(vii) CCTV

10.2.2 Sizing of UPS shall be done considering the above-mentioned load at power factor of 0.8 lagging inclusive of 10% design margin at 50 ˚C.

10.3 System Description

10.3.1 The UPS shall automatically provide continuous, regulated AC power to critical loads under normal and abnormal conditions, including loss of input AC power. The UPS system shall consist of the following major equipment.

(i) UPS Module

(a) Insulated Gate Bipolar Transistor (IGBT) Converter
(b) Insulated Gate Bipolar Transistor (IGBT) Inverter
(c) Digital Signal Processor (DSP) using Pulse Width Modulation (PWM) for Direct Digital Control (DDC) of all UPS control and monitoring functions
(d) Static bypass switch

(ii) Battery system for 2 hours
(iii) Battery protective and disconnect device
(iv) Maintenance bypass switch
(v) LCD display panel and LED indications
(vi) Integrated UPS Communications Protocols capable of communicating with SCADA system

10.3.2 The UPS shall meet the following minimum specifications.

Parameter	**Specification**
Topology	Online double conversion UPS
Input	
Voltage	230 V ± 10% AC
Frequency	50 ± 5 Hz
Power factor	0.95
Output	
Voltage	230V ± 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Sealed, Maintenance-Free (AGM) battery

Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED Indicators	Load on Inverter, Battery operation, Load on Bypass, Overload, LCD Fault, UPS Fault
Electrical contacts	Closing contacts for each of the following conditions: 1. Unit on Battery 2. Low Battery 3. Summary Alarm 4. UPS On 5. Input Fail
Local Display	LCD/ LED
SCADA communications	RS-485 Interface Port
Overall efficiency	>90%
Electrical Protection	Input/ output under voltage, over temperature, overload, Short circuit, battery low trip

10.3.3 The UPS shall be forced air cooled by internally mounted fans. The fans shall be redundant in nature to ensure maximum reliability. The fans shall be easily replaceable without the use of special tools.

10.3.4 Contractor shall provide the Operation & Maintenance Manual and mandatory spare parts list along with the equipment

10.4 Warranty

UPS shall be warranted for minimum of 5 (five) years and batteries shall be warranted for a minimum of 2 (two) years against all material/ manufacturing defects and workmanship from the date of supply.

10.5 Tests

10.5.1 Routine tests and acceptance tests on final product shall be done as per QAP approved by the Employer.

10.5.2 On completion of installation and commissioning of the equipment on site tests shall be carried out with the max. available load, which does not exceed the rated continuous load. An on-site test procedure shall be submitted by contractor include a check of controls and indicators after installation of the equipment.

11 Battery and Battery Charger

11.1 Standards and Codes

Standard/Code	Description
IEC 60896-22:2004	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements
IEC 60896-21:2004	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IS 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates)
IS 8320	General requirements and methods of tests for lead acid storage batteries.
IS 15549	Stationary Regulated Lead Acid Batteries

11.2 General

110 V DC system (Battery, Battery Charger & DCDB) in accordance with this specification and standards stated herein, shall comprise of the following.

(i) Sealed Maintenance Free (VRLA) Battery complete with racks & accessories.
(ii) One No. Float charger.
(iii) One No. Float cum Boost charger.
(iv) DC Distribution Board (DCDB)

11.3 Battery

11.3.1 Battery shall be used to supply the following loads with back up of two hours in case of complete power failure:

(i) Trip and closing coil of HT circuit breaker
(ii) Spring charging motors for HT circuit breaker
(iii) Annunciator and Indication circuit of HT panel
(iv) Auxiliary supply to protection relays

11.3.2 The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.25 & depth of discharge of 80%.

11.3.3 The design of the battery bank and sizing calculation along with the data sheet for the battery and battery charger shall be submitted for approval.

11.3.4 Battery voltage – 220V dc or 110V dc

11.4 Battery Charger

11.4.1 The Float Charger shall be used to supply normal DC loads and float charging current of charged battery. The Float cum Boost charger shall be designed to supply boost charging current requirement of the associated battery as well as to

supply normal DC load. After full discharge of battery bank, the Float Cum boost charger shall be capable of charging the battery to its full capacity in 8 hours duration while supplying normal DC load.

11.4.2 The float charger shall have both auto and manual voltage regulation arrangements with provision of selector switch.

11.4.3 Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage and current to 2% and 5% respectively.

11.4.4 Digital Outputs shall be configured for connection to the SCADA to monitor the outputs like charger output current, output voltage, float/boost mode, etc.

11.4.5 The charging equipment shall be housed in a free standing, floor mounted compartmentalized panels. Panel shall have provision for bottom cable entry with removable undrilled cable gland plate of 3.0 mm thickness.

11.4.6 The panel shall be of CRCA sheet steel construction having thickness of at least 2.0 mm. Degree of protection provided by the enclosure to the internals of charger shall be IP-42.

11.4.7 The instruments, switches and indicating lamps shall be flush mounted on the front panel.

11.5 DC distribution board (DCDB)

11.5.1 DCDB shall be an integral part of battery charger panel board.

11.5.2 Doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust. Also, door shall be provided with lock and key arrangement to prevent unauthorized access to the board.

11.5.3 DCDB shall have adequate number of outgoing feeders with double pole, DC MCBs. At least 20% feeders shall be provided as spare.

11.6 Warranty

Batteries and battery charger shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

11.7 Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

12 Earthing

12.1 Standards and Codes

Earthing system shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, earthing system shall comply with the following standards and codes.

Standard/Code	Description
IS 3043	Code of Practice for Earthing
IEC 62561-2	Requirements for conductors and earth electrodes
IEC 62561-7	Requirements for earthing enhancing compounds
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
Indian Electricity Rules	

12.2 General Requirements

12.2.1 Earthing system shall be designed based on system fault current and soil resistivity value obtained from geo-technical investigation report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.

12.2.2 The earth electrode shall be made of high tensile low carbon steel rod, molecularly bonded by high conductivity copper on outer surface with coating thickness not less than 250 micron as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS 3043.

12.2.3 Earth conductors shall be made of copper bonded steel or galvanized steel of sufficient cross section to carry the fault current and withstand corrosion.

12.2.4 Earth conductors buried in ground shall be laid minimum 600 mm below ground level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures.

12.2.5 Earth electrodes shall not be situated within 1.5m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be two times the driven depth of the electrode.

12.2.6 Transformer yard and switchyard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.

12.2.7 All welded connections shall be made by electric arc welding. For rust protection, the welds should be treated with red lead compound and afterwards thickly

coated with bitumen compound.

12.3 Earthing of PV array field

12.3.1 All PV Modules, Module Mounting Structures (MMS) and String Combiner Box (SCB) structures in the PV array field shall be bonded to the earthing system by two distinct connections.

12.3.2 Each PV Module frame shall be earthed using copper wire of sufficient cross section. The copper wire shall be connected to the earth hole provided in the module frame using suitable arrangement in line with the manufacturer recommendation. The earthing arrangement shall use stainless washers to prevent galvanic corrosion between aluminium frame and copper wire. In order to achieve effective earthing, serrated washers shall be employed to penetrate the anodization layer of the module frame.

12.3.3 Continuous copper earthing wire shall be run to connect a group of modules and both ends of the loop shall be bolted to the DC earth grid using bimetallic lugs and stainless-steel fasteners. The copper earthing wire shall be routed in such a way to avoid physical contact with the module aluminium frame.

12.3.4 The connection between MMS and DC earth grid shall be bolted or welded. Portion of the MMS which undergoes welding at site shall be coated with two coats of cold galvanising and anti-corrosion paint afterwards.

12.3.5 Earth electrodes of the DC earth grid shall be uniformly distributed throughout the PV array field so that optimum earth resistance is offered to leakage current flowing from any module frame or MMS.

12.3.6 SCB equipment earthing point shall be connected to the DC earth grid using flexible copper cable of sufficient cross section as recommended by the manufacturer. The connection with the DC earth grid shall be done using suitable bimetallic lugs and stainless-steel fasteners.

12.4 PCU Earthing

DC negative bus bar of the PCU shall be earthed to avoid Potential Induced Degradation (PID). DC negative bus bar and PCU equipment earth shall be bonded to the PCU earth bus and connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by the manufacturer. The interconnection of PCU earth electrodes with DC earth grid shall be as per PCU manufacturer recommendation. In case DC negative grounding is not possible, appropriate anti-PID device shall be provided.

