following standards & codes.

16101:2012 General Lighting. LEDs and LED modules Terms and definitions
16102(Part-1 Safety Requirements):2012 Self Ballasted LED Lamps for General Lighting Services.
16102(Part-2 Performance Requirements.):2012 Self Ballasted LED Lamps for General lighting Services.
16103(Part I):2012 LED modules for General lighting Safety Requirements.
15885(Part 2/Sec. 13) :2012 Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules
16104:2012 d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements.
16105:2012 Method of Measurement of Lumen maintenance of Solid-state Light (LED) Sources.
16106:2012 Method of Electrical and photometric Measurements of Solid State Lighting (LED) Products
16107:2012 Luminarie Performance
16108:2012 Photobiological safety of Lamps and Lamp Systems
IS 513 Cold rolled low carbon steel sheets and strips
IS 12063 Classification of degree of protection provided by enclosures.
IS 14700(Part 3/Sec. 2): Electro magnetic compatibility (EMC) – Limits for Harmonic emission – THD < 15% (equipment, input current < 16 Amps. per phase.
IS 9000 (Part 6) Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
IS 15885(Part 2/Sec. 13)/ IS 16004 (1 and 2)- Lamp control gear: particular requirements for (Part 2/Sec. 13) DC or AC supplied electronic control gear
IS 16004 – 1 and 2) for LED modules.
IS 4905 Method for random sampling
IEC 60598 Ingress protection, luminaire performance and safety
IEC 61000-3-2 Total Harmonic Distortion
IEC 61000-4-5 Surge Protection
IES-LM 80 along with Lumen Depreciation and Rated life of LED chip TM 21/ IS 16105
IES-LM 79 / IS 16106 Luminaire optics and color parameter and electrical parameter

26.4.2 LED LIGHTING SYSTEM

LED Luminaires shall be used for the lighting of all the outdoor areas.
However for DC lighting & hazardous areas conventional type luminaires shall be used.
The individual lamp wattage for LED shall be upto 3 watt for outdoor type luminaires. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall not be less than 80 Lm/W. Heat sink/heat dissipation arrangement shall be provided in the luminaires. The LED used in the luminaires shall have colour rendering index (CRI) of Min 70 for outdoor luminaires.
Colour designation of LED shall be “cool day light” (min 5700K) type for indoor type LED luminaires. Further for outdoor type luminaires, the colour designation shall be 5000K, except for well glass type LED luminaires, where the colour designation shall be 4000K. The LED luminaires shall have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life.
For highbay & flood light type outdoor luminaires the LED chip with suitable beam angle shall be used to deliver better lumen-output. The maximum junction temperature of bare LED without heat sink shall be limited to 85 deg C, further the lumen maintenance at this temperature shall be min 90%. The THD of tube light based LED Luminaires shall be less than 20%. For other type of luminaries, it shall be minimum 10%. #1

Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink/ heat dissipation arrangement, with proper thermal management shall be designed for the luminaires.

Driver Circuit: LED modules and drivers shall be compatible to each other. The LED module driver's ratings and makes shall be as recommended by corresponding LED manufacturer.

LED Drivers may have following control & protections:-

- Suitable precision current control of LED.
- Open Circuit Protection
- Short Circuit Protection
- Over Temperature Protection
- Overload Protection
- Surge Protection

Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have IP55 degree of protection.

Wires of different phase shall normally run in separate conduit.

Power supply shall be fed from 415 / 240 V normal AC supply through suitable number of conveniently located lighting distribution boards (LDB) and at least one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc.

Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location.

Incandescent lamps may be used only with DC Lighting.

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

All luminaries and their accessories and components shall be of type readily replaceable by available Indian makes.

Following test reports to be submitted for LED chip/LED luminaires:

a) LED parameters like Lumen per watt, CRI, Beam angle from manufacturer.

b) LM 80/IS: 16105 report.

c) LM 79/IS: 16106 report

27.0 JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES

Junction boxes for street lighting poles and lighting mast as applicable, shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.

All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.

Conduits, Pipes and Accessories:

Pull out boxes shall be provided at suitable interval in a conduit run .Boxes shall be suitable for mounting on Walls, Columns, etc. Pull-out boxes shall have cover with screw. Pull out boxes used outdoor shall be weather proof type suitable for IP: 55 degree of protection and those used indoor shall be suitable for IP: 52 degree of protection.

28.0 LIGHTING POLES

The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. Height of the poles should be chosen so as not to affect working of Solar panels. The poles shall be hot-dip galvanized as per relevant IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall be min. 70 micron. The System shall be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.

The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB. The luminaries used shall be minimum

32 W with minimum pole height of 2.5 m with 35 m inter-pole spacing for peripheral roads & 50 m for internal roads respectively.
For internal roads, the spacing shall be 50 m with same specification.
Hot dipped Galvanized with 80 mm thickness hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable

28.1 EARTHING

Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor.
The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends.

28.2 AVERAGE ILLUMINATION LEVEL

Location	Average Illumination Level (Lux)	Type of Fixture
Switchgear Room, HT Breaker, Transformer	150	LED Luminaries
Street lighting-Roads	Refer Cl. 6.0 LED Luminaries	LED Luminaries

5.29 Fire Alarm and Firefighting systems

The SPV plant shall be equipped with suitable fire protection & fire fighting systems for protection of entire plant & control room as per CEIG requirements.

29.1. Bidder shall comply with recommendation of Tariff Advisory Committee to incurring minimal premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

29.2 The fire fighting system for the proposed power plant for fire protection shall be supplied and installed by bidder and shall consist of:

a) Sand buckets
b) Portable fire extinguishers
c) Microprocessor based fire alarm panel.

29.2.1 Portable Fire Extinguishers and Sand Buckets

Bidder to provide following numbers of type tested portable fire extinguishers as per relevant code in the room/location as per scope of the specification as mentioned below.

Rooms	DCP Type (ABC type) (10 Kg. Capacity)	CO2 Type 9 kg capacity	Foam Type Hand 9 kg	Hand Portable pressurized water C02 9 Litre	Sand Buckets
Main Control Room	2	2	1	1	1
Each Inverter Station/Location	1	1			
ACDB/SCADA Room	1	1			
Each Transformer yard	1	1	1		1
132KV Switchyard	2	2			1
Main Pooling Yard	2	2			1
Security Room		1		2	
Pantry				2	

29.2.2 Microprocessor based fire alarm panel

Bidder to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions in

each loop. Fire detection alarm system shall include) but not limited to the following items

1. Fire Alarm control Panel
2. Multi Sensor smoke detector
3. Heat Detectors
4. Hooter cum strobe
5. Manual call Point
6. Hooter
7. Fault isolation modules
8. Control Modules
9. Cables from Sensors to Fire panels.
10. Digital output from the fire detection system shall be integrated with SCADA, necessary cables will be in scope of bidder
11. Network Control Module
12. Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA, necessary cables will be in scope of bidder

Multi sensor type smoke detectors and heat detectors shall be provided for below false ceiling areas of control room and ACDB and/or inverter rooms. One (01) sensor shall be provided for each 20 sqm of area. All the cable trench inside the control room and inverter room shall be provided with Multi Sensor smoke detector.

Bidder shall prepare and submit the layout and scheme indicating fire protection system for approval.

Fault Isolation module shall be provided in every room and for every 15 sensors at location proposed by Bidder to be approved by employer during detail engineering.

29.2.3 Fire Alarm Control Panel Indication

i. Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.

ii. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.

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

iv. All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset

There shall be weather proof Hooter cum strobe outside and strobe inside each Inverter room and control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. All the hardware, relay and accessories required for completeness of fire alarm system is in Bidder scope. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Each Inverter room and control room shall be also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

Bidder shall submit document to BHEL/NTPC for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report. Bidder shall consider 30 % design and aging margin for selection of nos. of sensors in each loop and length of each loop. Bidder shall submit the certificate or technical datasheet from OEM indicating maximum nos. of sensors in single loop and maximum length of single loop allowed with offered panel and type of cable to be used. Each Fire Alarm Control panel shall have provision for minimum 10 (Ten) % rounded to next higher integer but not less than 2 (two) nos. spare loops for future use of employer.

Bidder shall submit Site Acceptance Test (SAT) for approval by employer.

