responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.

4.4.2.4.3 Maximum Power Point Tracker (MPPT)

Maximum power point tracker (MPPT) shall be integrated in the power conditioner unit to maximize energy drawn from the Solar PV array. The MPPT should be microprocessor based to minimize power losses. The contractor shall submit the details of working mechanism of MPPT during detail engineering. The operating range of PCU and the MPPT shall be large enough such that it satisfactorily operates for PV Modules exposed to the maximum ambient temperature of 50°C. The MPPT Unit shall conform to IEC 62093 for design qualification.

a) **Low Power Mode (Auto):** The system shall automatically 'wake up' in the morning and begin to export power provided there is sufficient solar irradiation and the grid voltage and frequency are in range.

b) **Standby Mode**: The control system shall continuously monitor the output of the solar power plant until pre-set value is exceeded & that value to be indicated in datasheet.

c) **Basic System Operation (Full Auto Mode) :** When solar radiation increases further, the PCU shall adjust the voltage of SPV array to maximize solar energy fed into the grid. When the solar radiation falls below threshold level, the PCU shall enter in low power mode/standby mode.

d) The PCU control shall prevent excessive cycling of shut down during insufficient solar radiance

e) **Sleep Mode**: Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized at night. The PCU must also automatically re-enter standby mode when threshold of standby mode reached.

4.4.2.4.4 Other Technical Features

PCU Mounting	As per Design
Wave Form	Pure Sine wave
MPPT Voltage (Max. & Min.)	As per standard manufacturing norms
Minimum Efficiency at 100% load	> 98%, measured as per IEC 61683
No load loss	<1% of rated power maximum loss in sleep mode shall be less than 0.05%
Output frequency	50 Hz
Power Factor Control Range	>=0.95 lead or lag
Maximum Input voltage	1000 V **or 1500V as per application**
THD	Less than 3 % of rated power
Ambient temperature	0 to (+) 55°C
Humidity	95 % non- condensing or more

Enclosure (type)	Minimum IP 21 (Indoor rated) **& Minimum IP 54 (Outdoor rated)**
Maximum noise level	75 dBA
DC injection	Less than 0.5% of nominal load current
Maximum Noise Level	75 dB
Flicker	As per IEC 61000

The inverter /PCU shall meet the following requirements.

1. Inverter shall be equipped with Voltage Ride-Through (VRT) capabilities to stay online during grid disturbance as per IEC 61727 or equivalent standard. Inverter shall be able to support low and high frequency ride through and reactive power compensation as response to abnormally low or high grid voltage.
2. Sinusoidal current modulation with excellent dynamic response.
3. Unit wise & integrated Data logging.
4. Dedicated open protocol modbus / RS 485 or any other compatible networking
5. The Inverter/PCU shall have protection against various faults including but not limited to

a) AC/DC Over current
b) Sync loss
c) Over temp.
d) line to ground fault
e) short circuit
f) surge voltage induced at output due to external source
g) AC/ DC bus over/under voltage
h) Cooling System failure
i) Anti-islanding
j) Unbalance Protection
k) A under & over frequency
l) AC &DC Short Circuit
m) Over load Protection
n) AC &DC Lightening/surge Protection

6. Power regulation in the event of thermal overloading
7. Set point pre-selection for VAR control
8. Remote control via telephone modem or mini web server & SCADA
9. Insulation monitoring of the PV array with sequential fault location
10. Ground fault detector to sense discharge current with respect to ground

11. Inverters shall offer the possibility to set a constant reactive power mode to absorb or inject reactive power during night time.
12. Overvoltage voltage against atmospheric lighting discharge to the PV Array
13. Inverter shall offer provision for both local and remote emergency stop
14. **Earthing of Inverter**: DC side of each inverter shall be earthed to distinct earth pit through adequate size conductor as per IS 3043-1987.The size of conductor shall be as per the maximum fault current of DC
15. The contractor shall submit to the Employer the Drawings, design calculations, 'the temperature versus output characteristics' of the Inverter Operation & Maintenance manual and other information as per Engineering Information schedule during detailed engineering
16. The Inverters/PCUs installed in the solar power plant must have a warranty for 5 years

4.4.2.4.5 Standards and Codes:

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose *(The Inverters of the SPV Power Plant must confirm to latest edition of IEC/equivalent BIS standards as specified at page no. 100 of the RfS document also)*:

Standard	**Description**
IEC 61727 or Equivalent Standard.	Photovoltaic(PV) System – Characteristics of utility interface
IEC 61683	Photovoltaic systems – Power conditioners – Procedure for measuring efficiency
EN 50530	MPPT efficiency of grid connected photovoltaic inverters
IEC 60068-2/IEC 62093	Environmental testing
IEC 61000-6-2, IEC 61000-6-4	Electromagnetic compatibility (EMC)
IEC62109-1&2/IEC 62103 or equivalent standard.	Electrical Safety of power converters for use in photovoltaic power systems – Particular requirements for inverters
IEEE Standard 929-2000 or equivalent	Recommended practice for PV Utility Interconnections
IEEE 1547/UL1741/IEC 62116 or equivalent EN/BIS Standards	Protection against islanding of Grid
Grid Connectivity	Relevant CERC/CEA regulations (including LVRT Compliance) and grid code as amended from time to time

Standard	Description
BDEW 2008 or Latest	Technical guidelines for generating plant connected to medium voltage network
IEEE 519	Recommended practices and requirements for harmonic control in electrical power system.
IEC 62093	Reliability test standards

As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, Inverters used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards.

