

it rests on the foundation pad shall be 2.55 meters The various minimum heights of the switchyard shall be as given below from plinth level:

(i) Gandhar Power station

Voltage level Eqpt./	1 st Level Bus	2 nd Level Bus	3 rd Level Bus
220 kV	6000 mm	11700 mm	16200 mm

The peak of towers of 220 kV shall be 5000 mm.+ 2000mm spike

The indicative structure heights of equipment such as CT, CVT, LA, Isolator, BPI etc. for Gandhar has been mentioned in tender drawings, however, bidder to note that the total height of the equipment along with structure shall match with existing bay equipment height.

5.1.15.10 The Bay width (Beam Span) for 220kV Switchyard Gantry structures should be 18 m.

5.1.15.11 Circuit breakers shall be supplied with necessary interpole cabling, and its cost shall be included in the cost of equipment.

5.1.15.12 All equipment shall be suitable for hot line washing.

5.1.15.13 The Contractor shall cooperate in all respects and exchange the necessary technical data/ drawings with other agencies and Employer's other Contractors under intimation to Employer to ensure proper coordination and completion of work in time.

5.1.15.14 Short circuit force calculation shall be submitted by the bidder as per relevant IEC for flexible & rigid bus as applicable. This short circuit force shall be considered for designing of Tower, Girder and equipment structure and their foundation as applicable.

5.1.15.15 The sag tension, conductor spacing, short circuit forces, spacer location, conductor swing and clearances shall be carried out in accordance with IEC 60865 to achieve the specified clearances.

5.1.15.16 All overhead stringing shall be carried out by minimum double tension String insulator assembly.

5.1.15.17 All the cables used for the switchyard shall be armoured type, irrespective of whether they are laid in ground or air.

5.1.15.18 The towers and gantries shall be suitable for a normal conductor tension of minimum 1.5T/conductor in case of Quad moose ACSR conductor and 2T/conductor in case of Twin/Single moose ACSR conductor & Shield wire tension shall be min. 0.8T. The foundations and structures if required shall be designed accordingly.

5.1.15.19 In 220 kV switchyard per feeder one bay marshalling box (BMK) is to be provided. The duplicated power supplies for BMK shall be extended.

5.1.15.20 The space for placing CRP and other installations in on second (2nd) floor in the existing Switchyard Control Room Building. The control & protection panels shall be located in this building.

5.1.15.21 The Contractor shall lay the cables properly dressed and clearly identifiable along the control cable trench as there shall be other existing bay's cables running along the trench.

5.1.15.22 For earthing 50x6 mm GS flat shall be used in all cabinets, MOM boxes, panels and balance all other earthing such as all equipments, towers, LM, cable trenches etc shall be through 75x12mm GS Flat.

5.1.15.23 Two (2) nos. of suitable industrial socket and suitable power cable for oil filtration equipment for Transformers shall be provided for future use.

5.1.15.24 The illumination level shall be 20 lux in general and 50 lux on equipment boxes. Lighting Mast/Lighting Mast shall be used for mounting lighting fixtures for outdoor switchyard lighting. No lighting fixture shall be mounted on towers/gantries.

5.1.15.25 Voltage drop for sizing of power cables shall not be more than 6%. The connectors and clamps shall be rated same as the connected equipments.

5.2 Services to be performed by the equipment being supplied

All the equipment/materials covered in this specification shall perform all its function satisfactorily without undue strain, restrike etc. under normal operating voltage conditions.

5.3 Site Supervision of Equipments

The contractor shall ensure that, erection, testing and commissioning of Transformer, Circuit Breaker, Isolator, Instrument Transformer, Surge Arrestor, Substation Automation System, Control & Protection System & Protective relays is carried out under the supervision of manufacturer of respective equipment.

5.4 Clearances

The minimum clearances shall be as given below:

Clearance	220 KV	33 KV
Phase to earth clearance	2100 mm	320 mm
Phase to phase clearance	2100 mm	320 mm
Section clearance	5000 mm	3000 mm

The Contractor shall supply the structures suitable to meet the above clearances.

5.5 SYSTEM PARAMETERS

The system parameters shall be as under:

	220 KV	33 KV
Highest system voltage	245 KV rms	36 KV rms
Lightning Impulse voltage	±1050kVp	±170kVp
Power frequency withstand for 1 min. (rms)	460 KV rms	70 KV rms
Max. fault level (1 sec.)	40 kA	12.5 kA
Minimum creepage distance	8575 mm	1260 mm
Rated ambient temperature	50 deg C	50 deg C
System earthing	Effectively earthed	
Rated frequency	50 Hz	
Max. Radio Interference level at 156 kVfor 0.5 MHz to 2.0 MHz	1000 microvolt	

5.6 TYPE TEST REQUIREMENTS FOR EQUIPMENTS

5.6.1 All equipments to be supplied shall be of type tested design. During detail engineering, the contractor shall submit for BHEL/NTPC's approval the reports of all the type tests as listed in this specification and carried out not earlier than ten years prior to the date of techno –commercial bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a Client.

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

5.6.3 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.

5.7 RIV TESTS:

The RIV tests shall confirm to the requirements as per below:

5.7.1 General

Unless otherwise stipulated, all equipment together with its associated connectors where applicable shall be tested for measurement of radio interference voltage (RIV).

5.7.2 Test Levels

The test voltage levels for measurement of external RIV are listed under the relevant clauses of the specification.

5.7.3 Test Methods for RIV:

5.7.3.1 RIV tests shall be made according to measuring circuit as per International Special – committee on Radio Interference (CISPR) Publication 16 -1 (1993) Part – I. The measuring circuit shall preferably be tuned to frequency with 10 % of 0.5 MHz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The result shall be in microvolts.

5.7.3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107 – 1964 except otherwise noted herein.

5.7.3.3 In measurement of RIV temporary additional external corona shielding may be provided. In measurement of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

5.7.3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, 115% and 130% for the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 220 KV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

5.7.3.5 The metering instruments shall be as per CISPR recommendations or equivalent device so long as it has been used by other testing authorities.

5.7.3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to the voltage read by the noise meter.

