991	Specification for Heavy Washers for Steel structures
28)	IS:6623-1992	High Strength Structural Nuts
29)	IS:6639-1990	Hexagon Bolts for Steel Structure.
30)	IS:6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles.
31)	IS:8500-1992	Specification for Weldable Structural Steel (Medium & High Strength
32)	IS:10238-1989	Step Bolts for Steel Structures
33)	IS:12427-1988	Bolts for Transmission Line Towers
34)		Indian Electricity Rules.
35)	Publication No. 19(N)/700	Regulation for Electrical Crossing of Railway Tracks
36)	ASCE 48-11	Design of Steel Transmission Pole Structures.
37)	ASCE Manuals and reports on Engineering practice No.	Design of Steel Transmission Pole Structures.

13.13.2.2 The letter and spirit of Central Electricity Authority, (Measure relating to Safety and Electric Supply), Regulation, 2010, Central Electricity Authority, (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 shall be the supreme guiding factor for resolution of conflicts, if any.

13.13.3 Manufacturing Quality Plan

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The Contractor shall submit the Manufacturing Quality Plan (MQP) for monopole structures to the Owner for review and approval. Manufacturing of monopole structures shall be carried out only after approval of the Manufacturing Quality Plan by the Owner. All manufacturing activities for monopole structures shall strictly comply with the approved Manufacturing Quality Plan


#### 13.13.4 TESTS

##### 13.13.4.1 General:

- i) All standard tests, including quality control tests in accordance with relevant IS / ASTM / ASCE shall be carried out. The black monopole of each type shall be subjected to design and destruction tests by applying tests equivalent to the specified maximum, in manner approved by the Owner. The monopoles shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter the monopoles may be subjected to destruction by increasing the loads further in an approved manner till they fail. No part of any monopole subject to test shall be allowed to be used in the work. The price will be quoted after allowing rebate for the scrap value for the monopole material which will be retained by the supplier. Poles shall be tested at Government approved third party testing facility only.
- ii) In case of premature failure, the monopoles shall be retested. The supplier shall provide facilities to the owner or their representatives for inspection of materials during manufacturing stage and also during testing of the same.
- iii) The supplier shall submit documents for approval, proposal for testing monopoles showing the methods of carrying out the tests and manner of applying the test loads. After the owner has approved the test procedures and program, the Business Associate will intimate the owner about carrying out of the tests at least 10 day in advance of the scheduled date of tests during which the owner will arrange to depute his representative to be present at the time of carrying out the tests. Six copies of the test reports shall be supplied.

##### 13.13.4.2 MONOPOLE TESTING PROCEDURE

- a) Each type of monopole to be tested shall be a full scale proto type black monopole and shall be erected vertically on rigid. The monopole erected on test bed shall not be out of plumb by more than 1 in 360.

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#### b) CALIBRATION OF MEASURING INSTRUMENTS

All measuring instruments shall be calibrated in systematic manner with the help of Universal Testing Machine or by standard weights. In case the calibration is done with the use of UTM, the UTM shall be periodically (once in every six months) calibrated by an external third party. The calibration shall, before commencing the test on each monopole be done up to the maximum anticipated load to be applied during testing. Calibration curves for the instruments shall be drawn and the test load be corrected accordingly.

#### 13.13.4.3 LOAD AND DEFLECTION MEASUREMENTS

- i) All loads shall be measured through a suitable arrangement of strain devices or by using weights. Positioning of strain devices shall be such that the effect of pulley friction is eliminated. In case the pulley friction cannot be avoided, the same shall be measured by means of standards weights and accounted for in the test loads.
- ii) Monopole deflections under load shall be measured by suitable procedure at the top cross arm level on the front sides of the transverse faces. Deflection readings shall be recorded for the before load, 'load on' and 'load off' conditions.

#### 13.13.4.4 TESTING PROCEDURE DETAILS


The testing procedures shall be in accordance with the relevant ISS / ASTM / ASCE codes & standards.

#### 13.13.4.5 TYPE TESTS CERTIFICATES

The Contractor shall furnish the type test certificates for the tests as mentioned above as per the corresponding standards. All the tests shall be conducted at CPRI / ERDA as per the relevant standards. Type test should have been conducted in certified Test Laboratories during the period not exceeding 5 years from the date of opening the bid. In the event of any discrepancy in the test reports i.e. any test report not acceptable or any/all type tests (including additional type tests, if any) not carried out, same shall be carried out without any cost implication to the Owner.