4.4.2.4.6 Routine Testing & Inspection at Work

All the Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per the Final Quality Assurance Plan and reports shall be submitted to Employer. All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

4.4.2.4.7 Type Test:

PCU supplied must be of type tested design and certified by any of the accredited certifying agencies in accordance with relevant standards /codes and the type test reports shall be submitted to Employer for approval. If the type tests are not done previously, then they shall be conducted without any additional cost to the Employer and the type test report shall be submitted before supply of PCUs.

4.4.2.5 Solar & DC CABLES

4.4.2.5.1 Solar Cables

The Solar Cables in a solar PV plant shall be used in the following areas

i. Interconnecting SPV modules

ii. From SPV Modules up to String Combiner Box (SCB)

4.4.2.5.2 DC Cables

i. From SCB up to the Inverter.

4.4.2.5.3 Solar Cables

a) All cables and connectors for use in installation of solar field must be of solar grade which can withstand harsh environment conditions for 25 years and shall conform to the requirements of **TUV specification 2 Pfg 1169/08.2007/EN 50618** for DC cable for photovoltaic system.
Note: IEC Standard for DC cables for PV systems is under development. It is recommended that in the interim, the Cables of 600-1800 Volts DC for outdoor installations should comply with the EN50618/T**UV 2pfg 1169/08/07 / EN 50618** equivalent IS for service life expectancy of 25 years.

b) These cables shall meet the fire resistance requirement as per **TUV specification 2 Pfg 1169/08.2007 / EN 50618** and shall be electron beam cured. In case higher system voltage (>1000 V) are used, the Module Interconnecting wires shall be as per 2 Pfg 1190/05.12.

c) The Cables used for (+) ve and (-) ve shall have distinct colour identification on outer sheath of the cable.

d) DC Plug in connectors used for connecting SPV Modules and SCBs shall be in accordance with DIN EN 50521. Connector shall be of plug and socket design to be plugged together by hand but can be separated again using tool only.
Cable used for module interconnection shall also be referred as Solar Cables.

4.4.2.5.4 DC Cables

Cables used between SCB's and Inverters shall be of min. 1.5 kV (DC Grade). In case Contractor offers 1500V DC system, 3.3 kV (E) grade cables shall be provided. These Power cables shall have compacted Aluminium/copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), Armoured/Unarmoured, FRLS PVC outer sheathed conforming to IS: 7098 (Part-I/**II/Latest).** These cables shall confirm to the requirements of the standards & codes specified in 4.4.3.4 i.e. Cabling system of Technical specifications

4.4.2.5.5 DC Cables Sizing Criteria

The Maximum voltage drop of DC Cables (SPV Modules to Inverters) shall be limited to 2% and shall submit the same for the Employer's review & reference.

4.4.2.5.6 Drawings

The Contractor shall submit all the drawings and documents in respect of cabling system such as DC Cable layout drawing, DC cable trench, and other relevant drawings during the time of detailed engineering for employer's review as per the Engineering information Schedule.

4.4.2.5.7 Routine Testing & Inspection at Works

All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to

Employer. The Employer or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

4.4.2.5.8 Type Test Reports

DC Cables must be tested and certified by any of the accredited certifying agencies according to **TUV specification 2 Pfg 1169/08.2007/EN 50618** and the type test reports shall be submitted to Employer for approval. If the type tests are not done previously, then they shall be conducted without any additional cost to the Employer and the type test report shall be submitted before supply of DC Cables.

4.4.2.5.9 Cable Installation

a. Cable installation shall be as per IS 1255.

b. Solar cables shall be provided with UV resistant printed ferrules and DC cables shall be provided with punched/ embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

c. Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles.

d. A.C and D.C cables shall be kept in separate trenches. The horizontal and vertical clearances between power and communication cable shall not be less than 300mm.

e. Solar cables shall be aesthetically tied to Module Mounting Structure using UV resistant cable-ties suitable for outdoor application.

4.4.3 AC Systems

4.4.3.1 Transformers

4.4.3.1.1 Power Transformers

The Contractor shall provide the complete EPC Design, supply, erection, testing and commissioning of transformers along with all necessary items such as bushings, undercarriage, current transformers, instrumentation, valves, piping, mounting plates, hardware, fittings, cable trays, marshalling box accessories etc. and Stage I 33 KV transformer interconnecting station to the output of the Inverter as per the design requirement at detailed engineering stage, where the power is collected at the common location and where it is stepped up to Stage II (132 kV) Voltage level as per the STU/CTU requirements.

4.4.3.1.2 Rating and Functional Characteristics – Power Transformers

The transformer shall be copper wound, 3 phase, natural cooled, core type Construction, and oil immersed and shall be suitable for outdoor applications.

Power Transformers and associated switchgear of approved make should be utilized. Power Transformer(s) to be installed in Stage II switchyard have to be designed in accordance with the Interconnection point voltage level as per the requirements of SPIA.

All the transformers shall be suitable for outdoor installation with 3 phase 50 Hz in which the neutral is effectively earthed and they should be suitable for service under fluctuations in supply voltage up to plus 10% to minus 15%. Bidder can adopt any of the following criteria or better for EHV power transformers:

1. 2x50% + 1 spare of 50% equivalent capacity

All the transformers shall be provided with the statutory requirement such as oil pits, fire barrier wall etc. as applicable as per applicable standards.