12.5 Transformer Earthing

12.5.1 Inverter transformer neutral shall be floating, not to be earthed. However, recommendation of inverter manufacturer shall also be taken into account.

12.5.2 Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.

12.5.3 Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.

12.5.4 Neutral and body of the auxiliary transformer shall be earthed.

12.6 Inverter Room and Main Control Room Earthing

12.6.1 Metallic enclosure of all electrical equipment inside the inverter room and main control room shall be connected to the earth grid by two separate and distinct connections.

12.6.2 Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.

12.6.3 SCADA and other related electronic devices shall be earthed separately using minimum two no. of earth electrodes.

12.7 Switchyard Earthing

The metallic frame work of all switchyard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.

Switchyard shall be shielded against direct lightning stroke by provision of over head shield wire or earth wire or spikes(masts) or a combination there of as per CEA regulations 2010 (Technical standards)- 42(2)(C).

12.8 Tests

Type test reports for earthing electrode, earth enhancing compound and its associated accessories shall be submitted during detailed engineering for approval.

On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.

The earth plate shall be provided to facilitate its identification and for carrying out periodical inspection.

13 Lightning Protection System

13.1 Lightning Protection System (LPS) for entire plant against direct lighting strokes shall be provided as per IEC 62305:2010 or NFC 17-102:2011.

13.2 Protection level for the entire plant shall be Level-III.

13.3 LPS as per IEC 62305

Location of air terminals shall be designed as per rolling sphere method.

13.4 LPS as per NFC 17-102

Lightning Protection System shall consist of following accessories.

(i) Early Streamer Emission (ESE) air terminal

(ii) Highly insulated poly-plastic adaptor to fix the ESE air terminal with the FRP mast

(iii) Fiberglass Reinforced Plastic (FRP) mast

(iv) Coupler to connect FRP mast with GI mast

(v) Galvanized Iron mast with base plate and guy wire kit

(vi) Down-conductor: PVC insulated flexible copper cable of suitable size complying with EN 50164-2 or equivalent standard. It shall be routed along the mast with suitable fixings and connecters

(vii) Test joint with each down conductor

(viii) Lightning event counter complying with EN 50164-6 or equivalent standard. It shall be fixed at suitable height in series with the down conductor.

(ix) Earth termination system in accordance with NFC 17-102. Earth electrodes shall comply with the EN 50164-2 or equivalent standard. Earth enhancing compounds complying with EN 50164-7 or equivalent standard, may be used where soil resistivity is higher and making it impossible to achieve system resistance within specified limit.

13.5 Accessories listed above are indicative only and any other fittings or accessories, which are usual or necessary for satisfactory operation of the lightning protection shall be provided by the Contractor without extra charges.

13.6 Necessary foundation/anchoring for holding the lightning mast in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

13.7 The product shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

13.8 Type test reports as per IEC 62305:2010 or NFC 17-102:2011 shall be submitted

during detailed engineering for approval.

14 Communication Cables

14.1 Optical Fibre Cables

14.1.1 Optic Fibre cable shall be 4/8/12 core, galvanized corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor/ indoor application so as to prevent any physical damage.

14.1.2 The cable shall have multiple single-mode or multimode fibres on as required basis so as to avoid the usage of any repeaters.

14.1.3 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.

14.1.4 The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling.

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

14.1.6 The Contractor shall ensure that minimum 100% cores are kept as spare in all types of optical fibre cables.

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

14.1.8 Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standard.

14.2 Communication Cable (Modbus)

14.2.1 Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 Sq.mm. Cable shall be flame retardant according to IEC 60332-1-2.

14.2.2 Cable shall be tested for Peak working voltage of not less than 300 V and shall be suitable for serial interfaces (RS 422 and RS 485).

14.2.3 Communication cable shall be laid through underground with suitable HDPE ducts.

15 SCADA

15.1 General Requirements

15.1.1 The Contractor shall provide complete SCADA system with all accessories,

auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire solar plant and its auxiliary systems.

15.1.2 The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall etc. needed for the completeness.

15.1.3 SCADA System shall have the provision to perform the following features and/or functions:

(i) Web enabled Operator Dashboards: Showing key information on Generation, Performance and Current Status of various equipment in Single Line Diagram (SLD) format with capability to monitor PV array Zone level (i.e. SCB level) parameters.

(ii) Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.

(iii) Fault and System Diagnostics with time stamped event logging.

(iv) Support for O&M Activities: The interface shall allow integration with Surveillance System(s), Module Cleaning System and various other O&M support systems to provide a Data Analysis and Decision Support System for smooth and efficient Plant Operations.

(v) AI based Distributed Analytics for Predictive Maintenance, trend analysis and Alerts.

(vi) Generate, store and retrieve user configurable Sequence of Event (SOE) Reports.

(vii) Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.

(viii) Transfer of plant data reliably, to a Cloud server on any kind of remote network including low bandwidth and wireless links such as 2G/3G/VSAT

(Note: Telecom Lease line connection, if required for transferring data from Plant over internet shall be taken by Contractor in the name of Employer for O&M period)

15.1.4 The Control system shall be designed to operate in non-air-conditioned area. However, the Contractor shall provide a Package/ Split AC of suitable capacity

decided by heat load requirement in SCADA room at Main Control Room.

15.2 Architecture

15.2.1 The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database.

15.2.2 Data acquisition shall be distributed across MCR and LCRs while plant level data aggregation shall be done in both local and remote server (as specified by Owner).

15.2.3 Analog and Digital IO modules shall have integrated processor for distributed IO processing and control.

15.2.4 Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.

15.2.5 Plant SCADA Server shall have Industrial Grade server hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.

15.2.6 Plant data for monitoring and control operations should be accessible without dependence on external network.

15.2.7 A virtual/cloud server running SCADA & Monitoring Software shall be configured in parallel with Plant Server to enable easy access to plant data from outside the plant without having to login to plant server. Effectively, the plant data shall be replicated in both places i.e. between systems at the Plant Server and Remote Server to provide data redundancy for complete plant data.

Note: Configuration of Cloud server and procurement of associated subscription services shall be in the scope of the EPC Contractor.

15.2.8 Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant or remote server. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software and Plant Data shall be installed/stored on local and remote servers only with user access control for protecting the software and data assets from accidental deletion or corruption.

15.2.9 Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher

bandwidth. In case no broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided. SCADA system shall be capable of sending all plant data in real time to the Remote Server.

15.2.10 GPS based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with antenna, receiver, cabinet and internal interconnection cables. All SCADA controllers, servers, OWS and communicating equipment shall be synchronized to the GPS clock.

15.3 Industrial IoT Controllers & Data Acquisition

The Plant SCADA and Monitoring System may use one or more IIoT Controllers at each Inverter Control Room and MCR for the purpose of data acquisition and data forwarding to the Local and Remote SCADA Servers. The IIoT Controllers shall meet the following minimum requirements:

15.3.1 The IIoT Controllers shall be distributed in nature and work independently of other IIoT Controllers or any central controller in the system.

15.3.2 Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)

15.3.3 Shall have local storage for a minimum of 2 weeks (in case of network failure).

15.3.4 Provide web-based interface to configure the controller for various equipment in the field.

15.3.5 IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT & Transformer panels through distributed DI/AI modules.

15.3.6 Controls: Shall be capable of Controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.

15.3.7 Data Communication with Servers: Shall send the data collected, from all the equipment at Inverter Control Room and/or Main Control Room, to the Monitoring & Control Server.

15.3.8 Controllers shall be capable of sending data over Internet connections USB data cards.

15.3.9 Shall not require a static public IP address, at the plant for the purpose of remote access.

15.4 Functionalities

15.4.1 SCADA system shall enable PV array Zone monitoring i.e. the total current from

each String Combiner Box shall be monitored on the DC side of the inverter (Central).

15.4.2 The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC& AC Equipment including inverters, weather station, MFM, Transformer and Switchgear (LT & HT Panels) at regular intervals not greater than one minute.

15.4.3 The SCADA system shall monitor Instantaneous and cumulative environment parameters from weather sensors or data loggers at same interval as electrical parameters and provide PR, CUF on the fly.

15.4.4 The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on status change of hardwired DI shall also be provided.

15.4.5 The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds. The list of such parameters shall be finalised in consultation with the Owner.

15.4.6 The SCADA system shall enable integration with other sub-systems at the plant for supporting O&M activities. The list shall include but not limited to:

(i) Surveillance Cameras,

(ii) Module Cleaning System – For monitoring of water usage and efficacy of cleaning process (in case of Wet Type Cleaning System).