#### 13.13.4.6 PRE-DESPATCH INSPECTION

- i) Equipment shall be subject to inspection by a duly authorized representative of the Purchaser. Inspection may be made at any stage of MANUFACTURE at the option of the purchaser and the equipment if found unsatisfactory as to workmanship or material is liable to rejection. The Contractor shall grant free access to the places of MANUFACTURE to the Purchaser's representatives at all

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times when the work is in progress. Inspection by the Purchaser or its authorized representatives shall not relieve the Contractor of his obligation of furnishing equipment in accordance with the specifications. Material shall be dispatched after specific MDCC (Material Dispatch Clearance Certificate) is issued by the Owner.

- ii) Each component shall be inspected for conformance to the fabrication drawings. This inspection shall include, but not limited to:
  - a) Ultrasonic inspection of base plate more than 50mm thick prior to welding for laminations.
  - b) Visual inspection of dimensions to assure that tolerances are met.
  - c) visual inspection of cut edges to ANSI/AWS D.1.1 criteria.
  - d) visual inspection of bent surfaces for surface separations(supplemented by magnetic particle in questionable areas);
  - e) visual inspection of bolt holes to assure that they are cylindrical, perpendicular, free of burrs and without torn or ragged edges;
  - f) visual inspection of all welds to ANSI/AWS 01.1 Section 8 criteria;
  - g) ultrasonic inspection of all full penetration welds
  - h) ultrasonic inspection of shaft to base plate weld after galvanizing for base plate thicker than 50mm (maybe waived if routine audits show no history of defects);
  - i) visual inspection of all structural partial penetration or fillet welds, in questionable area use magnetic particle inspection according to ANSI/AWS D1.1 Section 8 criteria;
  - j) visual inspection of finish;
  - k) magnetic thickness measurement of finish coatings.


#### 14 Operation and Maintenance

The successful Contractor shall carryout Operation and maintenance of complete Pooling substation(s) and EHV Transmission System till point of grid interconnection (including grid substation bays) from date of commissioning for the period mentioned in SCC of the tender document.

Owner may suitably depute its personnel to associate with O&M activities. Contractor shall assist them in developing expertise through their day to day O&M activities. All records of maintenance must be maintained by the contractor which can be accessed by Owner on demand. These records are to be handed over to Owner after the O&M period of contract.


##### 14.1 Scope

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 for the approval of Owner.


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- 14.1.1 The Scope of Works shall include deputing manpower necessary to operate & maintain PSS, EHV transmission line and grid substation bay to ensure trouble free and smooth day-to-day operation of the complete Pooling substation and power evacuation system.
- 14.1.2 The Contractor shall ensure continuous, un- interrupted Operation, Monitoring and Maintenance activities, etc. of transmission system with grid substation bay and PSS for the interim period i.e. period commencing from Commissioning to the signing of the O&M Agreement and for defect liability period as well.
- 14.1.3 Contractor to ensure the periodic calibration of main & check meter at PSS & ISTS end as per statutory requirement.
- 14.1.4 The Contractor shall ensure that all safety measures are taken at the site to avoid accidents. The Contractor shall provide all the personal protective equipment (PPEs) for O&M personnel. The Contractor shall immediately report the accidents, if any, to the EIC & to all the concerned authorities as per prevailing laws of the state and central government.
- 14.1.5 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.
- 14.1.6 The Contractor shall provide necessary routine and preventive maintenance schedules in accordance with the recommendations of equipment manufacturers and as per the OEM manuals for the PSS equipment and transmission system with grid substation bay for the Owner's approval and shall carry out all routine, preventive maintenance and periodic overhauls accordingly.
- 14.1.7 Necessary co-ordination shall be made by the Contractor with CTU, SLDC/RLDC and other agencies as may be required during the Operation and Maintenance term for smooth operation of the plant. The Contractor shall be responsible for liasoning with statutory authorities and local authorities to ensure smooth operation of the PSS & transmission system with grid substation bay.
- 14.1.8 The Contractor shall provide required Spare Parts, tools and tackles, consumables required for comprehensive operation and maintenance of the facility as per prudent/ standard utility practices, OEM recommendations and warranty clauses for the entire O&M period at his own cost.