Sr No	Parameters	Requirements
1	No. of phases	Three Phase
2	Installation	Outdoor
3	Rated VA and Qty	As per system requirement
4	Voltage Ratio	As per system requirement
5	Minimum % Impedance at , Rated MVA and Rated frequency	As per IS 2026
6	Type of cooling	ONAN
7	Type of conservator	As per Manufacturer

Sr No	Parameters	Requirements
8	Max. flux density at rated voltage and frequency	Not to exceed 1.9 Tesla
9	Connection of Transformer	
(a)	- HV winding	As per system requirement
(b)	- LV winding	
(c)	Vector group	As per system requirement
10	Tap Changer	As per system requirement
11	Type of bushing	
(a)	- HV terminal	Oil/Air bushing
(b)	- LV terminal	Oil/Air bushing
(c)	- Neutral terminal	
12	Rated frequency, Fr	50 Hz
13	Voltage ratio	As per system requirement
14	Rated voltage, Ur	
(a)	- H.V. winding	As per system requirement
(b)	- L.V. winding	
15	Highest voltage, Um	
(a)	- H.V. winding	As per relevant IEC/IS std.
(b)	- L.V. winding	
16	Power frequency withstand voltage	
(a)	- H.V. winding / Bushing	As per relevant IEC/IS std.
(b)	- L.V. winding / Bushing	
(c)	- H.V. neutral / Bushing (minimum)	
(d)	- L.V. neutral / Bushing (minimum)	
17	Lightning impulse withstand voltage	
(a)	- H.V. winding / Bushing	As per relevant IEC/IS std.
(b)	- L.V. winding / Bushing	As per relevant IEC/IS std.
(c)	- H.V. neutral / Bushing (minimum)	As per relevant IEC/IS std.
18	Switching impulse withstand voltage of H.V Winding and Bushing	N/A
19	Minimum creepage distance in air	

Sr No	Parameters	Requirements
(a)	- H.V. bushing	As per relevant IEC/IS std.
(b)	- L.V. bushing	As per relevant IEC/IS std.
20	Short circuit current for 1 sec. on HV side	As per Table-2 of IEC 60076-5
21	Short circuit apparent power	As per Table-2 of IEC 60076-5
22	Maximum temperature rise with a reference maximum ambient temperature of 50 °C	
(a)	-Top oil (Measured by thermometer)	50°C
(b)	- Winding (Measured by resistance method)	55°C
23	Insulation	
24	Voltage withstand capacity during sudden	As per relevant IEC/IS std.
25	Noise level	As per NEMA TR- 1
26	H.V. Line Bushing CT	
(a)	CT ratio	As per system design
(b)	No. of CT cores for each phase of transformer	As per system design
27	H.V. Neutral Bushing CT	
(a)	CT ratio	As per system design
(b)	No. of CT cores for each phase of transformer	As per system design
28	L.V. Neutral Bushing CT	
(a)	CT ratio	As per system design
(b)	No. of CT cores for each phase of transformer	As per system design

4.4.3.1.3 Inverter Transformers & Auxiliary Transformer

The Contractor shall provide Inverter Transformers as per system requirement, complete with cubicles and all necessary accessories such as bushings, off-circuit tap changer, CTs, instrumentation, fittings etc. They shall be compatible with offered model of grid connected PCU inverters.

The total kVA capacity of Inverter transformer shall not be less than cumulative kVA capacity of PCU connected to all the LV windings of Inverter Transformer. The overall cumulative capacity of Inverter Transformer(s) shall **not be less than total rated kVA capacity of respective Inverters.** The overall number of the Inverter transformers depends on the plant layout design.

Auxiliary Transformer (s) shall be connected **Low voltage side of the Inverter Transformer** through XLPE cable. A suitable Oil / Air bushing at HV end of the transformer shall be provided. LV side shall be connected to AC distribution board(s) through suitable size cables.

The Contractor shall provide suitable capacity of Auxiliary Transformer(s) complete with cubicles and all necessary accessories such as bushings, off-circuit tap changer, CTs, instrumentation, fittings etc. The Contractor shall make detailed calculations based on the actual power consumption of the connected equipment to check the adequacy of capacity and submit these data to the Employer's review & reference. In case actual power consumption comes out to be more, the Contractor shall have to supply the transformer(s) as per actual requirement.

The Inverter Transformers and Auxiliary Transformers shall be of proven design for intended duty specified to ensure a high reliability and availability. The transformers shall be suitable and design shall be capable to withstand frequent start and stop sequence.

4.4.3.1.4 Rating and Functional Characteristics – Inverter Transformers & Auxiliary Transformer

Sl. No.	Parameter	Inverter Transformer	Auxiliary Transformer
1	kVA Rating	As per system requirement	
2	Quantity	As per system requirement	
3	Voltage Ratio (KV)	As per System Requirement	
4	No. of Winding	As per system requirement	2 (Two)/3 (Three) Nos.
5	Frequency	50 Hz	50 Hz
6	Service & Duty	Continuous Solar Application and Converter Duty (Outdoor)	Outdoor/Indoor & Continuous
7	Nos. of Phase	THREE	THREE
8	Vector Group & Neutral earthing	As per system requirement	
9	Cooling	ONAN	ONAN/AN
10	Tap Changer	As per System Requirement	
11	Impedance at 75 degree C a) Principal Tap b) Other Taps	AS PER IS 2026 and system requirement	AS PER IS 2026

12	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap) a) Top Oil b) Winding	 50 deg.C 55 deg.C
13	SC withstand time	2 sec.
14	Fault Level & Bushing CT	As per system requirement
15	Termination	As per system requirement
16	Bushing rating, Insulation class	As per relevant IS/IEC
17	Noise level	AS PER NEMA TR-1
18	Loading Capability	Continuous operation at rated KVA on any tap with voltage variation of +/- 10%, also transformer shall be capable of being loaded in accordance with IS:6600/ IEC60076-7.
19	Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with +/- 10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following overfluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Contractor shall furnish over fluxing characteristic up to 150%
20	Air Clearance	As per CBIP

4.4.3.1.5 General Requirement (Applicable to Power Transformers, Inverter Transformers & Aux. Transformer)

Adequate set of rails with all related embedment and hardware for handling and installation of all the above transformers in switchyard shall be provided by the Contractor.