15.4.7 The SCADA system shall have user-friendly browser-based User Interface for secure access from anywhere, for minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of total plant generation, day's export, irradiance, Inverter Control Room level generation and performance indicators like PR and CUF.

15.4.8 Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.

15.4.9 The system shall have Configurable Analysis page for self-configured as well as on demand Analytics charts.

15.4.10 The SCADA system shall be extensible to include maintenance of O&M schedules and related activities for plant equipment as per the O&M Manual.

15.4.11 Connectivity shall be provided to Owner's Data Monitoring Centre. Data collected by Plant SCADA shall be replicated in real-time, using industry

standard interfaces such as Web Services, OPC-UA, data files, as required – with Owner's Central Monitoring System in New Delhi. The data recording intervals for different parameters from different devices in the solar plant shall be considered when creating schedules to "push" the data from Plant SCADA to data receivers stationed at New Delhi.

15.4.12 Mobile User Interface: summary of plant performance and issues should be accessible in a mobile Native UI or browser UI.

15.4.13 Data Communication to SLDC: SCADA system shall provide required interface to integrate with TRANSCO-SLDC, in compliance with grid code, to send any parameters specified by SLDC.

Note: The methodology and specification of SLDC interface will be provided separately by SLDC/TRANSCO and it shall be the responsibility of the Contractor to determine the same.

15.4.14 Power Plant Control: SCADA system shall provide required interface to the local SCADA operator to set various power control modes (active/reactive power/frequency/PF) through the inverters over industry standard communication protocols like Modbus over TCP/IP.

15.4.15 Forecasting and Scheduling: SCADA shall provide day ahead and week ahead forecasting and scheduling for power generation at the plant as per SLDC/Utility stipulations.

15.4.16 Predictive Maintenance: SCADA system shall have in-built or pluggable frameworks to support AI based Predictive Maintenance for all key equipment including inverters, transformers and switchgear at the plant.

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

15.4.18 The Contractor shall provide software locks and passwords to Employer for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

15.5 Earthing

15.5.1 Two isolated electronic earth pits near to SCADA panel at every Inverter and Control Room with < 1 Ohm resistance shall be provided. One earth pit shall be used for protective/body earth and the other to be used for Signal Earth.

15.5.2 Apart from providing separate earth pits, manufacturer specified earthing

recommendations shall be followed for all communicating equipment connected to SCADA. This includes but is not limited to SMBs, Inverters, WMS and Switchgear panels.

15.6 Communication Cable Laying

15.6.1 All RS485, IO and CAT6 cables shall be laid in separate conduits with a minimum separation of 1.5ft from AC/DC power cables all along.

15.6.2 Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure minimum 1.5 ft separation between power and communication cables all along the trench.

15.6.3 IO Cables between switch gear panels and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

15.6.4 RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

15.7 Control Cabinets / Panels / Desks at Main Control Room

15.7.1 The cabinets shall be IP-22 protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.

15.7.2 The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications.

15.8 Software Licences

The Contractor shall provide software license for all software being used in Contractor’s System. The software licenses shall be provided for the project and shall not be hardware/ machine-specific.

15.9 Hardware at Main Control Room

15.9.1 The Hardware as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

15.9.2 The Local Monitoring & Control Server and the Operating Work station, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories:

Plant Server	
Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 X 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (prefarably RedHat Linux or equivalent Linux OS, Oracle/MySQL or equivalent DB), with required AMC for 5 years.
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3. Pointing Device: Mouse 4. Intelligent UPS (on line): Minimum 2 hour battery backup.
Operator Workstation	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 500GB hard disk, 25" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. Screen Display Unit: Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer. 3. UPS of required capacity with 2 hour battery backup.

15.9.3 All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

15.10 Factory Acceptance Test (FAT)

FAT procedure shall be submitted by bidder for approval. SCADA shall communicate with all third devices which are part of solar plant and same shall be demonstrated during the FAT.

16 Energy Management System

16.1 Energy Management System (EMS) system shall be a computerized system for real time monitoring, operation, control, reliable & efficient operation of the Plant facilities. EMS shall be able to acquire real time data of various equipment of Plant facilities, have in built logic/programming to monitor, control, and optimize the performance of Plant facilities as per specification. Contractor shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire Plant facilities and its auxiliary systems. Contractor shall include in his proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in this specification.

16.2 Standards and Codes

16.2.1 The EMS shall comply with IEC 61970 for interoperability.

16.2.2 The EMS shall have the functionality to ensure compliance to the CEA Technical standards for Connectivity (2019) regulations.

16.2.3 The EMS shall comply with cyber security guidelines issued by the Central Government, from time to time, and the technical standards for communication system in Power Sector laid down by the Authority.

16.3 EMS functionality for the Plant Control

16.3.1 The EMS monitors grid and Plant facility variables and should be programmable for selecting the optimum-operating mode of the whole plant w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behaviour to the new settings.

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

Communication with grid or SCADA

- Communications with PV Inverters and other power units
- Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)

- Control capability of PV Inverters and other power units
- The EMS shall allow following operation modes for the Plant facilities:
- Reactive Control (Q Control, setting point of reactive power Q at EMS)
- Power Factor Control (PF Control, setting point of cos(L) at EMS)
- Voltage Control (V closed loop control, setting point of V at EMS)
- Voltage Droop (Reactive power vs Voltage programmable curve or droop)
- Apparent Power Control (S Lim, setting point of S Lim at EMS)
- Active Power Limitation (P Lim, setting point of P Lim at EMS)

16.3.3 The EMS shall have the functionality to receive the target values specified by operators using a standard protocol (i.e. Modbus TCP/IP).

16.4 Control & Power Supply Scheme

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

17 Power Transformer

17.1 Standards and Codes

Power Transformer shall comply with the latest edition of the following standards and codes including amendments.

Standard	Description
IS 2026, IEC 60076	Specification of Power Transformers
IS 2099, IEC 60137	Bushings for alternate voltage above 1000 V
IS 8468	On-load tap changers
IS 335, IEC 60296	Insulating oil
IS 3639	Fittings and Accessories for Power Transformers

17.2 Technical Requirements

Parameter	Specification
Rated Capacity	As per system design
Rated Voltage	33 kV / 132 kV
Duty & Service	Continuous duty & Outdoor
Number of phases	3
Frequency	50 Hz

Vector group	As per system requirement			
Cooling	ONAN / ONAF			
Impedance at principal tap and 75°C	10%			
Tap changer	On Load Tap Changer (OLTC) on HV side, +/-10% with steps of 2.5%			
Winding Insulation Level	HV	HVN (If applicable)	LV	LVN (If applicable)
One min power frequency withstand voltage (kV)	275	38	70	38
Full wave lightning impulse withstand voltage (kVp)	650	95	170	95
Chopped wave lightning impulse withstand voltage (kVp)	715	-	187	-
Switching impulse withstand voltage (kVp)	540	-	-	-
Permissible temperature rise over an ambient of 50°C (irrespective of tap)				
Top oil	50°C			
Winding	55°C			
Fault level & duration	As per system requirement			
Short-circuit withstand time (Thermal)	2 second			
Bushing Insulation Level	HV	HVN (If applicable)	LV	LVN (If applicable)
Rated voltage (kV)	145	36	36	36
One min power frequency withstand voltage (kV)	305	77	77	77
Full wave lightning impulse withstand voltage (kVp)	650	170	170	170
Switching impulse withstand voltage (kVp)	-	-	-	-
Termination	As per system requirement			
Noise level	As per NEMA TR-1			
Loading capability	Continuous operation at rated MVA on any tap with voltage variation of +/- 10%, also transformer shall be capable of being loaded in accordance with IEC 60076-7			
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with +/- 10% voltage variation of voltage			

	corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds The Contractor shall furnish over fluxing characteristic up to 170%
Air clearance	As per CBIP

17.3 Tank

17.3.1 The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of adequate thickness. The tank and the tank cover shall be of welded construction. All seams and joints shall be welded and where practicable, they shall be double welded. The tank so welded shall be reinforced by stiffener of structural steel for general rigidity.

17.3.2 The transformer top shall be provided with a detachable tank cover with bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

17.3.3 The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760mm of Hg.

17.3.4 Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

17.3.5 Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

17.3.6 All bolted connections to tank shall be fitted with suitable oil-tight gasket, which shall give satisfactory service under the operating conditions. All gaskets shall be closed design (without open ends) and shall be of one piece only. Gasket of nitrile rubber or equivalent shall be used. Gaskets of neoprene and / or any kind of impregnated / bonded core or cork only which can easily be damaged by over-pressing are not acceptable. Use of hemp as gasket material is also not acceptable.