Complete fire alarm system shall be checked at site for verification of faithful performance

	and completeness of the system. Bidder shall carry out necessary modification and supply hardware/accessories if required free of cost at site.
5.30	**Design, Supply and installation of Module Cleaning System** 30.1 Bidder shall provide permanent arrangement for module washing in the SPV Plant. This shall include supply and installation for drawl and discharge of water from existing Reservoir, requisite storage arrangement and laying network of HDPE pipe conforming to IS 4984 and other relevant codes. The module washing shall be complete in all respect and the details shall conform to the relevant IS codes. The complete scheme shall be subject to approval of BHEL/NTPC including inputs points, design and drawings for the system. Opening from the HDPE pipe with manual isolating valves should be provided at regular intervals. The opening pipes for fixing the movable/Hose pipes for spraying water on module shall be made of GI pipe. Bidder shall install flow meter for measurement of water consumption. 30.2 Design of solar PV module cleaning system shall be such that complete solar plant shall be cleaned with fresh water twice in a month. Module cleaning system piping network shall be closed looped pipe network configuration consists of Main pipe, sub-main and branches. Minimum 5 tapping /washing point shall be functional at same time. In array layout, if solar blocks is separated from main plot due to water body, Nallah, roads, etc; Module cleaning system piping network may be design for dead end/tree pipe network configuration. Minimum 2 tapping /washing point shall be functional at same time. Cut-off valves shall be provided at suitable junction point so that the repair works may be conducted at a particular area without disturbing the whole area. The water used for cleaning should be of appropriate quality fit for cleaning purpose as per the recommendations of module manufacturer. 30.3 Bidder shall provide the piping and the instrumentation diagram (P&ID) of water washing arrangement including the physical sequence of branches, reducers, valves, pressure gauge, cleaning points with location of pump(s) and water storage tanks to NTPC for approval during detailed engineering. 30.4 The HDPE pipe shall be suitably protected against any impact load. The HDPE pipes shall be covered higher diameter GI pipe at roads crossing for protection against any heavy loads etc. at roads section. The same protection shall also be provided wherever higher loads are expected. The bidder may also propose some other protection system for HDPE pipes. 30.5 These pipes shall be buried in ground by at least 150 mm deep from NGL/FGL. Only in case of rock at surface and difficulty in cutting the surface rocks pipe may be accepted at surface at some location. The same shall be subject to approval from the owner. 30.6 Maximum length of hose pipe shall be 50 meter from tapping point. Tapping point shall be place above PCC slab/block. 30.7 After laying and jointing, Testing of main pipe, service pipe and fitting shall be checked by charging with water. The test pressure shall be minimum 0.5 N/mm2 or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or, in the case of long mains or mains of a large diameter, by a power-driven test pump, provided the pump is not left unattended. 30.8 End of the branch pipes/tapping points to be bent horizontal/downward to avoid entry of foreign materials like, earth, sand leaf, gravels, etc. 30.9 Bidder to ensure interconnection between the sub-systems of module washing system through isolating valve, so as module cleaning may be continued in case of outage of any sub-system. 30.10 Bidder shall ensure that the complete module washing system is integrated suitably with water source (reservoir), check dam, motor and water pipe line coming at the periphery of the plant.

30.11 Any additional item, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of cleaning system for satisfactory operation of the plant shall be included under scope of the bidder.

5.31 Identification marking using painting

Following items shall be identified by way of artistic painting in black letters with yellow background. For danger symbol/text, white letters in red background. Identification number/ text to be painted shall be submitted for BHEL/NTPC approval during detailed engineering for the following.

(1) Solar array structures: ~1616 Nos
(2) String monitoring boxes: 104 Nos
(3) Size/ source/ destination of DC cable 1Cx400 with arrow mark (power flow direction) to be painted on SMBs and PCUs
(4) PCUs front side: PCU ID number (1 to 8) with rating 2500kW, AC chamber/ DC chamber, Danger text/symbol.
(5) PCUs DC chamber back side: SMB ID numbers, cable size (1Cx400 +,-) with upward arrow mark, danger text/symbol
(6) PCUs AC chamber back side: Inv Trnfmr ID, cable size (5Rx1Cx400 / ph) with downward arrow mark, danger text/symbol
(7) Same way as above, the corresponding panel ID with rating, cable destination with arrow mark in power flow direction, danger text/symbol shall be painted for all VCB panels, Inverter transformers (HV and LV sides), Aux transformer (HV and LV sides), ACDB panel.
(8) For UPS/ FCBC/ SCADA/ all DB boards/ fire alarm panels ID number shall be painted. Cable size/ destination/ arrow marks not required to be painted as cable tags shall be adequate.
(9) For earth chambers of inverter rooms, main control room, transformer yards, Main pooling switchgear yard, array, ESE LA, ID number with resistance value and due date shall be painted.

All switchboards shall be painted with ID number.

5.32 Cable markers and cables tags

(1) Cable markers and joint markers for underground cables shall be provided along the route of the cables as per section "**Cable installation methodology**" of this specification.
(2) Cable tags shall be provided at either of the cable (at the entry point to the panel / equipment to which it is connected / terminated) shall be provided as per section "**Cable installation methodology**" of this specification.
(10) Cable tags details shall be provided by BHEL during detailed engineering.

5.33 Display boards and sign boards

Sl. No	Description	Qty for Inverter Station	Qty for Control room
1	Board displaying instruction chart for restoration from Electric Shock	1 No	1 No
2	Board displaying instruction chart for artificial respiration	1 No	1 No
3	Board displaying dos and don'ts.	1 No	1 No
4	Board displaying fire extinguishers details and operations	1 No	1 No
5	"No smoking" board	2 Nos	5 Nos
6	Danger boards: 33000V with danger symbol in Hindi, Telugu, English	As required	As required

	7	Identification boards, of suitable sizes, within and outside control room such as Inverter room, Main control room, Executive lounge, Store room, Gents toilet, Ladies toilet, SCADA room, Battery room, Pantry room etc. BHEL will provide list.	1 set	5 set

(a) 5mm thick sun board with LG make vinyl sticker (computerized cutting and pasting) shall be used for Sl Nos 5, 6 and 7.
(3) (b) For others, flex banner with design & printing shall be used.

5.34 Electrical insulation mat

(1) Vendor shall supply electrical insulating mats as follows:
- (a) Reputed make as shall be approved by BHEL/NTPC
- (b) As per IS: 15652:2006
- (c) Class C
- (d) Thickness 3 mm minimum
- (e) Size = 2m x 1m minimum, exact size shall be as approved by BHEL/NTPC during detailed engineering.
- (f) Colour: to be approved by BHEL/NTPC
- (g) Max use voltage = 33 kV
- (h) Marking of IS standard on the mat

(2) Test certificate shall be provided by vendor

Vendor shall lay the mats in front of all the indoor electrical panels viz. PCUs, VCB panels, ACDB panels, SCADA panels, UPS panels, battery banks etc.

5.35 Supply and Installation Miscellaneous Items

(1) Split Air conditioner of 1.5 tonne 5 star rating (2 Nos) of split type for SCADA room of Voltas/ Hitachi/ Samsung/LG make.

(2) Furnitures for SCADA room as below

- Table with drawer for desktop PC – 3 Nos
  Table shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the TFT monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. Telephone sets, very few PB stations and lamps shall be mounted on the control desk on mosaic grid structure and same shall be decided during detailed engineering. ASCII Keyboard shall be capable of being pulled out through a tray.
- Chair, industry standard, revolving type, with wheels, arm rest, provisions for adjustment of height (hydraulic/ gas lift):5 Nos
  Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators, unit in-charge &

other personnel. These shall be designed for sitting for long duration such that these are comfortable for the back.

Arm-rests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon.

- Storage almirah: 3 No
- Filing cabinet: 2 No
- Printer table: 1 No

Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.

(3) Furniture for security room and security cabins

- Table with drawers – 2Nos
- Chairs revolving type with arm rest – 10 Nos

(4) Note : Make of the above mentioned furniture shall be Godrej or equivalent.

5.36 Pre-commissioning inspections/ checks/tests, Quality checks, MRT tests, coordination/liaison with state /central departments/CEIG etc. for necessary approvals/clearances for commissioning, synchronization with grid/ plant commissioning

#	Scope description
	Vendor shall be responsible for carrying out following minimum tests/ checks for the respective Inverter stations, transformer yard, CMCS, Main pooling yard and any other tests as per requirements of NTPC / concerned state / central departments / TRANSCO/ GETCO/GEDA/ CEIG/ CEA etc. Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and pre commissioning trials start up tests, trial operation and performance and guarantee tests. The vendor shall be responsible for all site/commissioning tests. The vendor shall maintain all tests, calibration records in BHEL/NTPC approved formats, and these shall be countersigned by authorized quality assurance personnel of the vendor, BHEL and NTPC. The vendor shall maintain master checklists to ensure that all tests and calibration for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the vendor. The site / commissioning tests shall be categorized under following categories: (a) Start up tests (b) Calibration and configuration checks (c) Pre-commissioning tests (d) Trial Operation (e) Availability Tests Point-to-point testing of all the I/O signals under the present scope of work shall be done by the vendor at the plant and protection equipment end and the terminal end. Point-to-point testing shall include: - Verification of all status indications by operating the plant - Verification of event / alarm indications by simulating alarm conditions - Verification of all analogue indications by injection testing - Verification of all controls by operating the plant
1	Pre-commissioning inspections / checks / tests, MRT tests and coordination /

liaison activities with state / central departments / GETCO/ GEDA/ Transco/ DISCOM/ CEIG/ CEA etc for necessary approvals / clearances for commissioning, synchronization with grid and post-commissioning operation of the plant. (Clearances shall include obtaining prior approvals for all applicable drawings/ documents etc from concerned state / central departments / GETCO/ GEDA/ Transco/ DISCOM/ CEIG/ CEA etc.). Vendor shall coordinate with and support existing 220KV switchyard contractor in obtaining necessary approvals/ clearances.