5.8 CIRCUIT BREAKER

5.8.1 GENERAL

Circuit Breakers shall be outdoor type, comprising three identical single pole units, complete in all respects with all fittings and wiring. The circuit breakers and accessories shall conform to IEC-62271-100 or equivalent Indian Standard. The requirement of control switching is as clause 5.8.10 of this chapter.

5.8.2 DUTY REQUIREMENTS

5.8.2.1 Circuit breaker shall be totally restrike free(C-2 class) under all duty conditions and shall be capable of performing their duties without opening resistor. 220 kV Circuit Breaker shall meet M1 class of mechanical endurance requirements as per IEC. The circuit breaker shall meet the duty requirement of any type of fault or fault location and shall be suitable for line charging and dropping when used on 220 kV effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.

5.8.2.2 The circuit breaker shall be capable for breaking the steady & transient magnetizing current corresponding to 220/33 kV transformers upto 250MVA 3 phase rating. It shall be capable of breaking line charging currents as per IEC-62271-100 with a voltage factor of 1.4. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC:62271-100.

5.8.2.3 The Bidder may note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic/hydraulic pressure and arc extinguishing medium pressure, etc. While furnishing the

proof of the total break time of complete circuit breaker, the Bidder may specifically bring out the effect of non-simultaneity between same pole and poles and show how it is covered in the guaranteed total break time. While furnishing particulars regarding the D.C. component of the circuit breaker, the Bidder shall note that IEC-62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.

5.8.3 CONSTRUCTIONAL FEATURES

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

- a) Close position
- b) Arc initiation position
- c) Full arcing position
- d) Arc extinction position
- e) Open position.

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

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

5.8.4 SULPHUR HEXAFLUORIDE (SF₆) GAS CIRCUIT BREAKER

5.8.4.1 Circuit breakers shall be single pressure type.

5.8.4.2 Each pole shall form an enclosure filled with SF₆ gas independent of two other poles. Common monitoring of SF₆ gas can be provided for the three poles of circuit breaker having a common drive. The interconnecting pipes in this case shall be such that the SF₆ gas from one pole could be removed for maintenance purposes.

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

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

5.8.5 OPERATING MECHANISM

5.8.5.1 Circuit breaker shall be operated by pneumatic mechanism or electrically spring charged mechanism or electro-hydraulic mechanism or a combination of these. It shall be gang operated for 3-phase reclosing operation.

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

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

5.8.5.4 The hydraulic mechanism shall be suitable for at least two close open operations after failure of ac supply to the motor starting at pressure equal to lowest pressure of auto-reclose duty.

All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

5.8.6 FITTINGS AND ACCESSORIES

5.8.6.1 The insulators and terminal connectors shall conform to requirements stipulated elsewhere. All routine tests shall be conducted on the insulators as per relevant IEC.

5.8.6.2 UNIT COMPRESSED AIR SYSTEM

a) The unit compressed air system for each breaker shall be provided with compressed air piping, piping accessories, control and non-return valves, filters, coolers of adequate capacity, pressure reducing valves(if any), isolating valves, drain ports, etc. The air compressor shall be driven by automatically controlled motor. It shall be of air cooled type complete with preferably oil-less cylinder lubrication. The compressors or pumps shall be mounted within the operating mechanism housing or a separate weatherproof and dust-proof housing. Each compressor shall be equipped with a time totaliser.

b) The compressor size shall be such that it is capable of performing following operations satisfactorily:

- i) Total running time of compressor not exceeding 45 minutes per day, considering 2% leakage and 2 CO-operations.
- ii) Air charging time not exceeding 20 minutes after one CO operation of the breaker.

c) Air Receivers:

- i) The capacity of receivers shall be sufficient for two (2) CO operations of the breaker.
- ii) Air receiver shall be designed in accordance with the latest edition of the ASME Code for Pressure Vessel - Section VIII of BS:5179. A corrosion allowance of 3.0 mm shall be provided for shell and dished ends.
Receivers shall be hot dip galvanized.

d) Controls and Control Equipment:

- i) The compressor control shall be of automatic start stop type initiated by pressure switches on the receiver. Supplementary manual control shall also be provided.
- ii) All control equipment shall be housed in a totally enclosed cabinet. Pressure gauges and other indicating devices, control switches shall be mounted on the control cabinet.
- iii) Facility to annunciate failure of power supply to the compressor control shall also be provided.

e) Compressed Air Piping, Valves and Fittings:

- i) The flow capacity of all valves shall be at least 20% greater than the compressor capacity.
- ii) The high pressure system shall be such that after one O - 0.3 Sec – CO operation, the breaker shall be capable of performing one CO operation within 3 minutes.
- iii) All compressed air piping shall be bright annealed, seamless phosphorous Deoxidized Non-Arsenical Copper alloy or stainless steel pipe (C-106 of BS:2871).

5.8.7 TESTS

5.8.7.1 TYPE TESTS

Circuit breaker shall confirm to type tests as per IEC in accordance with the requirement stipulated under clause no. 5.5.

5.8.7.2 Routine Tests

Routine tests as per IEC-62271-100 on the complete breaker/ pole along with its own operating mechanism and pole column shall be performed on all circuit breakers.

5.8.7.3 SITE TESTS

All routine tests except power frequency voltage dry withstand test on breaker shall be repeated on the completely assembled breaker at site.