17.3.7 Lifting lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantling. In addition, the transformer tank shall be provided with lifting lugs and bosses properly secured

to the sides of the tank for lifting the complete transformer assembly with oil either by crane or by jacks.

17.3.8 The transformer tank shall be supported on a structural steel base equipped with forged steel single flanged wheels suitable for moving the transformer completely with oil. The wheels shall be bi-directional and mounted on swivels which may be turned through 90° when the tank is jacked up and capable of being locked in position parallel to and at right angles to the longitudinal axis.

17.4 Core

17.4.1 The transformer core shall be built up with high-grade non-ageing cold rolled grain oriented (CRGO) silicon steel laminations having high permeability and low hysteresis loss. The thickness of lamination shall be 0.27 mm or less.

17.4.2 The transformer shall be so designed that the flux density in the core shall not exceed 1.7 tesla at rated voltage and rated frequency. The maximum flux density in any part of core or yoke at 10% continuous over voltage condition shall not exceed 1.9 tesla.

17.4.3 The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.

17.4.4 The core shall be rigidly clamped to ensure adequate mechanical strength and to prevent vibration during operation and transportation. The clamping structure shall be designed to minimize eddy current loss.

17.4.5 The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux components at right angles to the plane of the laminations which may cause local heating.

17.4.6 The core shall be provided with lugs suitable for lifting the complete CCA of the transformer. The CCA shall be fixed with the tank so that it does not shift when transformer is moved or during short circuit.

17.4.7 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV RMS for one minute.

17.4.8 The core shall not be earthed at multiple locations. Terminal shall be brought on top of tank and earthed through link. Core and Frame terminals should be brought out on transformer top so as to enable megger.

17.5 Winding

17.5.1 The conductor for winding shall be made of electrolytic grade copper. The

winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs can be readily done without special equipment.

17.5.2 The coils shall be supported between adjacent sections by insulating spacers and barriers. Bracings and other insulation used in the assembly of the windings shall be arranged to ensure a free circulation of the oil and to reduce hot spots in the windings.

17.5.3 The insulation paper shall be of high quality and the value of degree of polymerization shall not be less than 1200 Pv.

17.5.4 Materials used for insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise get affected under the operating conditions.

17.5.5 All threaded connections shall be provided with locking facilities. All leads from the winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

17.5.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperature along the windings.

17.5.7 Windings shall be subjected to a shrinkage treatment before final assembly, so that no further shrinkage occurs during service. Adjustable device shall be provided for taking up any possible shrinkage of coils in service if required.

17.5.8 The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and windings shall be vacuum dried and suitably impregnated before removal from the treating tank. The copper conductors used in the coil structure shall be best suited to the requirements and all permanent current carrying joints in the windings and the locks shall be welded or brazed.

17.6 Insulating Oil

The oil for first filling together with 10% extra shall be supplied with the transformer. The oil shall comply in all respects with the provisions of the latest edition of IS 335 (as amended up to date). Particular attention shall be paid to deliver the oil free from moisture having uniform quality throughout in non-returnable steel drums.

17.7 On-Load Tap Changer

17.7.1 On-Load Tap Changer (OLTC) shall be designed for remote control operation

from Remote Tap Change Control (RTCC) Panel in the control room in addition to being capable of local manual as well as local electrical operation. The OLTC shall include the following.

(i) An oil immersed tap selector and arcing switch or arc suppressing tap selector, provided with reactor or resistor for reduction of make and break arcing voltages and short circuits.
(ii) Motor driven mechanism
(iii) Control and protection devices
(iv) Local /Remote tap changer position indicator
(v) Manual/Electrical operating device
(vi) Pressure relief device

17.7.2 The OLTC shall be so designed that the contacts do not interrupt arc within the main tank of the transformer. The tap selector and arcing switch or arc suppressing selector switch shall be located in oil filled compartment. The compartment shall be provided with Oil Surge Relay. It shall be designed so as to prevent oil in the tap selector compartment from mixing with the oil in the transformer tank.

17.7.3 The contactors and associated gear for the driving motor shall be housed in a local kiosk mounted adjacent to or on the transformer. The degree of protection of the complete arrangement shall be IP 55 or better. The motor shall be suitable for operation with three phase, 415 V, 50 Hz external power supply.

17.7.4 RTCC Panel

Remote Tap Change Control (RTCC) Panel shall include, but not limited to, the following.

(i) Automatic Voltage Regulator with SCADA compatibility
(ii) Under voltage relay to monitor the taper changer control voltage
(iii) Raise and lower push button
(iv) Tap position indicator
(v) Indication lamp showing tap changing in progress
(vi) Alarms and Annunciation
(vii) Any other accessory required for satisfactory operation or required during detail engineering

17.8 Bushing

17.8.1 The bushings shall have high factor of safety against leakage to ground and

shall be so located as to provide adequate electrical clearances between bushings and grounded parts. Bushings of identical voltage rating shall be interchangeable.

17.8.2 All bushings shall be equipped with terminals suitable for bimetallic connection. Each bushing shall be so coordinated with the transformer insulation that all flash over will occur outside the tank.

17.8.3 Bushings of rated voltage below 52 kV shall be porcelain insulator of oil-communicating type or OIP (non-oil communicating) or RIP type.

17.8.4 Bushings of rated voltage 52 kV and above shall be OIP condenser type (non-oil communicating) with porcelain insulator with following fittings.

(i) Oil level gauge

(ii) Oil filling plug and drain valve if not hermetically sealed

(iii) Tap for capacitance and tan delta test

17.9 Radiators

17.9.1 Radiators provided shall have sufficient cooling surface to limit the temperature rise to the values as specified in the 'Technical Requirements'. The radiators shall be seamless and made of mild steel/CRCA with minimum thickness not less than 1.2 mm. It shall be suitably braced to protect them from mechanical shocks.

17.9.2 The radiators shall be connected to the tank by machined steel flanges with adequate gaskets to avoid oil leakage. Each radiator unit shall be provided with butterfly type or positive operated gate type oil leak proof shut-off valve which can be fastened in either closed or open position and separate oil tight flange for each tank connection for use when the radiator unit is detached. Each radiator unit shall have a lifting arrangement and oil drain at the bottom and a vent at the top.

17.9.3 It shall be possible to take out any of the radiator unit without disturbing the transformer. The radiators shall be so designed as to prevent any accumulation of water on the outer surface or formation of gas pockets when the tank is being filled.

17.10 Accessories

17.10.1 Conservator

The conservator shall have air cell type constant oil preservation system to prevent oxidation and contamination of oil due to contact with moisture. The conservator

shall be provided with separate compartment for OLTC. No separate conservator tank shall be provided for OLTC. The conservator shall be fitted with oil filling hole, cap and drain valve. Prismatic toughened glass oil level gauge and 150 mm Magnetic Oil Gauge (MOG) with low oil level alarm contact shall also be provided.

17.10.2 Silica gel breather

The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel dehydrating breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. The capacity of breather should be such that it can contain minimum 5 kg silica gel for main conservator compartment and minimum 1 kg silica gel for OLTC conservator compartment. The GI pipe connecting breather with conservator should be seamless and no joint is permitted.

17.10.3 Buchholz relay

Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper or stainless-steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling when the transformer in service. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.

17.10.4 Pressure Relief Device

Pressure Relief Device shall be provided on main tank and OLTC for rapid release of any pressure in transformer which may endanger the equipment. The device shall operate at a static pressure of less than hydraulic test pressure of transformer tank/OLTC chamber. The terminal box of the PRD shall be water tight with protection class IP 56 or better as per IEC 60529. Electrically insulated contact shall be provided for trip signal.

17.10.5 Temperature Indicators

17.10.5.1 Oil Temperature Indicator (OTI)

150 mm dial type temperature indicator with 'Maximum' reading pointer and resetting device shall be provided. The indicator shall have adjustable, electrically independent, potential free alarm and trip contacts. A temperature sensing element suitably located in a pocket on top oil shall be provided. Accuracy class of OTI shall be 1.5% or better.

17.10.5.2 Winding Temperature Indicator (WTI)

A device for measuring the hot spot temperature of each of the winding shall be provided. It shall comprise the following.

(i) Temperature sensing elements, one each on HV and LV winding.
(ii) Image coil.
(iii) Auxiliary CTs, if required to match the image coil.
(iv) 150 mm dial type temperature indicator with 'Maximum' reading pointer and resetting device with adjustable, electrically independent, potential free alarm and trip contacts.
(v) Calibration device.