A	Basic checks	
	A1	Tightness checks:
		1) Terminations of AC/DC power cables at SMBs, PCUs, Inverter transformers, Aux transformer, ACDB panel, UPS/ Battery banks, Aux AC/DC DB boards, 33kV VCB panels, Inverter transformer, SCADA panels etc. 2) Terminations of Control/ Instrumentation/ Data/ Communication cables wherever applicable. 3) Terminations of earthing at all electrical equipment/ panels of inverter station/ control room/main pooling yard 4) Terminations of earthing of inverter transformers, aux transformer 5) Terminations of earth chambers of vendor scope. **Note:** For M10 and above, torque wrench settings shall be followed for reference.
	A2	Electrical continuity checks
	A3	Megger (5kV) checks for all HT (33kV) cables
	A4	Hi-pot testing for all HT (33kV) cables prior to connection to the panels/ transformers.
	A5	Megger (1kV) checks for all 1.1kV grade cables
	A6	AC/DC supply checks at TBs of all electrical panels/ DBs/ Transformers.
B	Pre-commissioning electrical tests:	
	B1	Power conditioning units (with the support of PCU service engineer at site)
		1) DC side open circuit voltage and verification with SMB side measurements 2) Vendor to provide technician support to PCU service engineer for all other pre-commissioning tests as per OEM checklist 3) Functioning of duct fans (operation, direction of rotation)
	B2	Inverter transformers and Aux transformer
		1) Oil filtration: Equipment of adequate evacuation/ heating/ oil circulation capacity shall be deployed at site for this purpose. Filtration shall be carried out adequately in order to achieve the BDV (min 60kV), ppm (max 10) values within the limits as per relevant standards and as measured by NABL accredited laboratory. The machine shall have built-in BDV measuring set up for in-situ checking of BDV during filtration process. DG if required for oil filtration shall be arranged by vendor. 2) IR tests LV-HV, HV-E, LV-E 3) Vector group

		4) Voltage ratio 5) Magnetizing current 6) Magnetic balance 7) Winding resistance at all taps 8) Fault simulation checks (at VCB breaker panels): Buchholz, OTI, WTI, PRV, LOLA etc 9) Alarm, trip settings (S1, S2) for WTI, OTI 10) Oil level at conservator (to be topped up, if required)
B3		CTs 33kV at VCB panel
		1) IR tests (all cores): Pri-Sec, Sec-Sec, Pri-E, Sec-E 2) Ratio tests / primary injection
B4		PTs 33kV at VCB panel
		1) IR tests (all cores): Pri-Sec, Sec-Sec, Pri-E, Sec-E 2) Voltage ratio test 3) Polarity test
B5		33KV VCB breakers
		IR tests Contact resistance measurement (CRM) Timing test: close/ open/ close-open Functional checks: breaker open/close, spring-charged motor Remote operation from SCADA panels: open/close, command/ status, lamp indications
B6		Numerical relays at 33KV breaker
		1) Relay calibration using applicable kit/ software 2) IDMT, DT curves with timing/pickup settings in all relays based on gradation across from downstream to upstream taking into account settings at substation 3) Overcurrent/ earth fault pickup/ tripping time tests 4) Undervoltage/ overvoltage protection test
B7		CT ratio / PT ratio to be set in meters/relays
		i. All MFM meters ii. Protection relays
B8		ACB breaker settings (with the help of PCU service engineer)
		1) Over load, Short time fault, ground fault
B9		Earth resistance measurements for all chambers of vendor scope
		1) With electrode connected to grid 2) Without connecting electrode to grid
B10		UPS/ Battery banks
		1) All functional checks: battery charging/ discharging, battery output parameters etc. as per OEM checklists
B12		Tests on 30KV LA in VCB panel
C	Testing agency	
		Credentials of testing agency shall be submitted to BHEL for approval prior to awarding of work.
D	Coordination and Liaison activities to be carried out by vendor:	
	1) Vendor shall lead in the process of obtaining approval from GETCO/GEDA/Transco/ DISCOM/ CEIG/ CEA etc as applicable for plant charging/ grid synchronization/ plant commissioning.	

	2) Liaison responsibility for getting the approvals rests with the vendor. Wherever technical clarifications are required by the approving agencies with regard to SPV portions (including solar array) up to Main pooling switchgear, vendor shall suitably coordinate/liaison with the concerned state/central approving agencies to make the approval process successful. Accordingly, vendor shall participate in direct discussions with the approving agency whenever necessary. Also, all the necessary payments/expenditures to be incurred with ref to such coordination/ liaison in this regard shall be borne by the vendor. 3) Vendor shall coordinate with and support existing 220KV switchyard contractor for successful commissioning of plant. 4) Following are the areas of approval, as applicable (a) GTP/ datasheets/ GA drawings/ Bill of materials, MQP etc of all (BHEL's/vendor's) supply items. (b) Site test reports of transformers, transformer oil, VCB breakers, CTs, PTs, LAs, resistance of earth mat grids etc (c) Interaction with supervising/ inspection agency such as GETCO, GEDA, Transco, CEIG, CEA etc, as applicable, for applying to them/ inviting them for supervision/ inspection at site. (d) Interaction/ coordination with customer in the above process as and when required. (e) All necessary testing kits/ instruments shall be arranged as per the requirements of inspection agency. Basic instruments such as digital multimeter, 5kV digital megger with PI feature, earth resistance meter, VCB open/close timing test kit, clamp meters etc shall be organized at site at the time of inspection. Competent electrical technician shall also be made available at the site. (f) Subsequent to site inspection by the concerned agency, vendor shall obtain the clearance for grid synchronization after implementation of all the observations of CEIG. (g) Vendor shall also coordinate with DISCOM for obtaining approvals such as grid connectivity approval etc.
E	Commissioning of Solar Power Plant
	1) Vendor shall organize all necessary tools/ measuring instruments required to operate the various electrical equipment at the time of commissioning: Digital megger 5KV with PI feature, Earth resistance tester, Phase sequence meter, Clamp meters etc., discharge rods, PPE safety gadgets (helmets, shoes etc.). 2) It is the responsibility of the vendor to successful charge solar plant from solar array to main pooling switchgear and grid synchronization of inverters/ plant commissioning for full DC capacity. 3) Vendor shall participate actively in the commissioning until it is established that there is successful export of power from all the strings, PCUs. 4) Vendor shall coordinate with and support existing 220KV switchyard contractor for successful commissioning of plant.
F	**Trial run, module cleaning (1 cycle), grass cutting and module cleaning (1 time activity) and Handing over of the Plant**
	Vendor shall participate actively in the commissioning until it is established that there is successful export of power from all the strings, PCUs. After commissioning and completion of all works including clearing of all

					punch points, trail run of the plant will be commenced for trouble free operation for cumulative 24 hours (effective solar generation hours) during which functionality of all plant components shall be demonstrated and the system shall be in Generating Mode. During trial run vendor shall deploy manpower, operate and maintain the plant and ensure that there are no breakdowns in any equipment. All required tools and instruments during this period will be provided by vendor. In case of extension of trail run schedule/ period, it is vendor's responsibility to ensure that vendor's teams are available at site till successful completion of trial run. Prior to trail run, vendor shall do one cycle of module cleaning and demonstrate the operation and functionality of module cleaning system in full. After successful completion of trial run and acceptance by NTPC, SPV Plant shall be deemed to be successfully erected & commissioned. Vendor shall propose for handover of the plant supplies and installations. Before handover of the project, vendor shall clean entire plant facility for the scrap/ unused material and remove the shrubs/ bushes/ Grass including uprooting of rank vegetation, brush wood, trees and saplings of girth upto 30 cm measured at a height of 1 m above ground level and removal of rubbish. The same shall be disposed at a remote location as shall be informed during execution. The contractor shall hand over the plant and equipment back to the owner in completely safe and healthy condition and without any pending defect.		

5.37 Spares required to be supplied along with main consignment:

1) Fuses of all types: 1 % of total population of respective items
2) MCB of all types: 1% of total population of respective items
3) Indicating lamp set of all types: 1% of total population of respective items
4) Surge protection devices/ MOV: 1% of total population of respective items
5) Lamps for peripheral lighting- 10 Nos
6) MC4 connectors: 150 sets (1 set = 2 nos)
7) Y connectors: 150 nos
8) 33KV, 1C, 300 sqmm (E) Indoor End termination kits- 3 Nos
9) 33KV, 1C, 300 sqmm (E) Straight through jointing kits- 1 Nos
10) Spares of aux transformers:
    a) HV bushings with metal parts and gaskets: 1 set
    b) LV bushings with metal parts and gaskets: 1 set
    c) Neutral bushing with met metal parts an gaskets: 1 set
    d) Gaskets : 2 sets
    e) Silica gel breather with charge: 1 set
    f) Diaphragm of explosion vent: 1 set
    g) Prismatic oil level gauge: 1 set
    h) Valves: 1 set

Notes:
(a) 1 set refers to total quantity of the item used in one transformer.
In case quantity arrived based on percentage is a decimal figure, it shall be rounded off to next higher integer.

6.0 SAFETY MANAGEMENT

6.1 Vendor shall follow the site safety plan at site.

6.2 During the execution of the contract, the bidder and it's sub-vendor(if any) shall follow safety procedures for the safety of the personnel and the equipments during erection, testing, commissioning during the contract period as per NTPC/BHEL safety plan, as per the regulatory requirements and the as per the original equipment manufacturer's recommendations.