5.8.8 PARAMETERS

- a) Type of circuit breaker- Outdoor SF6, single pressure, Live tank type
- b) Rated frequency- 50 Hz
- c) Number of poles- Three (3)
- d) Rated operating duty cycle- O - 0.3 sec. - CO - 3min. – CO

- e) Reclosing- Three phase high speed auto reclosing
- f) Total closing time- Not more than 150 ms.
- g) Maximum difference in the instants of closing/opening of contacts- As per IEC
- h) Trip and closing coil voltage- 110/220V DC
- i) Auxiliary contacts- As required plus 10 NO and 10 NC contacts per pole as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 millisecond at 220V DC.
- j) Noise level- Maximum 140dB at 50m distance from base of circuit breaker
- k) Rated terminal load- Adequate to withstand 100kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity.
- l) Type of operating mechanism- Pneumatic/spring/hydraulic/or a combination of these
- m) Rated ambient temp- 50 deg C
- n) System neutral earthing- Effectively earthed
- o) Support structure height- Adequate so that lowest part of support insulator of equipment is minimum 2550 mm from plinth level

5.8.9 245 kV Class Circuit Breakers

- a) Rated voltage- 245kVrms
- b) Rated continuous current- 2000 Amp (min.) at rated amb.
- c) Rated short circuit breaking- 40kA with percentage of DC current at rated voltage component as per IEC corresponding to minimum opening time under operating conditions specified
- d) Symmetrical interrupting- 40 kA rms Capability
- e) Short time current carrying- 40 kA rms for One (1) second Capability
- f) Short circuit making current- 100kAp Capability
- g) Rated out-of-phase breaking- 10 kA rms
- h) Rated line charging breaking- As per IEC Current (voltage factor of 1.4)
- i) Rated small inductive current Switching capability with over voltage less than 2.3 pu - Corresponding to interrupting steady and transient magnetising current upto 500 MVA transformers
- j) First pole to clear factor- 1.3
- k) Maximum total break time under any duty condition for any current under limiting condition of voltage and pressure- 65ms
- l) Rated one minute power frequency withstand voltage (Dry & Wet) between line terminals and ground 460 kV rms between terminals with CB open- 530 kV rms
- m) Rated Insulation levels :
Full wave impulse withstand voltage (1.2/50 micro sec.)
between line terminals and ground ± 1050 kV peak
between terminals with CB open ± 1200 kV impulse on one terminal & other terminal earthed
- n) Max. radio interference voltage for Frequency between 0.5 MHz and 2 MHz at 156 kV rms (Micro volts) both in open and closed position- 1000
- o) Phase to phase spacing 4500 mm (other type tested spacing are also acceptable)

5.8.10 Requirement of Controlled Switching Device for 220KV Circuit Breaker

The circuit breaker with controlled switching as indicated in single line diagram shall meet the following requirement:

1. The Switching controlled Device shall be used to reduce increased over voltages, re-ignition between circuit breaker contacts that may be caused by normal switching of high voltage circuit breakers and hence optimize the stresses on circuit breaker while switching the circuit. The switching controlled device will be called device henceforth. The switching controlled device shall make suitable adjustments to the switching instants of Main/Tie breakers so as to optimise the switching behaviour of Generator transformers and Bus reactors. These switching controlled devices shall be installed in Main and Tie breakers of Generator transformers and Bus reactors.

The switching controlled device for Generator transformers shall be primarily used for charging of Generator transformers from the grid side and optimisation of switching behaviour.

2. The device shall be such that only switching commands (for operating purpose) are processed in the device. Open command triggered by protection on fault shall be forwarded directly to the breaker. In these cases switching instance is not controlled.

3. Circuit breaker should be able to be switched while switching controlled device is not in operation e.g. during maintenance work or power supply is not connected, a bypass shall be provided to the device. In these cases the switching commands will then be forwarded directly to the circuit breaker via this Bypass. The switching time will not be controlled with these switching operations.

4. The device shall meet the requirements of IEC-60255-4 Appendix 'E' class III regarding HF disturbance test, and fast transient test shall be as per IEC-61000 – 4 level III and insulation test as per 60255 – 27.

5. The device shall have functions for switching ON & OFF the circuit breakers.

6. The device shall get command to operate the breakers manually or through auto re-close relay at random. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.

7. The device shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command and optimize the switching behavior as necessary. In calculation of next operating time of the breaker the controller must consider all factors that may affect the operating time of the breaker.

8. The device should have display facility at the front for the settings and measured values.

9. The device shall have self monitoring facility.

10. The device shall be suitable for operation considering transient and dynamic state values of the current and voltage from the secondary of the CTs and CVTs.

11. During the switching operations, current and voltage waveforms and other parameters shall be recorded and saved together with calculated values. The control switching device provided shall be networked to an Engineering work station (EWS) located in the switchyard control room. It shall be possible to extract the switching oscillographic records and also to do CSD parameterization from this EWS. All necessary software & hardware shall be in bidder's scope. Alternatively, a laptop shall be supplied to facilitate downloading of oscillographic records and CSD parameterization locally.

12. It shall have self monitoring facilities. Faults which impair the functioning of the device or peripheral components, failure of trip voltage or sensors shall be displayed visually and shall give alarm.

13. The device shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified elsewhere in the specification.

14. The device shall have time setting resolution of 0.1 ms or better

15. The device shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering the scheme.

16. Supply of all the necessary accessories required for the successful operation of controlled switching device shall be in the scope of supplier of the device.

5.9 CONTROL AND PROTECTION

5.9.1 GENERAL REQUIREMENTS FOR CONTROL AND PROTECTION

5.9.1.1 The Bidder's scope of work shall include the supply, delivery, installation, testing and commissioning of control, metering and protection system for 33/220kV Transformer bay, integration of new 220kV bay to Bus Bar protection of existing 220kV switchyard.

5.9.1.2 All associated power and control cabling shall be in the Bidder scope.

5.9.1.3 Interlocking to prevent unsafe operation of Switchyard equipment such as circuit breakers, isolators, earth switches etc. shall be implemented.

5.9.1.4 A portable engineering station (Laptop PC) with all the licensed software required for IED configuration, testing commissioning, DR & Event log downloading, Energy Meter & chartless recorder data downloading shall be provided.

5.9.1.5 Bay control and protection panels shall be placed at inside Switchyard control room. Bidder scope also includes all associated works required for the above purpose.

5.9.1.6 The communication protocol used for all devices including Bay Control Unit (BCU) and Bay Protection Units (BPU) shall be the IEC61850 protocol and BCU and BPUs shall be integrated into solar SCADA system.

5.9.2 OPERATIONAL REQUIREMENTS FOR NUMERICAL RELAYS AND AUXILIARY RELAYS

5.9.2.1 All protection relays to be supplied under this package shall be of Numerical type.

5.9.2.2 All numerical relays, auxiliary relays and devices shall be of latest version, reputed make and types proven for the application, satisfying requirement covered elsewhere and shall be subject to Owner's approval. Relays and timers shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.