The winding temperature indicator shall be responsive to the combination of top oil temperature and winding current, calibrated to follow the hottest spot temperature of the transformer winding. Accuracy class of WTI shall be 1.5% or better.

17.10.6 Marshalling Box

Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. One dummy terminal block in between each trip wire terminal shall be provided. At least 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene or synthetic rubber. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the marshalling box door.

17.10.7 Valves

The transformer shall be provided with the following (but not limited to) valves.

(i) Two nos. of filter valves, one at top and another at bottom on diagonally opposite corners
(ii) Two nos. of sampling valves at top and bottom of the tank
(iii) Drain valve on main tank
(iv) Drain valves on main and OLTC compartment of conservator
(v) Valves (for nitrogen injection and oil drain) as required by firefighting system

All valves shall be constructed of stainless steel, brass or gun metal except of shutoff valve for radiator and cooler. For radiator and cooler, valve shall be made up of gun metal or cast iron.

17.11 Painting

17.11.1 Before painting or filling with oil, un-galvanized parts shall be completely cleaned

and free from rust, scale and grease. All external rough surfaces on casting shall be filled by metal deposition. The interior of transformer tank and other filled chambers and internal structural steel work shall be cleaned of all scale and rust by send blasting or other approved method. These surfaces shall be painted with an oil resisting varnish or paint.

17.11.2 Except for nuts, bolts and washers, all external surfaces shall receive a minimum of three coats of paint. The primary coat shall be applied immediately after cleaning. The second coat shall be of oil paint of weather resisting nature. The final coat shall be of a glossy, oil and weather resisting non-fading paint. The paint shade shall be as provided by the Employer during detailed engineering.

17.11.3 All internal surfaces of mechanism chambers and kiosk except those which have received anticorrosion treatment, shall receive three coats of paint applied to the thoroughly cleaned metal surface. The final coat shall be of light coloured anti-condensation mixture.

17.11.4 Any damage to paint work incurred during transport and erection shall be made good by thoroughly cleaning the damaged portion and by applying full number of coats of paints.

17.12 Transportation

17.12.1 Transformer tank is filled with oil or pure dry nitrogen/ air depending upon the transport weight limitations. Necessary arrangement shall be ensured to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

17.12.2 Bushings shall be crated, packed and transported as per standard guide lines of the Bushing Manufacturer. All care should be taken to avoid any damage of the porcelain due to vibration during transport.

17.12.3 Special attention shall be paid in packing the accessories & spares to avoid moisture ingress. All parts shall be adequately marked to facilitate field erection.

17.13 Warranty

The power transformer shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

17.14 Testing and Inspection

17.14.1 Type Tests and Special Tests

The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar transformer by NABL accredited laboratory.

17.14.1.1 Type Tests

(i) Lightning impulse (Full & Chopped Wave) test on windings as per IS 2026-3/IEC 60076-3

(ii) Temperature Rise test at a tap corresponding to maximum losses as per IS 2026-2/IEC 60076-2. Dissolved Gas Analysis (DGA) shall be conducted on oil sample taken before and immediately after temperature rise test. Gas analysis shall be as per IS 9434/IEC 60567 and results will be interpreted as per IS 10593/IEC 60599.

17.14.1.2 Special Tests

(i) Short circuit withstand test as per IS 2026-5/IEC 60076-5

(ii) Measurement of zero-sequence impedance as per IS 2026-1/IEC 60076-1

(iii) Measurement of harmonics of no-load current as per IS IEC 60076-1

(iv) Measurement of acoustic noise level as per NEMA TR-1

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

17.14.2 Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IEC 60076 unless specified otherwise.

(i) Measurement of winding resistance at each tap

(ii) Measurement of voltage ratio between HV and LV windings at each tap

(iii) Check of vector group

(iv) Measurement of no-load loss and no-load current at 90%, 100% & 110% of rated voltage

(v) Measurement of short-circuit impedance and load loss at principal and extreme taps

(vi) Magnetic balance test & magnetizing current test as per CBIP manual publication no. 295

(vii) Separate source voltage withstand test

(viii) Induced over voltage withstand test

(ix) Measurement of insulation resistance and polarization index

(x) Measurement of tan delta and capacitance of winding

(xi) Core isolation test

(xii) Marshalling box functional test

(xiii) IR Measurement on wiring of marshalling box

(xiv) Test on on-load tap changer

(xv) Breakdown voltage test on transformer oil as per IS 335

(xvi) Jacking test followed by D.P. test

(xvii) Oil leakage test on completely assembled transformer along with radiators

18 Nitrogen Injection Fire Protection System

Nitrogen Injection Fire Protection System (NIFPS) shall use nitrogen as fire quenching medium. The protection system shall prevent transformer oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fire, fire from surrounding equipment etc., it shall act as a fast and effective fire extinguisher without any manual intervention.

18.1 Standards and Codes

All the equipment of NIFPS shall comply with the latest edition of the following standards and codes including amendments.

Standard	Description
IS 10028-2	Code of practice for selection, installation and maintenance of transformers; Part 2: Installation
IS 7285-2	Refillable Seamless Steel Gas Cylinders - Specification Part 2: Quenched and Tempered Steel Cylinders With Tensile Strength Less Than 1100 MPa (112 kgf/mm^2)
CEA Technical Standards for Construction of Electrical Plants and Electric Lines Regulations, 2010 with 2015 amendment	
CEA Measures relating to Safety and Electric Supply Regulations, 2010 with 2015 amendment	
CBIP Manual on Transformers, Publication No. 317	

18.2 Technical Requirements

Parameter	Specification
Fire extinction period from commencement of nitrogen injection	30 second (maximum)

Total time duration to bring oil temperature below flash point	30 minute (maximum)
Fire detector heat sensing temperature	141°C
TCIV setting for normal operation to ensure no obstacle for transformer breathing	40 litre per minute
TCIV setting for operation during abnormal flow of oil	60 litre per minute
Capacity of nitrogen gas cylinder	10 m^3 gas at pressure of 150 kg/cm^2 for up to 60,000 litre of oil 20 m^3 gas at pressure of 150 kg/cm^2 for above 60,000 litre of oil

18.3 System Components

NIFPS shall broadly consists of the following components. However, all other components which are necessary for fast, reliable and effective working of the fire protection system shall be deemed to be included in the scope of supply. The NIFPS shall have provision for SCADA connectivity.

18.3.1 Fire Extinguishing Cubicle

The Fire Extinguishing Cubicle (FEC) shall be made of CRCA sheet of minimum 3 mm thick with Polyurethane painting. The degree of protection shall be IP55 or better. It shall have hinged split doors fitted with high quality tamper proof lock. The following components shall be provided in the FEC.

(i) Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer. The nitrogen gas cylinder should have been certified by Bureau of Indian Standards and approved by Chief Controller of Explosives, Government of India.
(ii) Oil drain pipe with mechanical quick drain valve
(iii) Control equipment for draining of oil and injecting nitrogen gas
(iv) Pressure monitoring switch for backup protection for nitrogen release
(v) Limit switches for monitoring of the system
(vi) Butterfly valve with flanges on top of the cubicle for connecting oil drain pipe and nitrogen injection pipe
(vii) Panel lighting
(viii) Oil drain pipe extension of suitable sizes for connecting pipes to oil pit

18.3.2 Control Box

Control box shall be placed in the Master Control Room (MCR) for monitoring, automatic control and remote control. The rated control voltage of the control box shall be 110 VDC. The control box shall have suitable indications, alarms, switches and push buttons for complete monitoring and control of the system.

18.3.3 Transformer Conservator Isolation Valve

Transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipe line between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling. Locking plates shall be provided with handle for pad locking. It shall have proximity switch for remote alarm and indication glass window for visual inspection for physical checking of the status of valve. The TCIV shall be of the best quality and proven design as malfunctioning of TCIV could lead to serious consequences.

18.3.4 Fire Detector

Adequate number of fire detectors shall be fitted on top cover of the transformer and OLTC with brackets. Heat sensing temperature of the fire detectors shall be 141°C.

18.3.5 Signal Box

Signal box shall be mounted way from the transformer preferably near the marshalling box for terminating the cables from TCIV & fire detectors and to further connection to control box at the MCR. The degree of protection of the signal box shall be IP 55 or better.

18.3.6 Cables

The interconnecting cables shall be Fire Retardant Low Smoke (FRLS) type. Cables passing along the top of the transformer shall be Fire Survival type.