6.3 All the expenses, charges towards compliance of the safety norms by the bidder as per the Safety Plan, Safety Policy, and the Safety Coordination Procedures are deemed to be included in the bid price. No additional claims shall be entertained towards meeting the safety requirements

6.4 Safety sign board to be provided near all construction area/ installations.

7.0 General conditions applicable during supply, installation and commissioning

7.1	As already mentioned in previous clauses, vendor shall organize power supply on their own. Accordingly, DG sets of suitable capacity shall be deployed by the vendor for construction works.
7.2	Similarly, water required for construction works shall be organized by vendor (tankers etc).
7.3	All machinery such as cranes, hydra, JCBs, forklifts, transport trucks, trolleys etc necessary for movement and installation of materials / panels / equipment etc shall be organized by the vendor.
7.4	All necessary tools and tackles such as crimping tool (including heavy duty tools for crimping copper/ aluminium cables up to 630 sq-mm), screw driver set, power screw drivers, cutting pliers, nose pliers, spanner sets, adjustable spanners, hole-saw cutter set, bending tools, torque wrenches, hack saw blades, pipe wrenches, flat / round files, HV termination tools, drilling machines, welding machines, concrete mixers, steel bar bending tools / templates/ shuttering materials for RCC works, spade, shovel, hammer etc shall be organized by the vendor.
7.5	All necessary measuring instruments such as digital multimeters, measuring tapes, vernier calipers, electrical testers, digital meggers (1kV, 2.5kV, 5kV), earth resistance meters, clamp meters, transformer oil BDV kit, relay testing kit (secondary injection), primary injection kit, infrared thermal imaging handheld temperature meter etc. All these instruments shall possess valid calibration certificate issued from approved NABL laboratory.
7.6	Vendor shall make their own arrangements for necessary food, drinking water and accommodation for their labour and employees posted at the site. Similarly, food and drinking water required at the site, during the construction operations, shall also be in scope of vendor.
7.7	Vendor shall organize all necessary steps to meet statutory requirements such as labour license, PF, ESI etc and also ensure compliance with relevant acts such as minimum wages act, income tax act, employee insurance act etc for their labour deployed at site.
7.8	Vendor shall maintain updated labour register, with name, age, qualification, salary, attendance details etc. at the site.
7.9	Vendor shall use danger boards, wherever required, to ensure safety of the persons during the work at site.
7.10	Vendor shall adhere to all necessary safety norms such as use of helmet, goggles, hand gloves, gumboots, aprons etc. It is the ultimate responsibility of the vendor in all respect to prevent accidents at the site and safeguard their labour from accidents.
7.11	Vendor shall, at the completion of every work, clear off the debris, which resulted out of the work. In case of excavation work such as cable trench etc, vendor shall finish the land neatly with necessary leveling, rolling etc.
7.12	Vendor shall carry out the work without causing inconvenience to other contract groups at the site. In case of conflicts with other groups, vendor shall ensure that the matter is resolved at

	once amicably so that the progress of work is not affected.
7.13	Any damages on the building, structures etc. attributable to the acts of labour / employees of vendor shall be rectified and made good by the vendor at their own cost.
7.14	No child labour shall be employed for execution of the present contract.
7.15	Any miscellaneous materials, which are found essential for technical completion of the contract but not mentioned explicitly in this specification, shall be deemed to be included in the specification. Accordingly, such materials shall be included by the vendor as part of the offer.
7.16	Special instruction for earthing: In compliance with Rule 33 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode. Accordingly, all cases such as cable support structures, cable ladders, cable trays (control room) etc. shall be earthed.
7.17	BHEL/NTPC shall witness routine/ acceptance/ type tests performed at manufacturer works for the items supplied by vendor. Vendor shall accordingly provide inspection call to BHEL with submission of quality assurance plan in advance. For the items bought out from dealers, test certificates, as per relevant IS / IEC standards, as issued by manufacturer shall be submitted to BHEL. However, prior approval shall be obtained from BHEL/NTPC for procurement of the item from dealers.
7.18	Field Quality Plan / Quality control system (if applicable) Vendor shall set up a field quality control laboratory with full set up to facilitate testing of all construction materials in accordance with FQP (Field quality control plan) as approved by BHEL/NTPC. Vendor shall deploy a well experienced quality control engineer to monitor all QC activities at site as per approved FQP. Specifically with reference to civil works, vendor shall submit all concrete mix designs and bituminous mix designs for BHEL/NTPC approval before starting of the work. All the third party testing should be conducted in NABL approved laboratories only. Vendor shall submit the FQP for the civil construction works before starting of the works for approval of BHEL/NTPC.
7.19	Any deviations shall be discussed with BHEL/NTPC site engineers and implementation shall be taken up only after approval from BHEL /NTPC.
7.20	Vendor shall submit periodic status report, on daily as well as weekly consolidated basis, to BHEL on the progress of the contract.
7.21	Vendor shall, as and when required by BHEL/NTPC, participate in the review meetings conducted by BHEL/NTPC at project site, BHEL-EDN (Bangalore), BHEL-Corporate office (New Delhi), NTPC office, New Delhi etc
7.22	**General Guidelines** a) Any civil or electrical work which is not mentioned or included in this tender document but necessary for functional requirements of the plant shall be carried out by vendor. b) Vendor shall prepare all designs / drawings based on the specifications given in the tender and in light of relevant BIS/IS/ equivalent standard. c) Vendor shall provide type test reports and datasheet/ GTP for all equipments covered under vendor scope of supply. d) BHEL reserves right to modify the design at any stage to meet local site conditions / project requirements. e) All work shall be carried out in accordance with the latest edition of the Indian Electricity Act and rules formed thereunder and as amended from time to time.
7.23	For all current carrying parts and earthing, S.S hardware shall be provided and all other places, G.I hardware shall be provided. M.S hardware shall not be used in any place.

8.0 Documents to be submitted for BHEL/NTPC approval during detailed engineering

8.1	BHEL/NTPC approval shall be obtained for the following technical documents, which shall be submitted to BHEL in phased manner based on priority sequence of activities during detailed engineering (after receipt of purchase order from BHEL).
8.2	Name of vendor/ make, model number/ part number, specification/ sizes/ dimensions/ drawings/ datasheets shall be submitted for all the vendor supplied items.
8.3	Design calculations/ general arrangement drawings/ single line diagrams/ GTP particulars/ datasheets/ schemes/ layouts/ cable schedules/ bill of materials etc., as applicable.
8.4	Manufacturing Quality Plans for all the vendor supplied items
8.5	Field quality plan for the field work: civil works, electrical works
8.6	Detailed activity-time chart for project implementation
8.7	Detailed manpower deployment schedule

ANNEXURE-1

1. LT SWITCHGEAR

- **CODES AND STANDARDS**

The design, materials, and method of LT switchgear shall conform to the applicable IEC standard. All equipment shall be installed and all work shall be carried out in accordance with relevant IEC standards. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice. All standards, specifications and codes of practice shall be the latest editions including all applicable official amendments and revisions.
As a minimum requirement, the following standards shall be complied with:

IS	Details
IEC 60947/IS 13947	Low-voltage switchgear and control gear
IS 2705	Current Transformers
IS 3043	Code of practice for earthing.
IS 3072	Code of practice for installation and maintenance of Switchgear
IS 3156	Voltage Transformers
IS 3202	Code of practice for climate proofing of electrical equipment.
IS 3231	Electrical relays for power system protection.
IS 13703 / IEC 60269	HRC Cartridge fuses
IS 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear.
IEC 60255	Electrical Relays

- **TECHNICAL PARAMETERS**

➢ **POWER SUPPLY (AC SYSTEM)**	
Voltage	4 1 5 V + 1 0 %, 3 Phase, 4 wire, Neutral Solidly Earthed
Frequency	50 Hz +/- 5%
Minimum system fault level	As per system fault current (for 1 sec)
Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	As per system fault current (for 1 sec)
Maximum ambient air temperature	50 deg. C
➢ **BUS BARS**	
Continuous current rating at 50ºC ambient:	As Per Requirement
Temperature Rise allowed above ambient	400C for plain joints 550C for Silver plated joints
➢ **MCCB**	
Rated voltage	415V
Rated Insulation Level	690V
Rated ultimate and service SC breaking capacity(As per system requirement)	As per system fault current (for 1 sec)
Rated making capacity	2.1 times of System fault current

Utilization category	A
➢ **DIGITAL MFM**	
Accuracy class	0.5
MFM shall be provided at LT incomer feeder. MFM shall have suitable communication port for integration with SCADA system.	
➢ **CURRENT TRANSFORMERS**	
Type	Cast Resin Bar Primary
Voltage class and frequency	650V, 50HZ
CT Secondary Current	1 A
Class of insulation	E or better
Accuracy class & burden	
a) For Protection	5P20, 5VA
b) For Metering	Class 1.0, 5VA (min)
Instrument Security Factor for metering CT	5
➢ **VOLTAGE TRANSFORMERS**	
Type	Cast Resin
Voltage Ratio	415 / 110V for line PT 415/√3 / 110/√3V for Bus PT
Method of Construction	Vee Vee
Accuracy Class	0.5
Rated Voltage factor	1.1 continuous, 1.5 for 30 sec.
Class of insulation	E or better
One minute power frequency withstand voltage	2.5 KV
➢ **HRC FUSES**	
Voltage Class	650 Volts
Rupturing capacity	80kA (RMS) for AC circuits
➢ **CONTACTORS**	
Type	Air break electro magnetic
Utilising Category	AC3 of IS/IEC 60947 for non reversible AC4 of IS/IEC 60947 for reversible drives
➢ **SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS**	
Colour finish	
Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers) The paint thickness shall not be less than 50 microns
Cable entry	Bottom

The quantities/Nos. of the Feeders/MCCB shall be so as to meet the system requirements. 5% spare with minimum 01 No. to be provided on each board/switchgear having more than 5 MCCB. However, no spare Air circuit breaker panels are required.

- **DETAILS OF INDOOR DISTRIBUTION BOARDS**

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

- Switchboards shall be of metal enclosed, indoor, floor-mounted, free-standing type.
- All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material.
- All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.
- The switchboards shall be of bolted design. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cutouts shall be true in shape and devoid of sharp edges.
- All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. All cutouts shall be provided with EPDM / Neoprene gaskets.
- All switchboards shall be of uniform height not exceeding 2450 mm.
- Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates.
- All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/ component shall be possible without switching off or isolating the other equipments/components.
- Each switchboard shall be provided with undrilled, removable type gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.
- The minimum clearance in air between phases and between phases and earth for the entire busbars shall be 25mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be at least ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / fuses/MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.
- All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.
- All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet molded compound or equivalent type polyester fiber glass molded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be

provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.