5.9.2.3 Numerical relays shall be suitable for efficient and reliable operation of the protection scheme. Necessary auxiliary relays, timers, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. No control relay, which shall trip the circuit breaker when relay is de-energized, shall be employed in the circuits.

5.9.2.4 Relays shall be provided with self-reset contacts except for the trip lockout relays, which shall have manual reset facility.

5.9.2.5 Suitable measures shall be provided to ensure that transients present in CT & VT connections due to extraneous sources in EHV system do not cause damage to the numerical and other relays. CT saturation shall not cause mal-operation of numerical relays.

5.9.2.6 Except for event logging, alarm and annunciation type of non-trip functions, protective relay contact multiplier relay shall be high speed trip relay only.

5.9.2.7 Only DC/DC converters shall be provided in the solid state devices / numerical relays wherever necessary to provide a stable auxiliary supply for relay operation.

DC batteries in protective relays and timers necessary for relay operation shall not be acceptable. Equipment shall be protected against voltage spikes in auxiliary DC supply.

5.9.2.8 The internal clock of all the numerical relays being supplied under this package shall be synchronized through the GPS Time Synchronizing System.

5.9.2.9 All Protection Relays shall be provided with self-diagnosis and supervision functions to ensure maximum availability. An alarm contact shall be provided for hardware failures, failures of internal and external auxiliary supplies etc.

5.9.2.10 Each numerical relay shall have a serial interface on the front for local communication through PC. Further, all the numerical relays being supplied under this package shall have a rear communication port suitable for forming an engineering LAN(in future). Facilities shall be provided to access each discrete protection function including modification in the relay settings and monitoring of the relays through a portable engineering workstation. Necessary licensed software (latest version) for the above purpose shall be in the scope of the bidder. Display of various measured parameters during normal as well as fault condition on segregated phase basis shall be provided. Numerical relays shall also have LEDs and back lit LCD screen for visual indication and display of messages related to major trips / alarms generated in the relays. Necessary multilevel password protection shall be provided.

5.9.2.11 The sampling rate of analog inputs, the processing speed and processing cycle of digital values shall be selected so as to achieve the operating times of various protection functions specified. In case Bidder does not have all the protections specified, as a part of the standard

numerical relay, separate discrete numerical relays can be provided for such protection. The reasons for providing the same shall be clearly brought out in the bid.

5.9.2.12 All numerical relays shall be IEC61850 compliant.

5.9.2.13 The protection system shall be arranged to provide two independent, high performance and reliable systems with separate monitored DC supplies, separate CT/VT cores, separate cables and trip relays to obtain 100% redundancy.

Associated trip relays of the two systems shall be separate, having sufficient number of contacts for all the functions. Each protection shall energize both trip coils of the circuit breakers to be tripped.

5.9.2.14 The numerical relays shall be provided with built-in disturbance recorder to record the analogue form of instantaneous values of the current and voltage during faults and disturbances for the pre-fault and post-fault periods. The disturbance recorder shall have the facility to record the following external digital channel signals in addition to the digital signals pertaining to the differential relay itself: HV breaker (main and tie) status, LV breaker status, Buchholtz /On-load tap-changer, Buchholtz alarm/trip, Winding temperature/ Oil temperature/Pressure relief alarm/trip and other transformer mechanical protection signal.. The data from DR function shall be available in IEEE/COMTRADE format and compatible with the dynamic relay test system being supplied in this contract.

5.9.2.15 The manufacturer of the offered numerical protection system shall carry out complete engineering, testing & commissioning at site of the offered protections including the associated relay & protection panels.

5.9.2.16 The numerical relays offered shall have self-diagnostic features to reduce the down time of the relay and provide useful diagnostic information on detection of an internal fault to speed up the maintenance. Necessary support documentation explaining the self-diagnostic features of the numerical relays in detail shall be furnished for owner's use.

5.9.2.17 Pick up range of the Binary inputs shall be minimum 70 V DC /AC.

5.9.2.18 All the numerical relays shall have adequate processor capability to carry out programmable scheme logics (PSL) required for implementing approved protection and control schemes over and above its inbuilt protection functions algorithm. All numerical relays shall be supplied with all protection functions / features in disabled condition.

5.9.2.19 All the numerical relays shall have built in disturbance recording function. The built in DR function shall be used to record the graphic form of the instantaneous values of analog inputs such as voltages and currents in the case of a short circuit and a disturbance in the Power System. Fault/disturbance logs shall be clearly identified by Fault ID, Fault date and time (hour, minutes, seconds and ms). Time stampings on fault records shall be synchronized with a GPS clock. Shall have Scan rate of 1000 Hz or better for sampling each of the analog channels having a fundamental frequency of 50 HZ. The fault data from the Digital Fault Recording feature shall be available in IEEE / COMTRADE format.

5.9.3 PROTECTIONS FOR EHV SYSTEM

5.9.3.1 The general protection requirements for the 220 kV Transformer are indicated in the tender drawing for switchyard protection SLD.

5.9.3.2 The minimum fault current could be as low as 20% of the rated current. The characteristics shall be such as to provide satisfactory operation under such extremely varying conditions.

5.9.3.3 The protection and control equipment and circuitry, shall be arranged to provide two independent, high performance and reliable protection systems with separate DC supplies, separate CT/VT cores and separate cables and self reset (single phase) hand reset (three phase) trip relays to obtain 100% reliability. The DC supplies to these protections shall be monitored.

5.9.3.4 Associated trip relays of the two systems shall be separate having sufficient number of contacts for all the functions.