18.3.7 Pipes

Heavy duty pipe connecting the transformer tank for oil drain and for nitrogen injection shall be provided. Pipes, complete with supports, connections, flanges, bends and tees etc. shall be supplied along with the system.

18.3.8 Other Items

(i) Doors and covers of all the panels (FEC, Control box, Signal box, etc.) shall be provided with neoprene gaskets.

(ii) All the panels and piping system shall be painted with enamelled paint.

18.4 Protection Philosophy

18.4.1 The NIFPS shall have the operating modes and operate on receipt of corresponding activation signals.

18.4.1.1 Auto Mode

A. Fire Prevention

The system shall operate on receipt of all the following three signals.

(i) Differential relay trip

(ii) Operation of Buchholz relay (OR) Pressure Relief Device (OR) Rapid Pressure Rise Relay

(iii) Master trip (OR) Tripping of LV / HV circuit breaker in series

B. Fire Extinction

The system shall operate on receipt of all the following three signals.

(i) Operation of fire detector

(ii) Operation of Buchholz relay (OR) Pressure Relief Device (OR) Rapid Pressure Rise Relay (OR) Oil Surge Relay

(iii) Master trip (OR) Tripping of LV / HV circuit breaker in series

18.4.1.2 Remote Manual Mode

The system shall operate on receipt of both the following signals.

(i) Master trip (OR) Tripping of LV / HV circuit breaker in series

(ii) Operation of emergency operating switch on the control box

18.4.1.3 Local Manual Mode

In case the system fails in Auto Mode / Local Remote Mode (OR) Power Failure, the system can be operated manually from the Fire Extinguisher Cubicle.

18.4.2 On receipt of all required activating signals, the system shall drain pre-determined volume of oil from top of the tank through outlet valve to reduce tank pressure and simultaneously inject nitrogen gas at high pressure through inlet valves for stirring the oil and thus bringing the temperature of oil below flash point to extinguish the fire. Transformer conservator isolation valve shall block the flow of oil from conservator tank.

19 Control and Relay Panel

19.1 Standards and Codes

All equipment provided under Control and Relay Panel shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the C&R Panel shall comply with the following standards and codes.

Standard/Code	Description
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

19.2 Construction

19.2.1 The control and relay panel shall be free standing, floor mounted, simplex type, metal enclosed construction. The panel enclosure shall be made of CRCA steel sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.

19.2.2 All external surface shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 micron.

19.2.3 Controls, indications, relays, meters and other instruments shall be flush mounted on the front of the panel. Door shall be provided at the rear of the panel.

All doors and removable covers shall be provided with neoprene or synthetic rubber gasket.

19.2.4 The panel shall be dust, moisture and vermin proof with degree of protection not less than IP 4X as per IEC 60529.

19.2.5 Cable entry shall be through the bottom of the panel. Gland plate of thickness not less than 3 mm shall be provided.

19.3 Relays

19.3.1 All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.

19.3.2 Auxiliary voltage of the relays shall be 110 VDC and the relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.

19.3.3 All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO). All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

19.3.4 All numerical relays shall have sufficient number of current and voltage inputs required for all the required protection functions.

19.3.5 The numerical relay shall provide choice of ANSI/IEC/IEEE relay characteristic curves with wide protection setting ranges through a minimum of two protection setting groups.

19.3.6 Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

19.3.7 All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

19.3.8 The numerical relay shall be able to record faults and events in non-volatile memory.

(i) Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.

(ii) Event record – At least 200 events with date and time stamp.

19.3.9 The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.

19.3.10 The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

19.3.11 The numerical relay shall have two serial communication ports, one on front side for local communication with PC and another on rear side for remote communication with SCADA system as per IEC 61850.

19.3.12 The numerical relay shall have feature for time synchronization through the SCADA System / networking.

19.3.13 The numerical relay shall be provided with backlit alphanumeric LCD or LED to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

19.3.14 Necessary software and hardware to up/down load the data to/from the relay from/to the PC shall also be provided.

19.4 Protection Scheme

The following protection schemes shall be implemented for the protection of power transformer and its feeder.

(i) Biased Differential Protection with Second Harmonic Restraint
(ii) Non-directional Over Current and Earth Fault Protection
(iii) Restricted Earth Fault Protection
(iv) Under Voltage and Over Voltage Protection
(v) Buchholz Alarm and Trip
(vi) OTI Alarm and Trip
(vii) WTI Alarm and Trip
(viii) PRV Trip
(ix) MOG Alarm
(x) OSR Trip

The above-mentioned protection schemes are indicative only. All the protection schemes required for safe and reliable operation of power transformer and the feeder shall be provided.

19.5 Measuring Instruments

19.5.1 All measuring instruments shall be enclosed in dust proof, moisture resistant cases and flush mounted on the panel.

19.5.2 Analog Ammeter and Voltmeter with selector switch shall be provided. Accuracy class shall be 0.5 or better. Instrument dial shall be with white scale, black

pointer and black numerals.

19.5.3 Digital Multi Function Meter (MFM) of accuracy class 0.2 or better shall be provided. It shall have communication capability for integration with SCADA. MFM shall be able to measure line & phase voltages, line & phase currents, active power, reactive power, apparent power, power factor and frequency.

19.6 Control Switches

All control switches shall be rotary operated type with adequate making, carrying and breaking current ratings. The control switches shall be pistol grip type, lockable with spring return to normal position. They shall be flush mounted on the panel with shrouded terminals.

19.7 Indications

All indicating lamps shall be flush mounted LED type with supply voltage of 110 VDC. Lamp covers shall preferably be screwed type and moulded from heat resisting material. Indicating lamps shall be provided for R, Y, B PT supply, Breaker ON & OFF, Auto trip, Spring charged, Trip circuit healthy, etc.

19.8 Annunciation

Flush mounted static type annunciator with sufficient number of windows to accommodate all trip and alarm signals shall be provided. Separate audible annunciation for alarm and trip shall be provided by means of buzzer and hooter. Visual annunciation shall be by flickering of facia. Push buttons for test, accept and reset shall also be provided.

19.9 Earthing

19.9.1 An earth bus made of copper or aluminium shall be provided throughout the length of the panel and bolted to the framework of the panel. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

19.9.2 All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with earth grid.

19.9.3 All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less

than 2.5 sq. mm with green colour insulation.

19.9.4 Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

19.10 Mimic Diagram

Coloured mimic diagram made of metal or plastic with symbols to facilitate exact representation of the system shall be fixed on the front of control panel. Semaphore indicators shall be incorporated in the mimic diagram for indicating position of circuit breakers, isolators and earthing switches. The rated control voltage of semaphore indicator shall be 110 / 220 VDC.

19.11 Wiring and Terminal Blocks

19.11.1 All internal wiring shall be done with 1100 V grade, 2.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 4 sq.mm copper wire shall be used.

19.11.2 Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

19.11.3 Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.

19.11.4 The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

19.11.5 All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 1100 V, 10 A and made of non-inflammable material.

19.11.6 CT and VT secondary circuits shall be terminated on stud type, non-disconnecting terminal blocks.

19.11.7 At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

19.11.8 Screw driver operated stud type test terminal block shall be provided.

19.12 Accessories

(i) Thermostatically controlled space heater with switch for isolation

(ii) 240 V, 15 A industrial socket with ON/OFF switch

(iii) LED lamp controlled by door switch

19.13 Warranty

The control and relay panel unit shall be warranted for minimum of 2 (Two) years against all material/ manufacturing defects and workmanship.

19.14 Testing and Inspection

19.14.1 Type Tests

The Contractor shall submit type test report of the panel for degree of protection as required by the Technical Specifications as per IEC 60529. The test should have been conducted by NABL accredited laboratory.

19.14.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

20 132 kV Switchyard Equipment

20.1 Standards and Codes

All equipment provided shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the switchyard equipment shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IEC 60376, IS 13072	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IEC 61869	Instrument Transformers
IS 2099	Bushings for alternating voltages above 1000 Volts
IS 2544	Porcelain post insulators for systems with nominal voltage greater than 1000 Volts
IS 335, IEC 60296	Insulating oil
IS/IEC 60034	Rotating electrical machines

IS 996	Single-phase AC industrial motors for general purpose
IS 3070, IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
Indian Electricity Act, CBIP manual, CEA rules and guidelines	

20.2 General Technical Parameters

System Parameters	**Specification**
Highest system voltage	145 kV
Rated system voltage	132 kV
Rated frequency	50 Hz
Number of phases	3
One minute power frequency withstand voltage	275 kV (rms)
Full wave impulse withstand voltage (1.2 / 50 µs)	650 kV (peak)
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	500 µV at 92 kV rms
Rated short-time withstand current	31.5 kA for 1 s
Rated peak withstand current	80 kAp
System neutral earthing	Effectively earthed
Minimum creepage distance	As per site pollution level
Minimum clearance (i) Phase to phase clearance (ii) Phase to earth clearance (iii) Sectional clearance (iv) Ground clearance	 1300 mm 1300 mm 4000 mm 4800 mm

20.3 Supplier Qualification Criteria

Only PGCIL approved components shall be used for construction of 132 kV switchyard.