Adequate set of piping required for oil water separator and soak pit shall be provided by the Contractor.

Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system.

The power/inverter transformers shall be suitable and design shall be capable to withstand frequent start and stop sequence as per system requirement.

Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.

The transformer shall be suitable for continuous operation with a frequency variation of ± 2.5% from nominal frequency of 50 Hz without exceeding the specified temperature rise.

All the control and instrumentation panels / devices shall be so arranged that these are easily visible and conveniently and safely accessible from the front.

Normal operation shall be defined as operation with operating parameters within the following ranges:

Sl. No.	Grid Parameter	Normal Range
1	HV and LV side voltage	90 % to 110 % of rated value
2	Frequency	47.5 Hz to 52.5 Hz
3	Power factor	**0.9** (lag and lead)

Core: The cores shall be constructed from high grade Cold Rolled Non Ageing super Grain Oriented Silicon Steel Laminations equivalent to M4 grade steels or better. Adequate lifting lugs shall be provided to enable the core and windings to be lifted. Core insulation level shall be 2 kV (RMS) for 1 minute in air.

Windings:

a) The winding shall be designed to withstand the highest system voltage continuously and shall have uniform insulation.
b) The conductor shall be of electrolytic grade copper free from scales and burrs.
c) The coil clamping arrangement and the finished dimensions of any oil ducts shall be such that, it will not impede the free circulation of oil through the ducts. The edges of copper conductor shall be smooth so as to ensure that the vibrations do not damage the paper wrapped leading to a fault.
d) Tappings shall be so arranged as to preserve the magnetic balance of the transformers at all voltage ratios.
e) The Transformer shall be oil insulated type and class of insulation should be "A".

Bushings: All the HV, LV & Neutral bushing shall be supplied as per system requirement. A stress shield shall be considered as an integral part of bushing assembly.

Termination arrangement: The Contractor shall be responsible for the termination arrangement /interface arrangement for the transformers.

Tank:

a)

he transformer tank and cover shall be fabricated from good commercial grade low carbon steel. The tank construction shall be welded type and the cover shall be bolted to the tank. Stiffeners of structural steel for general rigidity shall reinforce the tank.

b)

he transformer tank shall be equipped with all necessary valves of appropriate size with standard screw connections for external piping for reliable operation and maintenance of transformer.

c)

uitable inspection holes with welded flange and bolted covers shall be provided on the tank cover. The inspection holes shall be of sufficient size to afford easy access to the lower ends of the Bushings, terminals etc.

d)

ll bolted connections to the tank shall be fitted with suitable oil tight gaskets.

e)

he transformer tank, fittings and all accessories shall be designed to withstand seismic acceleration.

f)

ll bolts and nuts used in connection with the tank and fittings shall be hot dip galvanized /electro-galvanized.

Conservator vessel, oil gauge and breather

a)

onservator tank will have adequate capacity to meet Oil preservation system and volumetric expansion of total transformer oil during operation of transformer. The conservator shall have sufficient strength to withstand, without permanent distortion, during filling under vacuum.

b)

he conservator shall have two filter valves one at the bottom at one end and other at the top on the opposite end. One number Magnetic Oil Gauge (MOG) with low-level alarm contacts shall be provided.

c)

ach conservator vessel shall be fitted with indicating type silica gel breather.Silica gel shall be isolated from atmosphere by an oil seal.

Gas and oil actuated relay (Buchholz relay): Each transformer shall be fitted with gas and oil actuated Buchholz relay having alarm and trip contacts.

Current transformer: Bushing or turret mounted current transformers shall be provided. It shall be possible to remove the CTs from the transformer tank without removing the transformer cover. CT secondary leads shall be brought out to a

weather-proof terminal box near the bushings and the wiring from terminal box to marshalling box shall be done.

Neutral formation: Neutral Earthing shall be done as per system requirement .In case of Solidly earthed neutral of Transformers, it shall be brought through Insulated Support from Tank to the Ground level at a convenient point with two numbers copper flat strips, for connection to ground network (as applicable).

Valves: All valves shall be heavy duty Gate type made of stainless steel material. Means shall be provided for pad-locking the critical valves in the open and close positions.

Pressure relief device: The pressure relief device, specifically designed for transformer protection, shall be provided for protection from internal overpressure. The no. of devices shall be worked out according to the volume of oil. The discharge of PRD shall be properly taken through pipes and directed away from the transformer / other equipment

Transformers shall have Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI) with accuracy class of +/- 2 deg C

Marshalling box: Marshalling Box shall be of Sheet steel, vermin proof, weather and dust proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP65. The Marshalling Box shall be capable of accommodating various Instruments (OTI,WTI , Relays, Selector switches etc), Electrical Wiring, Terminals, CT Connections ,TBs and other equipments as per system design. Sufficient spare Terminals shall be provided with each Marshalling Box. Wiring scheme shall be engraved in a stainless steel plate with viewable font size and same shall be fixed inside the Marshalling Box door. Marshalling Box of all transformers shall be preferably Tank Mounted and shall be at sufficient height above the ground level for safe operation.