5.9.3.5 Each protection system shall energize both trip coils of the circuit breaker.

5.9.4 EHV CIRCUIT-BREAKER PROTECTION

Each 220kV circuit breaker being supplied under this package shall be provided with following protection functions:

5.9.4.1 Numerical Local Breaker Back up Protection Function: Duplicated LBB protection function shall be provided for each 220kV circuit breaker supplied under this package. The LBB function as a built-in function of Bay Protection unit is acceptable provided it meets all the requirements specified below. In addition, the LBB protection function shall meet following criteria:

- Be three pole type having three single phase units
- Shall operate for stuck breaker conditions
- Have an operating/resetting time each of less than 15 ms.
- The LBB function shall be initiated by external trip contacts from various protection functions and after a set time delay shall energize the trip bus in the bus bar protection scheme on which the stuck breaker is connected for tripping of all breakers connected to the particular bus. **In addition, an instantaneous repeat trip command from LBB shall be given to the primary breaker through two different self reset trip relays on different DC supply.** The interlocking between different relays to achieve the LBB functionality shall be achieved by hard-wired logic.
- Have a setting range of 5 to 80% of rated current
- Have a continuous thermal withstand of 2 times rated current irrespective of the setting.
- Have time delay feature with a continuously adjustable setting range of 0.1 to 1 s.
- Shall be an individual phase comprehensive scheme.
- Shall not operate during the single-phase auto-reclosing period.
- Shall provide end-fault protection that initiates a direct transfer trip to the remote end.

5.9.4.2 Trip Coil Supervision: A Trip Coil supervision function shall be provided for each lockout trip relay and each of the circuit-breaker trip coils. It shall incorporate both the pre-close and post-close supervision of trip coils and associated trip circuits. An audible alarm shall be given in the event of operation of trip coil supervision function. It shall have a time delay on drop-off of not less than 200ms. Trip coil supervision function as a built in feature of BPU is also acceptable provided it meets all the specified requirements.

5.9.4.3 DC Supply Supervision

5.9.4.4 Pole Discrepancy Protection for each CB under this package.

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

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

5.9.5 INTERFACE WITH EXISTING SYSTEM PROTECTION

5.9.5.1 The bidder shall provide all interfacing requirements with the existing 220 kV bus bar protection scheme.

5.9.5.2 The bidder shall provide the Busbar relay setting calculations and revised relay settings, if required on account of new bays getting added to the switchyard for Gandhar. AT Gandhar Project, All trip relays, multiplication relays, two nos of Busbar protection peripheral unit as per existing system, any other hardware, associated cabling required to achieve the interfacing of the new 220kV bays covered in this package with existing Busbar protection shall be under the bidder's scope.

5.9.5.3 Supply of ABT meter and necessary interface with the existing ABT metering network are in the scope of Bidder. All required hardware shall be provided by the bidder. ABT meter shall be similar to the existing ABT meters of other 220kV bays. AT Gandhar Project, For ABT meter integration purpose, Bidder shall provide the following hardware:

- (a) MOXA convertor- 01 No.
- (b) 16-port Ethernet switch-01 No.
- (c) LAN Cable-200 meters

ABT meter data will be connected to plant SCADA as well.

5.9.6 INTERFACE WITH RLDC AND SOLAR SCADA SYSTEM

5.9.6.1 Necessary interface for extending status of circuit breaker, isolators, Trip relays, transformer tap position, MW/MVAR (4-20mA) data etc of new bays to RLDC through the existing RTU shall be in bidder's scope. Necessary contact multiplication relays, transducers, cable and cabling shall be in bidder's scope. Complete scope augmentation of existing RTU/interface system for sending data of 220kV Bay data as per regulatory requirements are in the Bidder scope.

5.9.6.2 Necessary interface with Solar SCADA system for extending status/alarm/trip signal of 220 bay equipments, protection and control panel, transformer including OLTC system & firefighting system, energy meter data etc of new bays to Solar SCADA system shall be in bidder's scope

5.9.7 TRANSFORMER PROTECTION

5.9.7.1 The Bay Protection Unit offered for each transformer should be such that it provides a comprehensive protection for the equipment for all types of faults and abnormal operating conditions.

5.9.7.2 The numerical relays, comprising the Bay Protection Unit, for transformer shall be configured into two protection groups operating on two separate DC supplies, such that one protection group shall always be available to detect and operate for any type of fault in the transformer, under condition of failure of other protection group or of associated DC supply of the other protection group.

5.9.7.3 The following protections shall be provided for 220/33 kV Transformer:

- 3 Winding Differential Protection (87T)
- Restricted E/F Protection (64T- HV & LV side)
- Directional Back up over current and E/F protection on HV and LV (67/67N)
- Back up over current and E/F protection on HV and LV (50/51/50N/51N)
- Back-up neutral E/F protection (51N)
- Over fluxing Protection (99T)
- Multiplication relays for the following : trip of Buchholtz /Pressure Relief Device / Sudden Pressure Relay and Fire protection etc

5.9.7.4 Should the protection functions specified for the transformer be available as a single discrete numerical relay, two such relays shall be supplied to meet the requirements of relevant clause above.

5.9.7.5 Differential , Back-up E/F in one channel and REF, Back-up O/C in another channel

5.9.7.6 Differential Protection shall:

- (a) be of numerical type and shall have continuous self-monitoring and diagnostic features;
- (b) be three-pole type, with faulty phase identification/indication. The operating time of the relay shall not be greater than 30ms at 5 times the setting.
- (c) be stable for magnetizing inrush currents and shall be stable under normal over-fluxing conditions. Magnetizing inrush stability shall not be achieved through the use of an intentional time delay;
- (d) have an internal feature in the relay to take care of the angle and ratio correction;
- (e) have a disturbance recording feature to record the analogue form of instantaneous values of the current in all three windings (i.e. nine analog channels) during faults and disturbances for the pre-fault and post-fault periods. The disturbance recorder shall have the facility to record the following external digital channel signals in addition to the digital signals pertaining to the differential relay itself:
 - HV breaker (main and transfer) status
 - LV breaker status

- On-load tap-changer position
 - Buchholtz alarm/trip
 - Alarm/trip of transformer on winding temperature/oil temperature/ pressure relief
- The necessary hardware and software for downloading the data captured by the disturbance recording function to portable engineering station shall be included in the scope.