- All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All copper to aluminium joints shall be provided with suitable bimetallic washers.
- All busbars shall be colour coded as per IS: 375.
- Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.
- The Bidder shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.
- Panel space heaters shall be provided and the supply for this shall be tapped from incomer, before the isolating switch/circuit breaker. Incoming circuit to spaceheater shall have an isolating switch, HRC fuse and neutral link of suitable rating.
- Panel illumination and plug-socket shall also be tapped from the space heater supply.
- A galvanized steel / Copper / Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.
- The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth without exceeding the allowable temperature rise.
- All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.
- All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable.
- However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.
- VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.
- All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.
- All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.
- All auxiliary wiring shall be carried out with 650V grade, single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm2 (min.) for control circuit wiring and 2.5 mm2 (min) for CT and space heater circuits.
- Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.

- All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.
- All internal wiring terminations shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component to component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.
- Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.
- Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminum conductor, PVC/ XLPE insulated, armoured / unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the contractor, to suit the final cable sizes.
- All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.
- All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local pushbutton stations etc. shall be provided with prominent, engraved identification plates.
- All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Employer's approval.
- Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.
- The gaskets, wherever specified, shall be of good quality EPDM / neoprene with good ageing, compression and oil resistance characteristics suitable for panel applications.
- The bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per indian standards / specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.
- ON/OFF status and protection trip status of incomers and bus coupler (if available) be provided for SCADA system.
- Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler.
- It shall be the responsibility of the contractor to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type ii class of co-ordination as per IS:8544.
- All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "class-c" as specified in is: 6005. The phosphated surfaces shall be rinsed and passivated. After passivation, electrostatic powder coating shall be used. Powder should meet requirements of is 13871 (powder costing specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the employer. The paint thickness shall not be less than 50 microns.

- **MCCB**

- MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.
- MCCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc).
- MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door can not be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked.
- The MCCBs being offered shall have common/interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

- **FUSES**

- All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be rated for 80kA rms (prospective) breaking capacity at 415V AC and for DC circuits, 20kA rms breaking capacity at 240V DC.
- Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.
- Fuse shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchboard.
- The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

- **CABLE COMPARTMENT/CABLE ALLEY**: - A full-height vertical cable alley of minimum 250mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations located in cable alley of capacity more than 400 A shall be designed to meet the Form IVb (as per IEC 61439) for safety purpose. Wherever cable alleys are not provided for distribution boards, segregated cable boxes for individual feeders shall be provided at the rear for direct termination of cables. For circuit breaker external cable connections, a separately enclosed cable compartment shall also be acceptable. The contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged.

- CONTROL COMPARTMENT:- A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.
- All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. However, the busbar chambers having a degree of protection of IP: 42 are also acceptable where continuous busbar rating is 1600A and above. Provision shall be made in all compartments for providing IP: 5X degree of protection, when circuit – breaker or module trolley has been removed. All cutouts shall be provided with EPDM / Neoprene gaskets.
- Provision of louvers on switchboards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating is 1600 A and above.
- Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. EPDM / Neoprene gasket shall be provided between the panel sections to avoid ingress of dust into panels.
- The minimum clearance in air between phases and between phases and earth for the entire busbars. and bus-link connections at circuit-breaker shall be 25mm. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.
- After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.
- All switchgear (circuit-breaker) panels shall be of single-front type. The covers shall be provided with "DANGER" labels. All panel doors shall open by 90 deg or more.
- All circuit-breaker modules shall be of fully draw out type having distinct 'Service' and 'Test' positions. Suitable arrangement with cradle / rollers, guides along with tool / lever operated racking in / out mechanism shall be provided for smooth and effortless movement of the chassis.
- All switchboards shall be provided with three phase and neutral busbars. Two separate sets of vertical busbars shall be provided in each panel of double front DBs. Interleaving arrangement for busbars shall be adopted for switchboards with a rating of more than 1600A. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
- ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked.
- The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear switchgear also.
- Temperature raise test of LT switchgear of rating more than 400A:- The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not

exceed 10deg. C for metallic & 15 deg.C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.

- The carriage and breaker frame shall get earthed while being inserted in the panel and positive earthing of the breaker frame shall be maintained in all positions, i.e. SERVICE & ISOLATED, as well as throughout the intermediate travel.
- Electrically controlled circuit breaker boards shall be provided with DC control supply.

- **CIRCUIT BREAKERS**

- Circuit breakers shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameters of continuous current rating and fault making / breaking capacity only after provision of cooling fans or special device shall not be acceptable.
- Circuit breakers along with its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.
- There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "Test" position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLLY WITHDRAWN" position. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition.
- Separate limit switches, each having required numbers of contacts shall be provided in both "SERVICE" and "TEST" position of the breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240 V AC and 1 Amp (Inductive) at 240 V DC respectively.
- Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.
- Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half a cycle of rated frequency.
- Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed circuit breaker shall preferably not trip the circuit breaker. In case the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exists between the fixed and drawout contact at the time of breaker trip so that no arcing takes place even with the breaker carrying its full rated current.
- Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.
- Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.
- Breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.
- Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.
- Circuit breaker shall be provided with anti-pumping feature and trip free feature, even if mechanical anti-pumping feature is provided.
- Mechanical tripping shall be possible by means of front mounted Red "trip" pushbutton. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

- Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels the busbar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live. Dummy panels if required to achieve the above feature shall be included in the Bidder's scope of supply.
- Circuit breaker open/close shall be possible from SCADA and open/close status and all other important signal status shall be provided for SCADA monitoring.
- Power operated mechanism shall be provided with a Universal motor suitable for operation on DC Control supply. In case of DC supply motor should satisfactorily operate with voltage variation between 85% to 110% nominal control supply voltage. Motor insulation shall be class "E" or better.
- The motor shall be such that it requires not more than 30 Seconds for fully charging the closing spring at minimum available control voltage.
- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.
- The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.
- Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.
- All circuit breakers shall be provided with closing and trip coils. The closing coil shall operate correctly at all values of voltage between 85% to 110% nominal control supply voltage. The trip coil shall operate satisfactorily at all values of voltage between 70% to 110% nominal control supply voltage.
- Provision for mechanical closing of the breaker only in "Test" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.
- The ACB Panel door shall not be possible to open in breaker closed condition. Further, the racking mechanism shall be accessible only after opening the breaker panel door.
- Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle at each location. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn /inserted of particular switchgear.

- **Electrical Parameter of Circuit Breaker**

Type	Air break spring charged stored energy type
Operating duty	O - 3 M I N - O C - 3 M I N -OC
Symmetrical interrupting	As per system fault current (for one sec)
Short circuit rating	2.1 times of System fault current peak)
Short Circuit Breaking current	
a) AC Component	As per system fault current (for one sec)
b) DC Component	As per IS:13947
Short time withstand	As per system fault current

- **DERATING OF COMPONENTS**

The Bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the

permissible temperature as per Indian Standards / Specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.
The Bidder shall indicate clearly the derating factors if any employed for each component and furnish the basis for arriving at these derating factors duly considering the specified current ratings and amb. temperature of 50 deg C.

2. LT POWER & CONTROL CABLES

LT Power & control cables shall be of minimum 1100 volts grade XLPE / PVC insulated conforming to IS 1554 for utilization voltages less than equal to 415 V.
All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).

- **LT POWER CABLES**

- The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.
- All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.
- If cables are to be laid underground, laying shall be as per latest relevant IS code. Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.
- XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg.C and short circuit conductor temperature of 250 deg C.
- PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.
- The cable cores shall be laid up with fillers between the cores wherever necessary.
- It shall not stick to insulation and inner sheath. All the cables, other than single core cables, shall have distinct extruded PVC inner sheath of black colour as per IS:5831. Single core cables shall have no Inner sheath as per IS: 7098 Part-I

- For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires.
- For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia. of cable under armour	**Size and Type of armour**
Up to 13 mm	1.4mm dia GS wire
Above 13 & up to 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & up to 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & up to 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & up to 70 mm	1.4mm thick GS formed wire /3.15mm dia GS wire
Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

- The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm_2 per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.
- The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wire / formed wire.
- Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
    - Oxygen index of min. 29 (as per IS 10810 Part-58).
    - Acid gas emission of max. 20% (as per IEC-754-I).
    - Smoke density rating shall not be more than 60 % (as per ASTMD-2843).
- Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:
- 1 core - Red, Black, Yellow or Blue
- 2 core - Red & Black
- 3 core - Red, Yellow & Blue
- 4 core - Red, Yellow, Blue and Black
- For reduced neutral conductors (in case of power cable), the core shall be black.

- **CONSTRUCTIONAL FEATURES FOR LT POWER CABLES**

- KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer-sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armoured.
- 1.1KV grade PVC power cables shall have aluminium/copper conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

- **TESTS**

- Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of LT power and control cables enclosed at relevant section.
- All acceptance and routine tests as per the specification and relevant standards
- shall be carried out. Charges for these shall be deemed to be included in the
- equipment price.
- All cables to be supplied shall be of type tested design.

- **LT CONTROL CABLES**

- The cables shall be suitable for laying on racks, in ducts, trenches, conduits and under ground (buried) installation with chances of flooding by water.
- All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.
- Conductor of control cables shall be made of stranded, plain annealed copper. Outer sheath shall be of PVC as per IS: 5831 &grey in colour for control cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
    - Oxygen index of min. 29 (as per IS 10810 Part-58).
    - Acid gas emission of max. 20% (as per IEC-754-I).
    - Smoke density rating shall not be more than 60 % (as per ASTMD-2843).
- Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core - Red, Black, Yellow or Blue
2 core - Red & Black
3 core - Red, Yellow & Blue
4 core - Red, Yellow, Blue and Black

- For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

- In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.
    - Cable size and voltage grade - To be embossed
    - Word 'FRLS' at every 5 metre - To be embossed
    - Sequential marking of length of the cable in metres at every one metre to be embossed / printed
    - The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.
- All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.
- Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets.
- Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

- **CABLE SELECTION & SIZING**

- Control cables shall be sized based on the following considerations:
  (a) The minimum conductor cross-section shall be 1.5 sq.mm.
  (b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

- For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

- **CONSTRUCTIONAL FEATURES FOR LT CONTROL CABLES**

- KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I).

- Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of LT power and control cables enclosed at relevant section.
- All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
- All cables to be supplied shall be of type tested design.

- **CABLE DRUMS**

- Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection.
- However, For Single core cables upto 6 Sq. mm size, supplier can do alternative packaging of whole Drum/Spool to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.
- Each drum shall carry manufacturer's name, purchaser’s name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

3. Instrumentation Cables

- **Common Requirement**

Property	Requirement
Voltage grade	225 V (peak value)
Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification.
Continuous operation suitability	At 70 deg. C for all types of cables
Progressive automatic on-line sequential marking of length in meters	To be provided at every one meter on outer sheath.
Marking to read 'FRLS	To be provided at every 5 meters on outer sheath
Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the
Variation in diameter	Not more than 1.0 mm throughout the length of cable.
Ovality at any cross-section	Not more than 1.0 mm
Others	a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name, insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacturer to be provided. b) Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground-buried installation c) Repaired cables shall not be acceptable.
Color	The outer sheath shall be of blue Blue

- **Specific Requirement**

	Property	Requirement
	Type of cable	F and G Type cables
➢ **Conductors**		
	Cross section area	0.5 sq. mm
	Conductormaterial	High conductivity Annealed bare copper
	Colour code	As per VDE-815
	Conductor Grade	Electrolytic
	No & dia of strands	7x0.3 mm (nom)
	No. of Pairs	4,8,12,16,24,48
	Max. conductor resistance per Km (in ohm) at 20 deg. C	73.4 (loop)
	Reference Standard	VDE 0815
➢ **Insulation**		
	Material	Extruded PVC type YI 3
	Thickness in mm (Min/Nom/Max)	0.25/0.3/0.35

	Volume Resistivity(Min) in ohm-cm	1 x 1014 at 20 deg. C & 1x1011 at 70 deg. C.
	Reference	VDE 0207 Part 4
	Core diameter above insulation	Suitable for cage clamp connector
➢ **Pairing and Twisting**		
	Single layer of binder tape on each pair provided	Yes
	Bunch(Unit formation) for more than 4P	To be provided
	Conductor /pair identification as per VDE081	To be provided
➢ **Shielding**		
	Type of shielding	Al-Mylar tape
	Individual pair shielding	To be provided for F-type cable
	Minimum thickness of Individual pair shielding	28 micron
	Overall cable assembly shielding	To be provided
	Minimum thickness of Overall cable assembly shielding	55 micron
	Coverage Overlapping	100% coverage with 20% overlapping
	Drain wire provided for individual shield	Yes (for F-type) Size=0.5mm2, No.of strands=7, Dia of strands =0.3 mm, Annealed Tin coated copper
	Drain wire provided for overall shield	Yes. Size=0.5 mm2, No.of strands=7,Dia of strands=0.3mm Annealed Tin coated copper
➢ **Fillers**		
	Non-hygroscopic, flame retardant	To be provided
➢ **Outer Sheath**		
	Material	Extruded PVC compound YM1 with FRLS properties
	Minimum Thickness at any point	1.8 mm
	Nominal Thick-ness at any point	>1.8 mm
	Resistant to water, fungus, termite & rodent attack	Required
	Minimum Oxygen index as per ASTMD-2863	29%
	Minimum Temperature index as per ASTMD- 2863	250 deg.C
	Maximum acid gas generation by weight as per IEC-60754-1	20%

	Maximum Smoke Density Rating as per ASTMD-2843	Maximum 60% To be provided (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as per ASTMD- 2843)
	Reference standard	VDE207 Part 5,VDE-0816
➢ **Electrical parameters**		
	Mutual Capacitance Between Conductors At 0.8khz (max)	120 nF/km for F type 100 nF/km for G-type
	Insulation Resistance(Min.)	100 M Ohm/Km
	Cross Talk Figure (Min.) At 0.8 Khz	60 dB
	Characteristic Impedance (Max) At 1 Khz	320 OHM FOR F-TYPE 340 OHM FOR G-TYPE
	Attenuation Figure At 1 Khz (Max)	1.2 db/km
➢ **Complete Cable**		
	Complete Cable assembly	Shall pass Swedish Chimney test as per SENSS 4241475 class F3.
	Flammability	Shall pass flammability as per IEEE-383 read in conjunction to this specification
➢ **Tests**		
	Routine & Acceptance tests	Refer Type Test requirement of Specification for C & I System
	Type tests	
➢ **Cable Drum**		
	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.
	Outermost layer covered with waterproof paper	Yes
	Painting	Entire surface to be painted
	Length	1000 m + 5% for up to & including 12 pairs 500 m + 5% for above 12 pairs

4. CABLE INSTALLATION METHODOLOGY

- **CODES AND STANDARDS**

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

IS:513	Cold rolled low carbon steel sheets and strips.
IS:802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS:1079	Hot Rolled carbon steel sheet & strips
IS:1239	Mild steel tubes, tubulars and other wrought steel fIttings
IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanising of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:3063	Fasteners single coil rectangular section spring washers.
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
IS:9537	Conduits for electrical installation.
IS:9595	Metal - arc welding of carbon and carbon manganese steels - recommendations.
IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6kv upto and including 33kv performance requirements and type tests.
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
DIN 46267 (Part-II)	Non tension proof compression joints for Aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring type ,for Aluminium conductors
VDE 0278	Tests on cable terminations and straight through joints

BS:6121	Specification for mechanical Cable glands for elastomers and plastic insulated cables.
	Indian Electricity Act.
	Indian Electricity Rules.

Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

- **General**

- The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.
- Sizing criteria, derating factors for the cables shall be met as per respective chapters. However for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.
- Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:
- Meet all safety requirements
- Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc
- All cables shall be supported by conduits or cable tray run in air or in cable channels. These shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turn made of symmetrical bends or fittings. When cables are run on cable trays, they shall be clamped at a minimum intervals of 2000mm.
- Each cable, whether power or control, shall be provided with a metallic or plastic tag of an approved type, bearing a cable reference number indicated in the cable and conduit list (prepared by the Contractor), at every 5 meter run or part thereof and at both ends of the cable adjacent to the terminations. Cable routing is to be done in such a way that cables are accessible for any maintenance and for easy identification.
- Sharp bending and kinking of cables shall be avoided. Installation of other cables like high voltage, coaxial, screened, compensating, mineral insulated shall be in accordance with the cable manufacturer's recommendations. Wherever cables cross roads and water, oil, sewage or gaslines, special care should be taken for the protection of the cables in designing the cable channels.
- In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop fault at a later date.
- Control cable terminations shall be made in accordance with wiring diagrams, using identifying codes subject to the Employer's approval.
- Multicore control cable jackets shall be removed as required to train and terminate the conductors. The cable jacket shall be left on the cable, as far as possible, to the point of the first conductor branch. The insulated conductors from which the jacket is removed shall be neatly twined in bundles and terminated. The bundles shall be firmly but not tightly tied utilising plastic or

nylon ties or specifically treated fungus protected cord made for this purpose. Control cable conductor insulation shall be securely and evenly cut.

- The connectors for control cables shall be covered with a transparent insulating sleeve so as to prevent accidental contact with ground or adjacent terminals and shall preferably terminate in Elmex terminals and washers. The insulating sleeve shall be fire resistant and shall be long enough to over pass the conductor insulation. All control cables shall be fanned out and connection made to terminal blocks and test equipment for proper operation before cables are corded together.

- **EQUIPMENT DESCRIPTION**

- **Cable trays, Fittings & Accessories**

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.
Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.
Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.
Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm

- **Support System for Cable Trays**

Cable tray support system shall be pre-fabricated similar or equivalent to "Unistrut make".
Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types : (i) C1:-having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder:
a. Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.
b. The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fitings and accessories shall be prefabricated factory galvanised.
c. The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanised surface shall be
brushed and red lead primer, oil primer & aluminium paint shall be applied
d. All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drill ing and other machining operation.
e. Support system shall be able to withstand

- ✓ weight of the cable trays

- ✓ weight of the cables (75 Kg/Metre run of each cable tray)
- ✓ Concentrated load of 75 Kg between every support span.
- ✓ Factor of safety of minimum 1.5 shall be considered.

- **PIPES, FITTINGS & ACCESSORIES**

Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria GI Pipes shall be of medium duty as per IS:1239
Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.
Hume pipes shall be NP3 type as per IS 458

- **Junction Boxes**

Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of thickness 2mm. Top of the boxes shall be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanised as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation.
Terminal blocks shall be 1100V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size upto 2.5 sq mm each. All internal wiring shall be of minimum 1.5 sq. mm cu. Conductor PVC wire.

- **Terminations & Straight Through Joints**

Termination and jointing kits for 33kV, 11kV, 6.6 kV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be premoulded type, taped type or heat shrinkable type. 33kV, 11kV and 6.6 kV grade joints and terminations shall be type tested as per IS:13573. 3.3kV grade joints and terminations shall be type tested as per VDE0278. Critical components used in
cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard.
Straight through joint and termination shall be capable of withstanding the fault level for the system.
1.1 KV grade Straight Through Joint shall be of proven design.