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- 14.1.9 Contractor shall supply the listed mandatory spares (Appendix B) at the beginning of service. In case any equipment or spares is not listed in the mandatory spares list but is required vitally for the operation of the PSS, EHV transmission line and grid substation bay, then the same shall be procured and provided by the contractor without any additional cost to the Owner.
- 14.1.10 In order to meet the emergency requirements, contractor, with the permission of Owner can utilize the mandatory spares being supplied under the contract. However, the used spares shall be replenished by the contractor within reasonable time.
- 14.1.11 It is the responsibility of the contractor to store the materials in appropriate stock yard or container at the site to ensure timely availability of the materials.
- 14.1.12 Contractor to purchase insurance covers during O&M period as mentioned in the GCC section of the tender.
- 14.1.13 The Contractor shall employ only such personnel who are adequately qualified and having minimum 5 years of experience for working at 220 kV voltage level. Details of such personnel to be submitted for the approval of Owner. The Contractor shall ensure that such personnel are always on duty at the plant, 24 (twenty-four) hours a day and 7 (seven) days a week commencing from the project commissioning date.
- 14.1.14 Contractor shall provide training to the Owner's personnel in relation to the operation & maintenance of the PSS, EHV transmission line and grid substation bay facility.
- 14.1.15 The Contractor shall maintain all accounting records regarding the facility in accordance with the generally acceptable accounting principles under the Laws of India.
- 14.1.16 The Contractor shall provide copies of all necessary documents including the following:
- Operation and maintenance manuals duly approved by Owner.
  - Failure Analysis/history/trouble shooting details of all the equipment.
  - Preventive maintenance schedule for complete system.
  - List of vendors supplying equipment for PSS and power evacuation system indicating name and addresses with credentials.
  - Record of consumables / spare parts.
- 14.2 Mandatory spares**
- 14.2.1 The contractor shall supply the Mandatory spares at no extra cost to Owner as per the list indicated in Appendix -B.

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14.2.2 All mandatory spares, special tools and tackles shall be delivered at site at least two months before scheduled commissioning of the solar plant.


**14.3 Special tools and tackles**

14.3.1 All required special tools and tackles required for erection, testing, commissioning, operation, and maintenance of equipment shall be supplied by Contractor at no extra cost to the Owner.

14.3.2 Following are the list of mandatory special tools and tackles to be supplied by the contractor at no extra cost to the Owner after getting the approval from the Owner.

- a) Complete First Aid Box as per CEA guidelines.
- b) Breathing apparatus - 2 nos.
- c) Defibrillator - 1 Nos.
- d) Resuscitation Chart - 4 Nos.
- e) Cat/megger make Voltage detection rod suitable up to 33kV - 2 No.
- f) Hand gloves suitable for 220kV / 33kV / 415V voltage grade - 2sets.
- g) Phase sequence rod suitable up to 33kV - 2 Nos.
- h) Arc suit suitable LV switchgear Operation- 2 sets.
- i) LOTO kit - 2 set
- j) Megger Make 5kV Insulation Resistance Tester (Digital) - 2 No.

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

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k) Earth resistance tester - 2 No.


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

l) Digital Multimeter - 2 Nos.

Parameter	Specification
Voltage range	1000 V AC (True RMS)
Display	4 $\frac{1}{2}$ digits, Backlit LCD or LED
Measuring category	1000 V CAT III as per IEC Standard 61010-1
Additional functions	Resistance, Temperature, Continuity, Diode, Capacitance, Frequency, Duty cycle measurement
<b>Accessories</b>	
Temperature Probe - 1	
Test Leads with Alligator Clips - 1 set	
Battery - 2 set	
Carry Case with sufficient space for accommodating accessories	

m) Clamp meter - 2 Nos.

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


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n) Infra-red thermal imaging camera - 1 No.

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


#### 14.4 Handing over

- 14.4.1 At the end of the contract period, the contractor shall hand over the Pooling Substation and Transmission lines and equipment back to the Owner in completely safe and healthy condition and without any pending defect
- 14.4.2 The items supplied by Owner on returnable basis, such as spares parts (from mandatory spares or through procurement), consumables, tools and tackles, documents etc. shall be returned back to Owner. Else suitable recoveries shall be made from the Contractor's bills.