5.9.7.7 Restricted Earth Fault Protection shall:

- (a) be single-pole type;
- (b) be of current/voltage operated high impedance type;
- (c) have a suitable non-linear resistor to limit the peak voltage
- (d) shall have setting range from 5-80%

5.9.7.8 Over fluxing Protection shall

- (a) Operate on the principle of voltage to frequency ratio.
- (b) Have inverse time characteristics compatible to transformer over fluxing withstand capability and also a separate high set feature.
- (c) Provide an independent alarm with continuously adjustable time delay.
- (d) Tripping time shall be governed by V/ F Vs time characteristic of the relay.
- (e) Have a set of characteristics for various multiplier settings.
- (f) Have a resetting ratio of 98% or better

5.9.7.9 Back-up Over current Protection with High-set Function (50/51)

- (a) Shall be triple pole type
- (b) Shall be of definite time characteristic & have built-in timer with suitable range
- (c) Shall have a low transient, overreach high-set instantaneous unit
- (d) Shall have an adjustable setting range for current and time setting
- (e) Shall include hand-reset indication per phase.

5.9.7.10 Backup Earth Fault Protection (50N/51N)

- (a) Shall be single pole type
- (b) Shall be of definite time characteristic & have built-in timer with suitable range
- (c) Shall have a low transient, overreach high-set instantaneous unit
- (d) Shall have an adjustable setting range for current and time delay
- (e) Shall include hand reset indication

5.9.7.11 Directional Back up Over Current and E/F Protection

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

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

5.9.8 CONTROL PANELS

IEC 61850 compliant Panel mounted bay control unit (BCU) based Control Panels shall be provided for 33/230kV transformer bay. Control Panels shall comprise minimum of the equipment as listed:

- a) Bay Control Unit (one no).
- b) Annunciation windows with test, accept and reset-push buttons.

5.9.8.1 Bay Control Unit (One No.)

The Bay Control Unit shall have following built-in functions:

i. Mimic control panel to display graphically the bay configuration, status of the plant, analogue measurands, alarms, and offer bay level control.

ii. Switching of Switchyard Bay Equipment depending on conditions such as interlocking, control mode, or external status condition. Adequate safety features like prevention of double operation, command supervision, block/deblock, over-riding the interlocking etc. shall be provided. All such security features shall be finalized and approved by Owner during detailed engineering.

iii. Status Supervision of switchyard equipment

iv. Interlocking Function to prevent unsafe operation of switchyard equipment such as circuit breakers, isolators, earth switches etc. Interlocking shall be implemented on bay level, by user-friendly, menu-driven configuration software within the BCU. The auxiliary contacts of each of the equipment shall be wired to the BCU for this purpose. An over-riding / bypass function for baylevel interlocking shall be provided at appropriate security level for maintenance or during emergency conditions. The interlocking logic shall be defined during the details engineering phase to prevent illegal operation.

v. Analogue Measurements for bay voltage (per phase), current (per phase), frequency, MW and MVAR, tap position / gas parameters / winding temperature of Transformers. These measurements shall not require the use of any intermediate transducers. The accuracy of measurement shall be 0.5% for voltage, current and frequency, and 1.0% for MW and MVAR. The measured and computed values shall be displayed locally on BCU.

vi. Event and Alarm Handling: BCUs shall acquire all the bay level alarms and events from field inputs with a resolution and time tagging of 1 milli sec and shall transfer these to Solar SCADA through SCADA LAN.

5.9.8.2 Annunciation System

The annunciation system shall be either relay based or based on state of the art static system of proven design. The annunciation facia shall be at least of 35mm x 50mm size for each point. The system shall have accept, reset and test facilities for alarms in each control panel. Annunciation alarm shall be provided for failure of annunciation dc supply by means of separate AC supply. No of annunciation windows per control panel shall be decided during detailed engineering.

5.9.8.3 Controlled Switching Device

Bidder to refer 220kV switchyard chapter for details specification and actual requirement for controlled switching device.

5.9.8.4 Any contact multiplication relays required to multiply the contacts of existing isolators, CBs, trip relays etc to be used in the scheme logics related to bays under present scope shall be provided by the bidder. Any cabling between the bidder's panels and existing control & relay panels for this purpose shall also be in bidder's scope. Any modification and associated cabling in existing scheme logics required due to addition of new bays in the existing switchyards shall also be in the bidder's scope. All such existing schemes shall be revised to show the modifications and submitted to NTPC for reference.

5.9.8.5 CONSTRUCTIONAL FEATURES

5.9.8.5.1 Panels:

- Shall be free standing, floor mounting type and completely metal enclosed. Cable entries shall be from bottom.
- Shall have removable gland plates with glands made of brass and suitable for armoured cables.
- Panels shall be of IP 31 class or better.
- Panels shall be painted. For panels to be located in the existing switchyard control room, the color of paint for exterior/interior of the panel and the dimensions of the panel shall be in line with that of the existing control/relay panels at site.
- Relays/Energy meters shall be flush mounted on the front with connections at the rear; shall be draw out or plug-in type/modular case with proper testing facilities. Provision shall be made for easy isolation of trip circuits for testing and maintenance.

- f) The dimensions of control / relay panel shall be matching with the existing panels at site, details of which shall be furnished during the detailed engineering.
- g) Shall be supplied complete with interconnecting wiring between all devices mounted therein.
- h) All equipment mounted on front and rear side of the panels shall have individual name plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.
- i) Each panel shall be provided with a 240V AC fluorescent lighting fixture controlled by door switch as well as a 5A, 240V AC switch-socket unit.
- j) Shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of AC & DC supplies for various circuits for control, signaling, lighting, interlocking, etc. Selection of main and sub-circuit fuse rating shall ensure selective clearance of the sub-circuit faults.
- k) Voltage circuits for protection and metering shall be protected by fuses. Suitable fuse failure relays shall be provided to give an alarm for voltage circuits of protection/metering. Voltage selection scheme based on relays shall be provided for meters wherever possible.
- l) The DC supplies at the individual relay and protection panels shall be monitored by suitable relays and failure of DC supplies shall be annunciated.
- m) Panels shall have a lockable front Plexiglas door and a swing frame. Panels shall facilitate direct access to any component mounted inside and shall have at least 20% free space for future expansion.