- **Cable glands**

Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation.
Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene or better synthetic material and of tested quality.
Cable glands shall be suitable for the sizes of cable supplied/erected.

- **Cable lugs/ferrules**

Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipments. Cable lugs and ferrule shall conform to relevant standard

- **Trefoil clamps**

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

- **Cable Clamps & Straps**

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, selflocking, de-interlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment

- **Receptacles**

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanised or of die-cast aluminium alloy of thickness not less than 2.5 mm.

The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break,AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position.

Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

- **Galvanising**

Galvanising of steel components and accessories shall conform to IS:2629 , IS4759 & IS:2633. Additionally galvanising shall be uniform, clean smooth, continuous and free from acid spots.

The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367 . The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified

- **Welding**

The welding shall be carried out in accordance with IS:9595. All welding procedures and welders qualification shall also be followed strictly in line with IS:9595

- **INSTALLATION**

- **Cable tray and Support System Installation**

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.

Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray

installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the
support system along with tray, spacing etc in line with relevant standard.
The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated.
The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval.
All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor.
In certain cases it may be necessary to site fabricate portions of trays, supports and other non standard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

- **Conduits/Pipes/Ducts Installation**

The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/ roof/ wall/ cable tunnel/ cable trenches made for conduit installation shall be sealed and made water proof by the Contractor **either with any proven fire sealing system rated for one hour or** Modular multi-diameter cable sealing system consisting of frames, blocks, Compression wedge and its accessories. **The Cable sealing system should have been tested for fire insulation for min. 1 hr as per BS 476 and shall also provide water sealing. System shall be anti- rodent and anti- termite. #1**
GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.
Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material
Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit /pipe size (dia).	**Spacing**
Upto 40 mm	1 M
50 mm	2.0 M
65-85 mm	2.5 M
100 mm and above	3.0 M

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

- **Junction Boxes Installation**

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

- **Cable Installation**

Cable installation shall be carried out as per IS:1255 and other applicable standards.
For Cable unloading, pulling etc following guidelines shall be followed in general :
Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends.
Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.
While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer.
Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.
Cables shall be laid on cable trays strictly in line with cable schedule Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two meter. All multi core cables shall be laid in touching formation.
Power and control cables shall be secured fixed to trays/support with self-locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multi core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by aluminium strips at every five meter interval and at every bend.
Bending radii for cables shall be as per manufacturer's recommendations and IS: 1255.
Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe.
No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.
In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.
Wherever few cables are branching out from main trunk route troughs shall be used.
Wind loading shall be considered for designing support as well Cable trays wherever required.
Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.
The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time

- **Separation**

At least 300mm clearance shall be provided between:
- HT power & LT power cables,
- LT power & LT control/instrumentation cables

Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:

No. of cores in cable	No. of spare cores
2C,3C	NIL
5C	1
7C-10C	2
14C and above	3

- **Directly Buried Cables**

Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255.

RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 5 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate.

Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

- **Cable Terminations & Connections**

The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer'' instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site.

Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.

The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.
Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.
All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.
All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

5. AUXILLARY POWER SUPPLY SYSTEM

- **GENERAL**

- Auxiliary power supply arrangement shall be in line with tender SLD. Each Inverter Room/local pooling/sub-pooling/CMCS room shall have its own auxiliary power supply system comprising of AC distribution board (ACDB) which shall be fed from LV side of Inverter transformer through suitably rated auxiliary transformers. All ACDB's shall have two incomer (100% rated) fed from two different sources. At CMCS, auxiliary transformer directly feed from 33kV switchgear are also acceptable. Following consideration shall be taken while arriving kVA capacity of auxiliary transformer,
  - 20% design margin.
- All non-critical auxiliary loads shall be fed directly from ACDB. However, emergency and important load shall be fed from suitable sized Uninterrupted Power Supply (UPS) or Battery Charged. Input AC supply for Uninterrupted Power Supply (UPS) and Battery Charger shall be fed from ACDB. Bidder shall consider the following one of the supply option for feeding different equipment loads:

Equipment Name	**Option-1 ACDB**	**Option-2 UPS**
SCADA including remote RTU/IO panel		√
SCADA HMI		√
Data logger		√
Fire Detection /Alarm Panel		√
Emergency Lighting		√
HMI of SCADA		√
Energy Meter/MFM		√
Sub and Local Pooling Switchgear control & protection		√
Main Pooling Switchgear (CMCS) control & protection		√
Switchgear spring charging motor		√

switchgear space heater	√	
Illumination, Fan supply etc	√	
Module washing system	√	
Other non-critical auxiliary loads	√	

- UPS system shall comprise of 2 x 100% UPS. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing 30 minutes backup. Bypass Line static switch, manual bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories. UPSDB shall have two incomer fed from two separate UPS as mention above. At a time one incomer shall be in service. Suitable auto changeover logic shall be provided. In place of UPS, bidder can provide DC supply system (2 x 100% Battery Charger) of 12V or above upto 220V DC if the auxiliary power supply requirement of loads are in DC.
- The rated AC output capacity shall be taken for UPS battery size calculation. However the minimum UPS rating shall be 2KVA and the battery sizing shall be calculated on a minimum load of 1 KW (DC) for 30 minute backup. All UPS having rating 5KVA or more shall have three phase input.
- The Bidder can provide alternate arrangement with suitable redundancies such as power pack with 30 minute backup for switchgears.
- Each Battery charger system shall consist of 1 x 100% charger and1 x 100% Battery bank for min 30 minutes back up and 1 x 100% DCDB, and other necessary protective devices and accessories. DC supply system voltage shall be 12V or above upto 220V DC.
- It is mandatory to use Battery charger system for control and protection supply of main pooling HT switchgear.
- Bidder shall submit configuration diagram, power supply distribution scheme, single line diagram and data sheets, all calculations such as Rectifier Modules/UPS Charger/Inverter rating calculations, battery sizing calculation etc. for UPS, Battery Charger & Battery system during detailed engineering stage for employer's review and approval.
- Size and rating of UPS, Battery Charger and Battery shall be finalized during details Engineeringstage.

- **UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM**

- The minimum capacity of the UPS at load factor of 0.8 lagging inclusive of 10% design margin at 50 deg C. The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The overall efficiency of UPS shall be at least 80% on full load.

- The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.

- For UPS capacity 5 kVA or more, in addition to indications/display on UPS panel, important alarms along with important analog signal shall also be provided for use in SCADA. For UPS capacity less than 5 kVA bidder shall provide status, common alarm and trip DI (soft or hard) signal to SCADA

- The UPS chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates. The charger should be capable to fully charge the required batteries as well

as supply the full rated load through inverter. The charger shall be able to re-charge the fully discharge battery within 8 hours. The charger shall be design for input supply variation of ± 10% and frequency variation of ± 5%. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The detailed specification for the battery charger for UPS rating of 5kVA and above has been mentioned in the battery charger section below in this specification.

- The UPS inverter shall be of continuous duty, solid state type using proven Pulse Width Modulation (PWM)/Quasi square wave/step wave technique. Ferro-resonant types Inverters are not acceptable. The nominal voltage output shall be 230 Volts single phase ,50 Hz. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, etc. The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum.

- The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from faulty inverter to standby AC source. Manual bypass switch shall be employed for isolating the UPS during maintenance.

- Contractor has the option of supplying either Nickel Cadmium type batteries or Lead Acid Plante type batteries. The detailed specification for the batteries has been mentioned in the battery and charger section below in this specification.

- Equipment enclosures shall match and line up in assemblies of freestanding floor mounted cabinets designed for indoor service.

- Individual enclosure shall be ventilated switchboard type fabricated from not less than 1.6-mm thick sheet steel. Enclosures shall be furnished with concealed hinges. Front and rear doors shall be designed to permit easy access to all components for maintenance or replacement. The enclosures shall be reinforced with formed steel members as required to form a rigid self-supporting structure. Doors shall have three point latches.

- Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings.

- The cabinets shall be IP-42 protection class for indoor application and IP65 for outdoor application.

- The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.

- The Contractor shall also carry out the site tests on UPS as required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.

- One set of tool shall be provided for maintenance and testing purposes.
- Battery shall be either Nickle Cadmium battery or Lead Acid Plante Battery. Specifications are as mentioned below-

- **BATTERY: NICKEL-CADMIUM BATTERY**

BATTERY PARAMETER
a) Battery Voltage- To be decide during Detail Engineering
b) No. of Cells- To be decide during Detail Engineering
c) Battery type- Nickel-Cadmium
d) Nominal discharge voltage per Cell- 1.2
e) Float voltage- 1.42V/Cell
Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

CODES AND STANDARDS
All standards, specifications and codes of practice referred to herein, shall be the latest editions including all applicable official amendments and revisions as on date of opening of techno-commercial bid. In case of conflict between this specification and those (IS codes, Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:
IEC 60623/ IS 10918 Specification for vented type Nickel Cadmium Batteries.
IS 106 Quality tolerances for water for storage batteries
IEC 60993 Electrolyte for vented Nickel-Cadmium cells
Indian electricity rules
Indian electricity acts
Equipment complying with other internationally accepted standards such as IEC., BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

DC Batteries shall be stationary Nickel Cadmium Pocket plate type conforming to IS:10918. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

DC batteries shall be suitable for standby duty. The batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

- **Construction Features:-**

- **Containers**

Containers shall be made of polypropylene plastic material. Containers shall be robust, heat resistance, leak proof, non-absorbent, alkali resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of translucent containers.

- **Vent Plugs**

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

- **Plates**

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS:10918. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminal posts shall be clearly marked.