Control wiring: All controls, alarms, indicating and relaying devices and secondary terminals of CTs provided with the transformer shall be wired up to the terminal blocks inside the marshalling box. The wiring shall be from PVC insulated copper cable of 1100V grade. All the control wiring shall be properly routed through perforated & covered cable tray fixed on the tank

Joints and gaskets: All gaskets used for making oil tight joint shall be of proven material such as granulated cork, bonded with synthetic rubber. The gasket used shall be of neoprene rubber.

Insulating oil

The oil supplied with Transformers shall be new and previously unused and must confirm to the relevant IS Standards while tested at Supplier's premises. The oil shall be free from moisture and have uniform quality throughout. The parameters of new oil at the time of dispatch of oil from refinery/manufacturer works shall confirm to IS 335-1994, IEC 60296-2003 wherever applicable, considering stringent values in case of overlapping standard/ references. No inhibitor shall be used in oil.

Internal Earthing arrangement:

a)

arthing of core clamping structure: The top & bottom of main core clamping structure shall be connected to the tank body adopting standard practice.

b)

arthing of magnetic circuit: The magnetic circuit shall be earthed to the clamping structure at one point only, through a link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection. The connections are to be brought out through a bushing for the convenience of measurements

c)

arthing terminal: Two earthing terminals capable of carrying the short circuit current of the transformer shall be provided.

d)

arthing of coil clamping rings: Where coil-clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of transformer as the main earth connections.

Locking arrangement: The Contractor shall ensure that all valves, ladder and other devices shall be suitable for safety of installation. Locking with the help of nuts, bolts and other hardware shall be provided for authorized operation of devices.

Guaranteed losses: The no load loss in kilowatts at rated voltage and rated frequency, load losses and total loss in kilowatts at rated output, rated voltage and rated frequency shall be guaranteed. The contractor shall submit the detailed losses calculation of the transformer for the Employer's review at the time of detailed engineering.

Termination arrangement: The Contractor shall be responsible for proper termination/interface arrangement for transformers.

Transformer movements: The transformers shall be provided with Bi-directional Wheel/Skids, jacking pads, lifting lugs, towing holes, core and winding lifting lugs and other necessary fittings so as to allow complete transformer to be lifted and permit movement of the transformer along its longitudinal or transverse axis on

standard broad gauge tracks and allow trouble free operation and maintenance of the transformers.

The Contractor shall submit to the Employer for review the Drawings, design calculations and other relevant information as per Engineering Information Schedule during detailed Engineering.

All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint.

4.4.3.1.6 Codes & Standards:

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards:

Sl. No.	Standard	Description
1	IEC 60076, IS 2026	Power/Inverter transformers
2	IEC 60137, IS 2099	Insulated bushings for alternating voltages above 1000 V
3	IEC 60296, IS 335	Specification for unused mineral insulating oils for transformer and Switchgear.
4	IS 3639	Fittings and accessories for Power/Inverter Transformers
5	IS 2544	Porcelain insulators for system above 1000 V
6	IS 5350	Part-III Post Insulators for system greater than 1000 V
7	IS 5621	Hollow Insulators for use in electrical equipment
8	IS 5556	Serrated lock washers-specification
9	IEC 60354, IS 6600	Loading guide for oil immersed power/Inverter transformers
10	IEC 60185, IS:2705,	Bushing CTs
11	Indian Electricity Act, CEA Notifications	

4.4.3.1.7 Routine Testing & Inspection at Works

All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer reserves the right to inspect the Equipment at the manufacturer's site prior to dispatch.

The Contractor shall carry out the following Routine Tests but not limited to the following:

Routine Tests

All the routine test shall be done in accordance with IEC 60076.

i. easurement of Voltage Ratio and Phase displacement. (as per IEC 60076-1)
ii. easurement of winding resistance on all taps. (as per IEC 60076-1)
iii. ector Group and Polarity Check(as per IEC 60076-1)Magnetic Balance and
iv. agnetizing Current Test
v. easurement of no load current with 415 V, 50 Hz AC Supply.
vi. easurement of no load losses and current at 90%, 100% & 110% of rated voltage
vii. R Measurement Test(as per IEC 60076-1)
viii. easurement of Capacitance & tan delta to determine a capacitance between winding & earth
ix. R Measurement on wiring of Marshalling Box.
x. nduced over voltage withstand test
xi. eparate Source voltage withstand test
xii. reakdown voltage test on transformer oil as per IS 335
xiii. easurement of short circuit impedance and load loss

Installation & Commissioning

Mainly following activities are required to be carried out before the commissioning of Power/Inverter Transformers:-

Assembling of Power/Inverter Transformers accessories and testing activities including the following

i. Ratio Test
ii. Megger Value
iii. Magnetic Balance
iv. Check of vector group
v. Oil BDV
vi. Earth Resistance
vii. Bucholz relay checking
viii. WTI/OTI/MOLG(OIL level) checking
ix. Checking of points of leakage of oil from Transformer body/Radiator Valve

x. Setting of relays in the panel

xi. **DGA of Oil before charging and also after charging.**

4.4.3.1.8 Type Test

Transformers supplied must be of type tested design and certified by any of the accredited certifying agencies in accordance with relevant standards /codes and the type test reports shall be submitted for employer's review. If the type tests are not done previously, then they shall be conducted by the Contractor without any additional cost to the Employer and the type test report shall be submitted before supply of Transformers.

Type Test Reports to be submitted by the Contractor shall be including but not limited to the following:

i. Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076.
ii. Measurement of harmonics of no load current.
iii. Measurement of acoustic noise level as per NEMA TR-1.
iv. Tank Vacuum & Pressure Test (as per CBIP Norms)

4.4.3.2 HIGH VOLTAGE (HV) SWITCHGEAR

4.4.3.2.1 The Contractor shall select the voltage level of HV Switchgear as per the system requirement. The indoor switchgear system shall include Requisite nos. incoming panels from field units,–and outgoing panels to Power/Inverter transformers or the outgoing lines depending on the evacuation voltage & system requirement, panels for **HV/415 V** Auxiliary Transformer, Bus couplers breakers and associated equipment.