5.9.8.5.2 Earthing:

- a) The panels shall be equipped with an earth bus of at least 50x6 mm² galvanized steel flat or equivalent copper.
- b) Earth buses of adjoining panels shall be connected for continuity. The continued earth bus so formed shall be connected to main earth grid at both ends.
- c) All metallic cases of the mounted equipment shall be connected to the earth bus by 2.5mm² copper wires.
- d) One breach in such earthing shall not cause loss of earthing of any equipment.
- e) CT/VT neutral secondary shall only be earthed at the terminal block of the panel through links, such that earthing of one group may be removed without disturbing others.
- f) An independent Electronic Earth System shall be provided as per bidder's standard. The electronic earth shall be connected to the substation earth mat through a dedicated riser.

5.9.8.5.3 Control Supply:

- a) Owner shall provide two set of DC and AC supply feeder panels for control and protection panel use. Necessary cabling including termination shall be in the scope of the Bidder.

5.9.8.5.4 Wiring

- a) Internal wiring to be connected to external equipment shall terminate on terminal blocks.
- b) The terminal blocks for CTs and VTs shall be provided with test links and isolating facilities. The CT terminal blocks shall be provided with short circuiting and earthing facilities.
- c) Shall have 20% terminals as spare terminals in each panel.
- d) All wiring shall be with 660V grade, single core, PVC insulated stranded copper conductor.
- e) Wires shall be vermin proof. Minimum size of conductor shall be 1.5 sqmm in general, but for CT & VT circuits it shall be 2.5 mm². Minimum number of strands shall be three. Contractor shall be solely responsible for completeness and correctness of all the wiring, and for proper functioning of the connected equipment.

5.9.8.5.5 Colour Mimic

Colour mimic diagram showing the exact representation of the system shall be provided in front of the control panel. Mimic colour shall be matching with that of the existing 220 kV control panels and the details shall be furnished by the Owner during detailed engineering.

5.9.8.5.6 Auxiliary Equipment

All control and instrumentation switches shall be rotary operated type with escutcheon plate showing the operating position and circuit designation. All switches shall be flush mounted. Handles of different shapes shall be provided as approved by Owner. Control switches for breaker

or disconnecting switch shall be of spring return to neutral type, while all other shall be stay-put type all the synchronizing switches shall have a removable common handle, removable only in off-position. Lockable type switches shall be provided for same application as specified by the Owner. The contact combination and their operation shall ensure completeness of the scheme function and interlock requirements. Contact ratings of the switches shall be as per relevant standards. Contacts shall be spring assisted and contact faces shall be made pure silver. Cluster type LED indicating lamps shall be provided. Position indicators for the earth switches of semaphore type shall be provided as specified in the mimic diagram. It shall be suitable for DC operation.

5.9.8.5.7 INDICATING INSTRUMENTS

- a) Shall conform to IS: 1248
- b) Shall be suitable for the instrument transformers as indicated in the drawings enclosed and shall be calibrated to read directly the primary quantities.
- c) Shall be calibrated and adjusted at works and shall also be tested and calibrated at site before commissioning. All these instruments shall be flush mounted.
- d) Shall be transducer operated, having 240 deg. scale and a dial of 96x96 mm², have an accuracy of 1.5 class and resolution of at least 50% of accuracy class
- e) Current coils shall be 120% of rated current and 10 times for 0.5 sec. without losing accuracy.

5.9.8.5.8 TRANSDUCERS

- a) Shall conform to IEC: 688-1.
- b) The output of the transducers shall be 4-20mA/0-10mA/10-0-10mA dc as necessary for the instruments.
- c) Accuracy class shall be 0.5 or better except for frequency transducer, which shall have an accuracy of 0.2.
- d) Summation transducer shall be suitable for taking multiple inputs from individual MW/MVAR transducers.
- e) Shall have dual output. One output shall be used for the indicating instrument/recorder provided and other shall be wired up to terminal block of the panel for Owner's use in future.
- f) Energy transducers shall be suitable for 3 phase, 4 wire connection.

5.9.9 CONTROL CABLING PHILOSOPHY

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

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

5.9.9.3 Duplicated cores with at least 4 mm² equivalent core cross-sectional area per connection shall be used for connection of all CT/CVT circuits.

5.9.9.4 VT leads used for tariff metering shall have an equivalent core cross-sectional area of at least 10 mm² per phase/neutral connection.

5.9.9.5 Duplicate channels of protection shall have independent cables for tripping, DC supply, etc. Duplicated cores shall be used for all closing/tripping commands and interlocking signals involving long cable lengths.

5.9.9.6 For the following applications multiple cores with at least 4 mm² equivalent core cross-sectional area per connection shall be used.

- a) DC supply to Bay Marshalling box
- b) DC supply to circuit breaker cubicle
- c) DC looping for closing and tripping circuits of circuit breaker

5.9.9.7 Any special cable required for hooking up 4-20 mA signals from yard to control room is in the scope of the bidder.

5.9.9.8 Spare cores shall be provided as per following norms,

Up to 3 core cable Nil

5 Core Cable Min. 1 core

7 to 14 core cable Min. 2 cores

More than 14 cores Min. 3 cores

5.9.10 SITE / COMMISSIONING TESTS

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

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

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

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

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

5.9.10.5 Point-to-point testing of all the I/O signals under the present scope of work shall be done by the bidder at the plant and protection equipment end and the terminal end.

5.9.10.6 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

5.9.11 TYPE TEST REQUIREMENTS

Test reports for following type tests shall be submitted for all numerical relays/ DR. Test reports / certificates of tests conducted in accredited laboratories (accredited by the national accreditation body of the country where the lab is located) are also acceptable.