20.4 Circuit breaker

20.4.1 Technical Parameters

Parameters	**Specification**
Type	Outdoor SF6, single pressure
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Rated break time	60 ms
Total break time	65 ms

Total closing time	Not more than 150 ms
Re-strike performance class	C2
Mechanical endurance class	M2
First pole to clear factor	1.3
Reclosing	Three phase high speed auto reclosing
Rated terminal load	Adequate to withstand 100 kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity
Noise level	Maximum 140 dB at 50 m distance from base of circuit breaker
Seismic level	0.5 g horizontal for the site location under Zone-V as per IS 1893 0.3 g horizontal for the site location under other than Zone-V as per IS 1893
Auxiliary contacts	
No. of contacts	As required plus 10 NO and 10 NC contacts per pole as spare
Thermal rating	10 A at 220 V DC
Breaking capacity	2 A DC with circuit time constant not less than 20 ms

20.4.2 Duty Requirements

20.4.2.1 The circuit breaker shall be shall be capable of performing their duties without opening resistors. The circuit breaker shall meet the duty requirements for any type of fault or fault location and shall be suitable for line charging and dropping when used on effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.

20.4.2.2 The circuit breaker shall be capable of breaking the steady and transient magnetizing current corresponding to power transformers of applicable rating. It shall be capable of breaking line charging currents as per IEC 62271-100 with a voltage factor of 1.4. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC 62271-100.

20.4.2.3 The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic/hydraulic pressure and arc extinguishing medium pressure, etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles shall be

brought out to establish the guaranteed total break time. While furnishing particulars regarding the D.C. component of the circuit breaker, the Contractor shall note that IEC 62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.

20.4.3 Construction

20.4.3.1 Circuit breakers shall be SF6 insulated, single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

20.4.3.2 Each pole shall form an enclosure filled with SF6 gas independent of two other poles and the SF6 density of each pole shall be monitored individually.

20.4.3.3 The SF6 gas density monitor shall be adequately temperature compensated to model the density changes due to variations in ambient temperature within the body of circuit breaker as a whole. It shall be possible to dismantle the monitor without removal of gas. Temperature compensated SF6 pressure gauge shall be provided which will be visible from ground level.

20.4.3.4 Sufficient SF6 gas shall be supplied to fill all the circuit breakers installed plus an additional 20% of the quantity as spare.

20.4.3.5 All making and breaking contacts shall be sealed and free from atmospheric effect. In the event of leakage of extinguishing medium to a value, which cannot withstand the dielectric stresses specified in the open position, the contacts shall preferably self-close. Main contacts shall be easily accessible for inspection and replacement. If there are no separately mounted arcing contacts, then the main contacts shall be easily accessible for inspection and replacement. Main contacts shall have ample area and contact pressure for carrying the rated current under all conditions.

20.4.3.6 All the three poles of the breaker shall be linked together either electrically/pneumatically or electro hydraulically.

20.4.3.7 Circuit breakers shall be provided with two (2) independent trip coils, suitable for trip circuit supervision. The trip circuit supervision relay would also be provided. Necessary terminals shall be provided in the central control cabinet of the circuit breaker.

20.4.4 Operating Mechanism and Control

20.4.4.1 Circuit breaker shall be operated by pneumatic mechanism or electrically spring

charged mechanism or electro-hydraulic mechanism or a combination of these. It shall be gang operated for 3-phase reclosing operation.

20.4.4.2 The pneumatically operated mechanism shall offer unit compressor with each circuit breaker with the breaker local air receivers having a capacity for two 'CO' operations of the breaker at the lowest pressure for reclose duty without refilling.

20.4.4.3 The spring-operated mechanism shall be complete with motor, opening spring & closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty. After failure of power supply to the motor, one close-open operation shall be possible with the energy contained in the operating mechanism. Motor ratings shall be such that it requires not more than 30 seconds for fully charging the closing spring.

20.4.4.4 The hydraulic mechanism shall be suitable for at least two close open operations after failure of ac supply to the motor starting at pressure equal to lowest pressure of auto-reclose duty. All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

20.5 Disconnector

20.5.1 Technical Parameters

System Parameters	**Specification**
Service	Outdoor
Type	Gang operated, Double break type
Rated short-time withstand current for isolator & earth switch	31.5 kA for 1 s
Rated peak withstand current for isolator & earth switch	80 kAp
Operating Mechanism	AC / DC / Universal motor operated
Maximum operating time	12 s
Control Voltage	110 / 220 V DC
Auxiliary contacts	
No. of contacts for isolator	As required plus 8 NO and 8 NC contacts per pole as spare

No. of contacts for earth switch	Total 6 NO and 6 NC
Thermal rating	10 A at 220 V DC
Breaking capacity	2 A DC with circuit time constant not less than 20 ms
Mechanical endurance class a) Isolator b) Earth switch	 M2 M0

20.5.2 Duty Requirements

20.5.2.1 Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the system in their closed position. They shall be constructed such that they do not open under influence of short circuit current and wind pressure together.

20.5.2.2 The earth switches, wherever provided, shall be interlocked so that the earth switches can be operated only when the isolator is open and vice versa. In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within stipulated variation range. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for DC control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

20.5.2.3 The earthing switches shall be capable of discharging trapped charges of the associated lines. Isolators and earth switches shall be able to bear on the terminals the total forces including wind loading and electrodynamic forces on the attached conductor without impairing reliability or current carrying capacity.

20.5.2.4 The isolator shall be capable for making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of the isolator on account of making/breaking operation.

20.5.3 Construction

20.5.3.1 Contacts

(i) The contacts shall be self-aligning and self-cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

(ii) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

(iii) Contact springs shall not carry any current and shall not lose their characteristics due to heating effects.

(iv) The moving contact of double break isolator shall preferably be turn-and-twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

(v) Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

20.5.3.2 Base

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structure.

20.5.3.3 Blades

(i) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

(ii) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces. Where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

(iii) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental

touching of the connecting rods of the operating mechanism.

(iv) The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e., after every 1000 operations or after 5 years whichever is earlier.

20.5.3.4 Insulator

(i) The insulator shall conform to IS / IEC 60168 and IS 16683 / IEC TS 60815.

(ii) In addition to all type, routine and acceptance tests, as per IS / IEC 60168, the following additional routine/ acceptance tests shall also be carried out.

(a) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as routine test

(b) Bending load test in four directions at 100% of minimum bending load guaranteed as a sample test on each lot

(c) Torsional test on sample insulator of a lot

(d) Ultrasonic test as a routine test

(iii) The porcelain of the insulator shall have minimum cantilever strength of 600 kg.

(iv) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

20.5.3.5 Earthing Switches

(i) Where earthing switches are specified, these shall include the complete operating mechanism and auxiliary contacts. The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

(ii) Earthing switches shall only be locally operated.

(iii) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

20.5.4 Operating Mechanism and Control

20.5.4.1 The Contractor shall offer motor operated switches having padlock arrangement for both ON and OFF positions.

20.5.4.2 Limit switches for control shall be fitted on the isolator / earth switch shaft within the cabinet to sense the open and close positions of the isolators and earth

switches.

20.5.4.3 It shall not be possible, after final adjustment has been made, for any part of the mechanism to be displaced at any point in the travel sufficient enough to allow improper functioning of the isolator when the isolator is opened or closed at any speed.

20.5.4.4 Control cabinet / operating mechanism box shall conform to requirements stipulated elsewhere in the document and IS/IEC 61439 as applicable.

20.5.5 Operation

20.5.5.1 Isolator shall be electrically/mechanically gang operated for main blades and earth switches. The operation of all the three poles shall be well synchronized and interlocked.

20.5.5.2 The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments.

20.5.5.3 The isolator and earth switches shall be provided with 'dead centre mechanism' to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

20.5.5.4 The design of linkages and gears be such so as to allow one man to operate the handle with ease for isolator and earth.