4.4.3.2.2 The HV switchgear panels located indoor shall be complete with cubicles, protection, metering, bus-bar system, cabling, wiring and other accessories, comprising of HV Vacuum/SF6 circuit breaker, AC bus bars (including N-bus bar),Current transformers, Potential transformers, Multifunction meters and other necessary equipment as per system requirements. The quantities shall be finalized during detail engineering based on the proposed configuration.

4.4.3.2.3 Rating and Functional Characteristics

Sl. No.	System	Description
1	Nominal System Voltage	As per system requirement
2	Highest System Voltage	As per IEC/IS Standards
3	Rated Frequency	50 Hz
4	No. of Phases/poles	Three (3)
5	System Neutral Earthing	Solidly earthed
6	One minute power frequency withstand voltage -for Type Tests	As per relevant IEC/IS standards

Sl. No.	System	Description
7	1.2/50 microsecond Impulse withstand voltage	As per Fault Level calculation/system requirement
8	Minimum system fault level	As per requirement
9	Short time rating for Bus Bars, circuit breakers, transformers and switchgear assembly	As per system requirement
10	Dynamic Withstand Rating	As per system requirement
11	Control Supply Voltage	As per system requirement
12	Maximum Ambient air temperature	50 deg. C
13.	**Bus Bars**	
i	Continuous current rating at 50 deg.C at ambient	As per system requirement
ii	Temperature rise allowed above ambient	As per system requirement
14.	**Circuit Breaker**	
i	Type	Vacuum /SF6
ii	Description	Three phase equipped with group control mechanism
iii	Rated normal current, A	As per system requirement
iv	No. of interrupter unit per pole	1
v	Short Circuit breaker current	As per system requirement
vi	Short Circuit Making Current	As per system requirement
vii	Total break Time	As per system requirement
viii	Total Make Time	As per system requirement
ix	Rated operating sequence	As per system requirement
x	Normal voltage for operating mechanism i.e., charging motor (DC)	As per system requirement
xi	Reclosing	As per Manufacturer
xii	Auxiliary Contacts	As per Manufacturer

Sl. No.	System	Description
xiii	Noise Level Maximum of Circuit Breaker	As per Manufacturer
15.	**Current Transformer**	
i	Secondary Current	As per system requirement
ii	Class of Insulation	Class E or better
iii	Current Ratio	As per system Requirement
iv	**Accuracy class**	
iv.(a)	Protection	Class PS for Differential & REF and core balance CTs (CBCT); 5P20 for other protection CTs
iv(b)	Metering	0.2S
v	Number of CTs.	As per the requirement of STU/CTU/UPNEDA/State Transmission Authority.
vi	Number of Cores	As per the requirement of STU/CTU/UPNEDA/State Transmission Authority.
vii	Partial discharge level	As per system requirement
viii	Rated VA Burden	As per system requirement
ix	Installation	Outdoor(IP 65)
x	Temperature Rise	As per IEC 60044
xi	Minimum primary earth fault current to be detected by CBCT	As per system requirement
xii	Instrument Security Factor for Measurement CTs	As per system requirement
16.	**Potential Transformer**	
i	Rated Voltage Factor	As per system requirement
ii	Class of Insulation	Class E or better
iii	Transformation ratio	As per system requirement
iv	Accuracy Class	
a)	Relaying	3P
	Metering	0.2
v	Rated Total Thermal	As per system requirement
vi	Partial Discharge	As per system requirement
vii	Number of Cores	As per the requirement of STU/CTU/UPNEDA/State Transmission Authority.
viii	Number of CTs.	As per the requirement of STU/CTU/UPNEDA/State Transmission Authority.

4.4.3.2.4 Standards & Codes

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable IS/IEC standards. In the event of other standards

being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No.	Standards	Description
1	IEC 60529/ IS-13947	Degrees of protection provided by enclosures (IP Code)
2	IEC 60044-1/ IS-2705	Instrument transformers – Part 1 : Current transformers
3	IEC 60044-2/ IS-3156	Instrument transformers – Part 2 : Inductive voltage transformers
4	IEC 60044-6	Instrument transformers – Part 6 : Requirements for protective current transformers for transient performance
5	IEC 62271-100	High-voltage switchgear and control gear – Part 100: High-voltage alternating-current circuit-breakers
6	IEC 62271-200	High-voltage switchgear and control gear – Part 200: A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
7	IEC 60694	Common specifications for high-voltage switchgear and control gear standards
8	IS: 8130 –1984	Conductors for Insulated Cables
9.	IEC 60255	Measuring relays and protection equipment
10.	IS 3231	Electrical relays for power systems protection
11.	IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
12.	IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
13.	IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
14.	IS 9385	High voltage fuses

4.4.3.2.5 General requirement

1. The Indoor HV Switchgear shall be of the steel enclosed type vermin proof, dust, Moisture protected and shall comply with the requirements of latest edition of IEC/IS. The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with IEC 62271-

200. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker truck, cable termination, main bus bars and auxiliary control devices. The adjacent panels shall be completely separated by steel / Aluzinc sheets except in bus bar compartments where insulated barriers shall be provided to segregate adjacent panels. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IS/ IEC 622771-200). However, manufacturer's standard switchgear designs without inter panel barriers in bus bar compartment may also be considered.