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**15 Appendix B: List of mandatory spares**

SN	Equipment/Material	Quantity (For each type and rating)
<b>220 kV Pooling Substation Equipment</b>		
<b>1.</b>	<b>SF6 Circuit Breaker</b>	
a)	One complete pole of Circuit Breaker, pole column, Interrupter, with driving mechanism Box and MB but without support structure	1 no.
b)	Rubber gaskets, O rings and seals for SF6 gas (complete replacement for one breaker)	1 set
c)	Trip coils with resistor	1 no.
d)	Closing coils with resistor	1 no.
e)	Molecular filter for SF6 Circuit for 1 Pole of CB	1 no.
f)	Terminal pads and connectors	1 no.
g)	Corona rings	1 no.
h)	Relays, power contactors, switch-fuse units, limit switches, push buttons, timers and MCBs etc.	1 set
i)	Pressure switches	1 set
j)	Auxiliary Switch Assembly	1 set
k)	SF6 gas	1 complete fill for at least one CBs
<b>2.</b>	<b>Isolator/Disconnecter</b>	
a)	One complete pole of disconnector including support insulator with 1 E/S with motor operating mechanism for main isolator and earth switch (excluding structure)	1 no.
b)	Copper contact fingers for female & male contacts	1 set
c)	Open/Close Contactor Assembly, Timer, Key Interlock push button switch & auxiliary switches	1 set
d)	Limit switch	1 nos.
e)	Terminal pads & Connectors	1 nos.
f)	Corona shielding ring	1 nos.
<b>3.</b>	<b>Surge Arrester</b>	
a)	Complete surge arrester excluding support structure	1 no.

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SN	Equipment/Material	Quantity (For each type and rating)
b)	Surge counter / monitor	2 nos.
4.	Current Transformer (excluding support structure / common JB)	
5.	Voltage Transformer (excluding support structure / common JB)	1 no.
6.	Bus Post Insulator	1 nos.
7.	Erection Hardware Items (Insulator strings & Hardware, Clamps & Connectors)	1 nos. of each type
8.	Terminal Clamps	1 set
9.	Lugs	10 of each type
10.	Heat shrinkable Termination and Jointing kits	5% of Total quantity used
11.	<b>33 kV Circuit breaker / switchgear assembly</b>	
a)	VCB	1 no.
b)	Closing coil	1 no.
c)	Tripping coil	1 no.
d)	Spring charging motor	1 no.
e)	Relay (each type)	1 no.
f)	Meter (each type)	1 no.
g)	Current Transformer	1 no.
h)	MCCB	1 no.
i)	MCB	1 no.
j)	Fuse	10% of total supply
k)	Indicating lamp	10% of total supply
l)	Rotary switch	10% of total supply
m)	33KV LA, CT & VT	One of each type together with terminal connectors
12.	<b>Control and Relay panel</b>	
a)	Meter	1 no.
b)	MCB	2 nos.
c)	Fuse	10% of total supply
d)	Indicating lamp	10% of total supply
e)	Rotary switch	10% of total supply
f)	BCU	1 no.
g)	Auxiliary relay	1 no.
13.	<b>LT Switchgear</b>	
a)	MCCB	1 no.
b)	MCB	1 no.



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	REQUEST FOR PROPOSAL FOR EPC PACKAGE FOR DESIGN, ENGINEERING, SUPPLY, CONSTRUCTION, TESTING & COMMISSIONING OF POOLING SUBSTATIONS AND ASSOCIATED POWER EVACUATION SYSTEMS, INCLUDING 5 YEARS OF COMPREHENSIVE O&M

SN	Equipment/Material	Quantity (For each type and rating)
c)	Fuse	10% of total supply
d)	Relay	1 no.
e)	Meter	1 no.
f)	Current Transformer	1 no.
g)	Voltage Transformer	1 no.
h)	Contact Assembly	1 set
i)	Indicating lamp	10% of total supply
j)	Rotary switch	10% of total supply
<b>220kV Transmission line</b>		
1.	Conductor Joint Sleeve, Earth Wire Joints, Armor Rods, Suspension insulator string with fittings and clamp, Tension insulator string with fittings and clamp	1 set