- **Sediment Space**

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

- **Electrolyte**

The electrolyte shall be prepared from battery grade potassium hydroxide conforming to IEC 60993. The cells can be shipped either in charged condition or in dry condition. Necessary electrolyte for make-up shall be supplied separately.

- **Connectors and Fasteners**

Nickel plated copper connectors shall be used for connecting adjacent cells and PVC insulated flexible copper cables shall be used for inter-row / intertier / inter-bank connections. Bolts, nuts and washers shall be Stainless Steel / Nickel coated steel to prevent corrosion. The thickness of Nickel coating of connectors should be not less than 0.02 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds.

g) Battery racks

Mild steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Testing

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146(for all applicable tests for containers) / IS-10918 (for NI-CD batteries).The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

- **BATTERY : LEAD –ACID PLANTE BATTERY**

- BATTERY PARAMETER

a) Battery Voltage- To be decide during Detail Engineering
b) No. of Cells- To be decide during Detail Engineering
c) Battery type- Stationary Lead Acid Plante
d) Nominal discharge voltage per cell- 2.0V
e) Float Voltage 2.25V/Cell

- CODES AND STANDARDS

IEC 60896 Stationary Lead-Acid Batteries
IS : 266 Specification for sulphuric acid
IS : 1069 Specification for water for storage batteries
IS : 1146 Specification for rubber & plastic containers for lead acid storage batteries.
IS : 1652 Specification for stationary cells and batteries, lead acid type (with plante positive plates).
IS : 3116 Specification for sealing compound for lead acid batteries.

IS : 8320 General requirements and methods of tests for lead acid storage batteries.
IS : 6071 Specification for synthetic separators for lead acid batteries.
Indian Electricity Rules
Indian Electricity Acts

- Equipment complying with other internationally accepted standards such as IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

- DC Batteries shall be stationary lead acid Plante positive plate type conforming to IS:1652. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

- DC Batteries shall be suitable for standby duty. The Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.25 V/cell.

- **Construction Features:-**

- **Containers**

Containers shall be made of transparent glass, hard rubber, suitable robust, heat resistance, leak proof, non absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of transparent containers. Float type level indicator shall be provided in case of opaque containers. The stem portion of the float should be long enough to prevent falling of the float inside the container even if there is no electrolyte in the container. The marking for the electrolyte level should be for the upper and lower limits. The material of level indicator shall be acid proof and oxidation proof. Container shall be closed/sealed lid type. Lid and sealing compound shall be non-cracking type. The container made of hard rubber and plastics shall be type tested as per IS : 1146. All type tests shall be carried out for sealing compound as per IS:3116. The pole sealing arrangement should be such that no acid particle get entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

- **Vent Plugs**

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte sample.

- **Plates**

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS : 1652 as applicable. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative post shall be clearly marked.

- **Sediment Space**

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

- **Cell Insulator**

Each cell shall be separately supported on PVC/porcelain/hard rubber insulators fixed on the racks with adequate clearance between adjacent cells. Minimum distance between adjacent cells shall be more than the bulge allowed for two cells in accordance with IS:1146.

- **Electrolyte**

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS:266 and distilled water conforming to IS:1069. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately.

- **Connectors and Fasteners**

Lead or Lead coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. The thickness of lead-coating of connectors should not be less than 0.025 mm. The lead coating thickness shall be measured in accordance with APPENDIX F of IS:6848 (latest edition). All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied by the contractor.

- **Battery racks**

Wooden racks for all the batteries shall be provided. These racks shall be made of good quality first class seasoned teak wood in line with CPWD specification. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries rack and wooden support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

- **Testing**

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for rubber & plastic containers for lead-acid storage batteries)/IS 1652 (for lead-acid plante batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

- **AUXILIARY EQUIPMENTS**

Manual discharge resistance bank suitable for each type of battery bank of UPS/Battery Charger has to be provided by contractor.

Following shall be provide (as per applicability) for maintenance purpose

a Hydrometer 2 Nos.
b Set of hydrometer syringes suitable for the vent holes in different cells 2 Nos.
c Thermometer for measuring electrolyte temperature 2 Nos.
d Specific gravity correction chart 2 Nos.
e Wall mounting type holder made of teak wood for hydrometer & thermometer 2 Nos.
f Cell testing voltmeter (3-0-3 V) 2 Nos.
g Alkali mixing jar 2 Nos.
h Rubber aprons 5 Nos.
i Pair of rubber gloves
j Set of spanners 5 Nos.
k No smoking notice for each battery room 2 Nos.
l Goggles (industrial) 2 Nos.
m Instruction card 2 Nos.

n Temperature indicator 1 No. per room
o Cell lifting facility 1 Set per room

- **SITE TESTS**

The contractor shall carry out the following site tests as applicable on UPS, Battery Charger and Battery system. However, any other site test is required to be conducted as a standard practice of the OEM or deemed necessary by the employer and mutually agreed between the contractor and the employer, the same shall also be carried out.

- **Light Load Test**

This test is carried out to verify that the UPS/Battery Charger is correctly connected and all functions operate properly. The load applied is limited to some percent of rated value. The following points should be checked:
a) Output voltage, frequency and the correct operation of meters;
b) Operation of all control switches and other means to put units into operation.
c) Functioning of protective and warning devices.

- **C. Input Failure Test**

The test is performed in UPS/Battery Charger with a fully charged battery and is carried out by tripping input supply feeder or may be simulated by switching off all rectifiers and bypass feeder as at the same time. Output voltage variations are to be checked for specified limits with an oscilloscope/Recorder.

- **C Input Return Test**

AC input return test is performed in UPS/Battery Charger by closing AC input supply feeder, or is simulated by energizing rectifiers. Proper operation of rectifier starting and voltage and frequency variations are to be observed. This test is normally performed with a fully or partially charged battery.

- **Auto changeover Test**

This test shall be carried out in UPS ACDB fed from two separate UPS system. Auto changeover of one UPS source to standby UPS to be check by tripping the active UPS manually or by simulation condition. This test shall be check as per approved auto changeover logic.

- **Transfer Test (for UPS)**

This test is applicable for UPS with bypass, particularly in the case of an electronic bypass switch. Transients shall be measured during load transfer to bypass caused by a simulated fault and load retransfer after clearing of the fault.

- **Full load test**

Load tests are performed by connecting the actual load to the UPS/Charger output. Load tests are necessary for testing output voltage and frequency, rated stored energy, recharge time, ventilation, and temperature.

- **Rated Stored Energy Time (Battery test)**

This test is a load test to prove the actual possible time of battery operation. If rated load is not available in the case of large UPS/Battery charger, it is possible to apply a partial load to check the actual battery discharge characteristics and compare these with characteristics specified by the battery manufacturer. Discharge time with rated load shall then be calculated. The test shall be performed with a fully charged battery and also may be done under other battery conditions to be specified, if so agreed. Active power output of the UPS/Battery Charger and the battery voltage shall be recorded during the test. Since new batteries often do not provide full capacity during a starting up period, the discharge test may be repeated after a reasonable recharge time if the original test has failed.

- **Rated Restored Energy Time**

Restored energy depends on the charging capacity of the rectifiers and the battery characteristics. If a certain recharging rate is specified, it shall be provided by repeating the discharge test after the specified charging period.

- **Battery Ripple Current**

If battery ripple currents are specified, then the ripple current which depends on UPS operation shall be checked under normal operating conditions. Rough measuring methods are sufficient.

SQE _10

4) LT SWITCHGEAR & LT BUSDUCT

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERIS-TICS → / ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLIY ↓	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per NTPC Spec.	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per NTPC spec	All Routine tests as per NTPC spec. & IS
Sheet Steel (IS : 513)	Y	Y		Y	Y		Y							
Aluminum Bus bar Material (IS : 5082)	Y	Y	Y	Y	Y		Y							
Copper Bus bar Material (IS : 613)	Y	Y	Y	Y	Y		Y							
Support Insulator	Y	Y	Y	Y			Y							
Air Circuit Breaker (IS: 13947)	Y	Y				Y	Y			Y	Y			Y
Energy Meters (IS : 13010, 13779)	Y	Y				Y	Y			Y				Y
Power & Aux. Contactors (IS : 13947)	Y	Y				Y	Y			Y				
Protection & Aux. Relays	Y	Y				Y	Y			Y				Y

(IS : 3231) (IEC 60255 / IEC 61850)														
Control & Selector Switches (IS : 13947)	Y	Y				Y	Y			Y				
CT's & PT's (IS 2705 / 3156)	Y	Y					Y							Y
MCCB (IS : 13947)	Y	Y					Y			Y				
Indicating Meters (IS : 1248)	Y	Y				Y	Y			Y				Y
Indicating Lamps (IS : 13947)	Y	Y				Y	Y			Y				
Air Break Switches (IS : 13947)	Y	Y				Y	Y			Y				
Control Terminal Blocks	Y	Y				Y	Y							

LT SWITCHGEAR

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERIS-TICS → **ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLIY** ↓	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per NTPC Spec.	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness &	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per NTPC spec	All Routine tests as per NTPC spec. & IS
Fuse (IS 13703)	Y	Y				Y	Y							
Control Transformer (IS : 12021)	Y	Y				Y	Y			Y				Y
Push Buttons (IS : 4794)	Y	Y				Y	Y			Y				
Transducer (IEC : 60688)	Y	Y				Y	Y			Y				Y
MCB (IS : 8828)	Y	Y				Y	Y			Y				
Breaker Handling Trolley	Y	Y				Y			Y	Y				Y
Synthetic Rubber Gasket (IS : 11149)	Y	Y		Y	Y		Y							