2. The circuit breakers and bus VTs shall be mounted on with drawable trucks which shall roll out horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trolley shall be provided by the Contractor for withdrawal and insertion of the truck from and into the panel. Testing of the breaker shall be possible in isolated position by keeping the control plug connected.
3. Switchgear assembly shall be with the truck in any position SERVICE, ISOLATED or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.
4. The doors and covers shall be constructed from cold rolled steel sheets of 2.0 mm or higher thickness .The gland plate thickness shall be minimum 3.00 mm for hot/cold rolled sheet steel. Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for non-magnetic material it shall be 3.0 mm. Switchboards shall have a degree of protection of IP: 5X for outdoor and IP4X for indoor as per IS/IEC:60947.
5. All the sheet steel work shall be pre-treated in accordance with IS: 6005. The gaskets shall be of good quality EPDM/Neoprene.
6. The indicating lamps be with multiple LEDs shall be installed in the panel.
7. The bus bars shall be of Copper conductors conforming to IEC/IS. The bus bar system shall be insulated with PVC sleeves and shall be complaint with UL 224.
8. Circuit breaker shall be according to IEC/IS and shall be complete with the proper interlocking.
9. The current transformer shall be of inductive type. It shall be mounted within the cubicles and shall comply with the requirements of relevant IEC/IS. It shall be used for protection and metering.
10. The potential transformer shall be of inductive type. It shall be mounted within the cubicles on a withdrawable trolley independent of the trolley for the circuit breaker and shall comply with the requirements of relevant IEC/IS. The potential transformer at bus bar shall have requisite number of cores for protection and metering as per the system requirement.
11. Insulating mats of appropriate size confirming to relevant standards are to be provided in front of all the HV switchgear panels for the safety of personnel.
12. Necessary provision/potential free contacts shall be made available

for control, status, alarm and indication of faults/status at Main Control Room.

13. In the Service position, the truck shall be so secured that it is not displaced by short circuit forces. Bus bars, jumpers and other components of the switchgear shall also be properly supported to withstand all possible short circuit forces corresponding to the short circuit rating specified.
14. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions.
15. To represent the single line diagram, a mimic diagram shall also be made available on the panel. The circuit breaker cubicle shall be provided with space heater and door operated illumination lamp.
16. Suitable lifting hooks shall be provided for each panel.
17. Restricted Earth fault relay for HV side Power transformer shall be provided. The system shall be compatible with station SCADA, regarding input and output needed for operation, control and monitoring of HV switchgear system.
18. All the auxiliary wiring shall be carried out with calculated design voltage grade, single core cable conductor, colour coded, and PVC insulated wires. Conductor size shall be 1.5 mm2 (min) for control wiring and 2.5 mm2 (min) for CT and space heater circuits.
19. Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment.
20. The Contractor shall submit to the Employer the layout arrangement ,equipment Drawings, design calculations for short circuit withstand capability , load calculation for bus bar rating selection etc. and other relevant information as per Engineering Information Schedule during detailed Engineering.

4.4.3.2.6 Routine Testing & Inspection

All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

The contractor shall perform the routine tests conforming IS/IEC 60044-1:2003 for the Instrument Transformers (CT & PT) including but not limited to following:-

a. Verification of terminal markings
b. Power-frequency withstand test on primary winding
c. Partial discharge measurement
d. Power-frequency withstand test on secondary windings
e. Power-frequency withstand tests, between sections
f. Inter-turn overvoltage test

4.4.3.2.7 Type Test

HT Switchgear supplied must be of type tested design and certified by any of the accredited certifying agencies in accordance with relevant standards /codes and the type test reports shall be submitted for employer's review. If the type tests are not done previously, then they shall be conducted by the Contractor without any additional cost to the Employer and the type test report shall be submitted before supply of Transformers.

4.4.3.2.8 The contractor shall perform the routine tests conforming IS/IEC 60044-1:2003 for the Instrument Transformers (CT & PT) including but not limited to following:-

a) Short-time current tests
b) Temperature rise test
c) Lightning impulse test
d) Switching impulse test
e) Wet test for outdoor type transformers
f) Determination of errors
g) Radio interference voltage measurement (RIV)

4.4.3.3 LT SWITCHGEAR

4.4.3.3.1 LT Switchgear

3-phase, 50 HZ, 415 V switchgear system shall consist of various LT metal enclosed Switchgear boards complete with suitably rated equipment including, Draw out type incoming air circuit breaker, required no. of MCCBs, Current transformers, of Potential transformers, of Multifunction meters, Energy meters, AC bus bars (including N-Bus bar),Local control switches, Indicators (LED Type) as per requirement, all necessary auxiliaries for control and supervisory circuits, and other necessary associated equipment

4.4.3.3.2 General Requirement

The switchgear system shall be solidly grounded, 3 phases, 4-wire TNS, according to IEC Publication 60364-3. The 415 V Switchgear shall be metal enclosed indoor cubicles free floor standing type and of uniform height not exceeding 2450 mm.

EPDM/Neoprene gasket shall be provided between the panel sections to avoid ingress of dust into panels.

All switches, push buttons etc. shall be operated front and shall be flush/semi-flush mounted

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.

Each switchboard shall be provided with undrilled, removable type gland plate having thickness of 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material.

Cable entries shall be from bottom. The opening of cable entry shall be covered by 3mm thick gland plates with proper sealing to avoid water and rodent entry.

Earthing bus bar of suitable cross section shall be provided throughout the length of panel.

All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP-5X for outdoor LT panels and IP-4X for indoor panels as per IS/IEC60947.

The minimum clearance in air between phases and between phases and earth for the entire run of horizontal and vertical bus bars and bus-link connections at circuit-breaker shall be 25mm.