20.6 Surge Arrester

20.6.1 Technical Parameters

Parameter	**Specification**
Arrester Classification	Station Medium (SM)
Nominal discharge current (8/20 µs)	10 kA
Repetitive charge transfer rating	1.6 coulomb
Rated thermal energy rating	7 kJ/kV
Rated arrester voltage	120 kV
Continuous operating voltage at 50°C	102 kV
Maximum Residual Voltage (i) At 30/60 µs, 1 kA current (ii) At 8/20 µs, 5 kA current (iii) At 8/20 µs, 10 kA current	 280 kVp 310 kVp 330 kVp
High-current short duration test value (4/10 µs)	100 kAp

Current for pressure relief test	40 kA
Partial discharge at 1.05 times the continuous operating voltage	≤ 10 pC

20.6.2 Duty Requirements

20.6.2.1 The Surge Arresters shall be capable of discharging over-voltages occurring due to switching of unloaded transformers, reactors and long lines.

20.6.2.2 The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

20.6.2.3 The Surge Arresters shall be capable of withstanding meteorological and short circuit forces under site conditions.

20.6.2.4 The SAs shall protect power transformers, circuit breakers, disconnecting switches, instrument transformers, etc. with insulation levels specified in this specification.

20.6.3 Construction

20.6.3.1 Each surge arrester shall be hermetically sealed single-phase unit. The non-linear blocks shall be made of sintered metal oxide material. The surge arrester construction shall be robust with excellent mechanical and electrical properties.

20.6.3.2 Surge Arresters shall be fitted with pressure relief devices and arc diverting ports suitable for preventing shattering of polymer housing and to provide path for flow of rated fault current in the event of SA failure.

20.6.3.3 Outer insulator of surge arrester shall be made of porcelain/polymer. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester. Arresters shall not fail due to insulator contamination.

20.6.3.4 Seals shall be provided in such a way that they are always effectively maintained even when discharging rated lightning current.

20.6.3.5 The cantilever strength of the insulator shall be minimum 150 kg.

20.6.3.6 The following details shall be furnished for quality checks.

(i) The heat treatment cycle details along with necessary quality checks used for individual blocks and insulation layer formed across each block.

(ii) Metalizing coating thickness for reduced resistance between adjacent discs.

20.6.4 Fittings and Accessories

20.6.4.1 Surge arrester shall be complete with insulating base having provision for mounting to structure.

20.6.4.2 Grading/corona rings shall be provided on each surge arrester unit, as required.

20.6.4.3 The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

20.6.4.4 Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection arrangement. Suitable leakage current meters shall also be provided in the same enclosure. The reading of ammeter and counter shall be visible through an inspection glass panel to maintenance personnel standing on ground. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 V DC which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

20.7 Instrument Transformer

20.7.1 Technical Parameters

Parameter	**Specification**
Current Transformer	
Accuracy class	Metering – 0.2S Protection – PS / 5P20
Rated VA burden	As per requirement
Insulation class	Class E
One minute power frequency withstand voltage between secondary terminals & earth	5 kV
Rated short time thermal withstand current	31.5 kA for 1 s
Rated dynamic current	80 kAp
Partial discharge level	10 pico Coulomb (max)
No. of terminals	All terminals of control circuits wired up to marshalling box plus 20% spare
Capacitive Voltage Transformer	
Accuracy class	Metering – 0.2 Protection – PS / 3P
Rated VA burden	As per requirement

Insulation class	Class E
Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance
Equivalent series resistance over entire carrier frequency range	< 40 ohm
One minute power frequency withstand voltage between secondary terminals & earth	
(i) Between LV (HF) terminal and earth terminal	10 kV for exposed terminals 4 kV for terminals enclosed in a weather proof box
(ii) For secondary winding	3 kV
Partial discharge level	10 pico Coulomb (max)
Rated voltage factor	1.2 continuous and 1.5 for 30 sec.
No. of terminals	All terminals of control circuits wired up to marshalling box plus 20% spare

20.7.2 General Requirements

20.7.2.1 Instrument transformers shall be hermetically sealed single-phase units, oil immersed, self-cooled suitable for outdoor installations and shall be supplied with common marshalling box for a set of three single phase units.

20.7.2.2 The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted with colour shade as decided by the Employer during detailed engineering.

20.7.2.3 Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS 335 / IEC-60296. Non–PCB based synthetic insulating oil conforming to IEC 60867 shall be used in the capacitor units of CVT.

20.7.2.4 Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

20.7.2.5 The insulators shall have cantilever strength of more than 350 kg.

20.7.2.6 Marshaling box shall conform to all requirements given elsewhere in the document. The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.

20.7.3 Current Transformer

20.7.3.1 Current transformer shall have single primary of either ring type or hair pin type or bar type. Wound type primary is acceptable only for metering CTs of ratio less than 400/1. In case of inverted type/live tank CT, the following requirements shall be met.

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) The insulator shall be one piece without any metallic flange joint.

20.7.3.2 Core lamination shall be of cold rolled grain-oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.

20.7.3.3 The CT shall be provided with oil filling plug, drain plug, and oil sight glass which should be clearly visible to maintenance personnel standing on ground.

20.7.3.4 The secondary terminals of CT shall be terminated to suitable number of stud type non-disconnecting and disconnecting terminal blocks as required inside the terminal box of degree of protection IP 55 at the bottom of CT.

20.7.3.5 Different ratios shall be achieved by secondary taps only; primary reconnection shall not be accepted.

20.7.3.6 The Instrument Security Factor (ISF) at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactors are used, then all parameters specified shall be met treating auxiliary CTs as an integral part of the CT. The auxiliary CTs/reactors shall preferably be in-built construction of the CT. In case these are to be mounted separately, these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

20.7.3.7 Current transformers shall be suitable for high speed auto reclosing.

20.7.4 Capacitor Voltage Transformer

20.7.4.1 Capacitor Voltage Transformer shall consist of a capacitor divider and an electromagnetic unit housed in independent, non-oil communicating hermitically sealed compartments.

20.7.4.2 The capacitor divider shall consist of primary and secondary capacitance housed in high quality porcelain insulators filled with oil. The electromagnetic unit shall comprise of compensating reactor, intermediate transformer, protective and damping devices.

20.7.4.3 Suitable damping device shall be permanently connected to one of the secondary windings and shall be capable of suppressing ferro-resonance oscillations.

20.7.4.4 All the secondary windings of the CVT shall be protected by HRC cartridge type fuses or MCBs. In addition, fuses/MCBs shall also be provided for protection and metering windings for connection to fuse monitoring scheme.

20.7.4.5 The secondary terminals of the CVT shall be terminated to stud type non-disconnecting terminal blocks via fuses/MCBs inside the terminal box of degree of protection IP 55. It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

20.7.4.6 CVTs shall be suitable for High Frequency (HF) coupling required for Power Line Carrier Communication (PLCC). Carrier signals must be prevented from flowing into EMU circuit by means of RF choke/reactor over the entire frequency range of 40 to 500 kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. Further, earthing link with fastener to be provided for HF terminal.

20.7.4.7 A protective surge arrester/spark gap shall preferably be provided to prevent break down of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Contractor for Employer's review.

20.7.4.8 The accuracy of metering core shall be maintained through the entire burden range up to rated value without any adjustments during operations.

20.7.4.9 The protection cores shall not saturate at about 1.5 times the rated voltage for a minimum duration of 30s.

20.8 Warranty

All switchyard equipment shall be warranted for minimum of 2 (Two) years against all material/ manufacturing defects and workmanship.

20.9 Testing and Inspection

20.9.1 Type Tests

All switchyard equipment shall be of type tested design. Type test reports as per the relevant IEC/IS standards shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory. In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

20.9.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

21 Illumination

21.1 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

21.2 General specification

21.2.1 This specification covers design, supply and installation of uniformly Illumination system along the peripheral & internal roads, main control room & inverter rooms, switchyard and other facilities including entry points/gate(s) inside the plant area.

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

21.2.3 Lighting system shall work on the auxiliary supply and same shall be incorporated in auxiliary loads. The Contractor shall provide minimum 20% of total lighting points as emergency lighting points, fed from UPS DB or DCDB as per scheme adopted by the Contractor. Indoor and outdoor emergency lights shall be provided at each inverter room, main control room, security room and main gate.

21.3 Lighting Levels

21.3.1 The average LUX level of 10 lumen is to be maintained in switchyard. However,