All auxiliary wiring shall be carried out with voltage grade as per system design single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5mm2 (min.) for control circuit wiring and 2.5 mm2 (min) for CT and space heater circuits.

Each switchgear panel shall be provided with thermostatically controlled space heaters to prevent condensation within the enclosure. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse

All Switchboards shall be provided with three phase & neutral bus bar. Bus bar conductors shall be made of copper of adequate size with PVC sleeves conforming to UL 224.

Copper/Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard with proper earthing arrangements.

Control switches and instruments shall be mounted on the circuit breaker compartment doors/front side of the panel.

The air circuit breakers shall be designed in accordance with the recommendations of IEC Publications 60947-1 and 60947-2.

The MCCBs shall be designed in accordance with the IEC Publications 60947.1 and 60947-2.

All fuses shall be of HRC cartridge fuse link type of suitable rating.

The current transformer shall be single-phase single core inductive type and shall comply with the requirements of relevant IEC 60044-1.

Required no. of potential transformers with fuses in all the phases shall be provided for metering and interlock.

The Contractor shall submit to the Employer the layout arrangement ,equipment Drawings, design calculations for short circuit withstand capability , load calculation for bus bar rating selection etc. and other relevant information as per Engineering Information Schedule during detailed Engineering.

4.4.3.3.3 Standards & Codes

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose.

4.4.3.3.4 R

Standards	Description
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60439	Low-voltage switchgear and control gear assemblies
IEC 60364	Electrical installations of buildings
IEC 60947	Low-voltage switchgear and control gear

i

n

e Testing & Inspection at Works

All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch

4.4.3.4 CABLING SYSTEM

4.4.3.4.1 Cabling System shall include the following:

i. T Power & Control Cable

ii. T Power cable

iii. able Installation Methodology

4.4.3.4.2 LT Power & Control Cable

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. The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.

4.4.3.4.3 General Requirements

1. ll 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. If Cables are to be laid Underground, laying shall be as per relevant IS Code.
2. opper/Aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.
3. LPE 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.
4. he minimum conductor cross-section for control cable shall be 1.5 sq.mm. KV Grade.
5. ontrol Cables shall have stranded copper conductor and shall be multicore PVC insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I)
6. ll the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath as per IS : 5831.
7. or single core armoured cables, armouring shall be of aluminium wires/formed wires. For multi core armoured cables armoring shall be of galvanized steel of suitable size and type of armour. The aluminium used for armouring shall be of H4 grade as per IS: 8130.
8. he aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm2 per meter at 20 deg C.
9.

uter sheath shall be of PVC as per IS: 5831. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.

i. xygen index of min. 29 (as per IS 10810 Part-58).

ii. cid gas emission of max. 20% (as per IEC-754-I).

iii. moke density rating shall not be more than 60 % (as per ASTMD- 2843)

10. ll cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.

11. llowable tolerances on the overall diameter of the cable shall be +/- 2 mm maximum over the declared value in the technical data sheet

12. n plant repairs of the cable shall not be accepted. Pimples, fish eye, blow hole etc are not acceptable.

13. able shall be supplied with Wooden drums which shall comply with IS: 10418.

4.4.3.4.4 HT Power Cable

All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.

4.4.3.4.5 Cable Selection and Sizing (Applicable for LT & HT Cables)

HT & LT Power Cables shall be sized based on the following considerations:

a) ated current of the equipment

b) he Maximum voltage drop

i. **T Power Cable**:- The maximum voltage drop in the cables Inverter to Inverter Transformer shall be limited to 0.5 % of the rated voltage. For other LT cables, Maximum Voltage drop shall be limited to 3% of rated voltage.

ii. **T Power Cable-**The Maximum voltage drop in the cables (Inverter Transformer to HT Panels shall be limited to 3 % of the rated voltage (excluding motor starting conditions)

4.4.3.4.6 Derating Factors (Applicable for LT & HT Cables)

Derating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) ariation in ambient temperature for cables laid in air

b)

rouping of cables

Variation in ground temperature and soil resistivity for buried cables

4.4.3.4.7 Codes and Standards (Applicable for LT Power & Control & HT Cables)

All the cables shall conform to the requirements of the following standards and codes:-

Standards	Description
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 galvanized 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 up to and including 1100V.
IS:7098 (Part -II)	Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 KV up to and including 33 KV.
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.
IEEE-383	Standards for Type Tests of Class IE Electric Cables
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).
IS- 1255	Code of practice for installation and Maintenance of power cables including and up to 33 KV rating.
IS-3043	Code of practice for earthing
IS:9537	Conduits for electrical installation
IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6 KV upto and including 33 KV performance requirements and type tests
DIN 46329	Cable lugs for compression connections, ring type for Aluminium conductors
VDE 0278	Tests on cable terminations and straight through joints.

Standards	Description
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:7098 (Part -II)	Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 KV up to and including 33 KV.
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.
IEEE-383	Standards for Type Tests of Class IE Electric Cables
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).
IS- 1255	Code of practice for installation and Maintenance of power cables including and upto 33 KV rating.
IS-3043	Code of practice for earthing
IS:9537	Conduits for electrical installation
IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6 KV upto and including 33 KV performance requirements and type tests
DIN 46329	Cable lugs for compression connections, ring type for Aluminium conductors
VDE 0278	Tests on cable terminations and straight through joints.

4.4.3.4.8 Cable Ends

a)

able end terminations and joint kits shall comply with the latest version of the relevant IS Codes

b)

he Cable end shall be terminated with adequate size copper lugs, Aluminium lugs,