5.9.11.1 Numerical Relays

A. Insulation Tests:

S No	Description	Standard
1	Dielectric Withstand Tests	IEC 60255-5 2kV rms for 1 minute between all case terminals connected together and the case earth. 2kV rms for 1 minute between all terminals of independent circuits with terminals on each independent circuit connected together. ANSI/IEEE C37.90-1989 1kV rms for 1 minute across the open contacts of the watchdog relays. 1kV rms for 1 minute across open contacts of changeover output relays. 1.5kV rms for 1 minute across open contacts of normally open output relays.
2	High Voltage Impulse Test, class III	IEC 60255-5 5 kV peak; 1.2/50 μ sec; 0.5 J; 3 positive and 3 negative shots at intervals of 5 sec

B. Electrical Environment Tests:

1	DC Supply Interruption	IEC 60255-11
2	AC Ripple on DC supply	IEC 60255-11
3	AC voltage dips and short Interruptions	IEC 61000-4-11
4	High Frequency Disturbance	IEC 60255-22-1, class III At 1MHz, for 2s with 200Ω source impedance: 2.5 kV peak; 1 MHz; T = 15 μsec; 400 shots/sec; duration 2 sec between independent circuits and independent circuits and case earth. 1.0kV peak across terminals of the same circuit
5	Fast Transient Disturbance	IEC 60255-22-4, class IV 4kV, 2.5kHz applied directly to auxiliary supply 4kV, 2.5kHz applied to all inputs.
6	Surge Withstand Capability	EEE/ANSI C37.90.1 (1989) 4kV fast transient and 2.5kV oscillatory applied directly across each output contact, optically isolated input and power supply circuit.
7	Electrostatic Discharge	IEC 60255-22-2 Class 4 15kV discharge in air to user interface, display and exposed metal work.
8	Surge Immunity	IEC 61000-4-5: 1995 Level 4 4kV peak, 1.2/50ms between all groups and case earth. 2kV peak, 1.2/50ms between terminals of each group.

C. EMC Tests:

S No	Description	Standard
1	Radiated Immunity	C37.90.2: 1995 25MHz to 1000MHz
2	Radiated Electromagnetic Field Disturbance Test	IEC 60255-22-3 80-1000MHz, 80% Amplitude Modulated
3	Disturbances Induced by Radio Frequency fields, Amplitude Modulated (Conducted Immunity)	IEC 60255-22-6 150kHz – 80 MHz; 80%
4	Power Frequency Magnetic Field	IEC 61000-4-8, class IV
5	Interference Voltage, Aux. Voltage (Conducted Emission)	EN 50081-2, 1994 or equivalent 150 kHz to 30 MHz
6	Interference Field Strength (Radiated Emission)	EN 50081-2, 1994 or equivalent 30 MHz to 1000 MHz

D. Atmospheric Environment Tests:

S No	Description	Standard
1	Temperature	IEC 60255-6 IEC 60068-2-1 for Cold IEC 60068-2-2 for Dry heat
2	Humidity	IEC 60068-2-3 56 days at 93% RH and +40°C

E. Mechanical Stress Tests:

S No	Description	Standard
1	Vibration (during Operation and Transportation)	IEC 255-21-1; IEC 68-2-6
2	Shock (during Operation and Transportation)	IEC 255-21-2, class 1, IEC 68-2-27
3	Seismic Vibration (during Operation)	IEC 60255-21-3

5.9.12 SETTINGS

The bidder shall provide BHEL/NTPC a philosophy document clearly setting out the philosophy the bidder will use in determining setting levels. Each setting will have a brief description of the specific function or element. The setting calculation and formula will also be shown on the document. All relevant system parameters, transformer data additionally used for calculating the setting will appear in the setting document. The bidder will conduct system studies in determining fault levels on different locations. These study results will also form part of the setting document. Any additional information required to complete this exercise shall be timely requested by the bidder.

The setting document will be presented and discussed with the Employer prior to final issue of the document. The final accepted setting document should be made available to the Employer in PDF format.

It is the bidder's responsibility to configure each protection relay to provide the protection and control facilities required. A full set of relay configuration and setting files shall be included in the design and documentation submissions. The bidder will issue three sets of setting documents once accepted.

5.10 DISCONNECTORS AND EARTH SWITCHES (ISOLATORS AND ACCESSORIES)

5.10.1 GENERAL

5.10.1.1 The isolators and accessories shall conform in general to IEC 62271-102 (or equivalent Indian standard) except to the extent explicitly modified in specification.

5.10.1.2 Earth switches shall be provided on isolators wherever called for.

5.10.1.3 The isolators and earth switches shall be A. C. motor operated.

5.10.1.4 Isolators shall be Horizontal Centre Break type

5.10.2 DUTY REQUIREMENTS

5.10.2.1 Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the system in their closed position. They shall be constructed such that they do not open under influence of short circuit current and wind pressure together. The earth switches wherever provided shall be constructional interlocked so that the earth switches can be operated only when the isolator is open and vice-versa.

5.10.2.2 In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in relevant section. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for 'DC' control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

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

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

5.10.2.5 All isolators of class above 72.5 kV shall be of mechanical endurance class M2 as per IEC. All earth switches shall be of class M0 duty.

5.10.3 CONSTRUCTIONAL FEATURES

5.10.3.1 The isolators shall be provided with high pressure current carrying contacts on the hinge/jaw ends and all contact surfaces shall be silver plated. The thickness of silver plating wherever provided should not be less than 25 microns.

5.10.3.2 The isolator shall be provided with a galvanised steel base provided with holes and designed for mounting on a lattice/pipe support structure. The base shall be rigid and self supporting. The position of movable contact system (main blades) of each of the isolator and earthing switch shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the isolator and earthing switch. The indicator shall be of metal and shall be visible from operating level.

5.10.3.3 All metal parts shall be of non-rusting and non-corroding metal. Current carrying parts shall be from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities, if provided on current carrying parts, shall be made of copper silicon alloy or equivalent. The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces.

5.10.3.4 The isolators shall be so constructed that the switch blade will not fall to the closed position if the operating shaft gets disconnected. Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by gravity, wind pressure, vibrations shocks or accidental touching of the connecting rods of the operating mechanism. The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals.

5.10.3.5 The insulator of the isolator shall conform to the requirements stipulated elsewhere and shall have a min. cantilever strength of 800 kg.

5.10.4 EARTHING SWITCHES

Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts. The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator. Earthing switches shall be suitable for local operation only. The earthing switches shall be constructional interlocked with the isolator so that the earthing switches can be operated only when isolator is open and vice versa.

5.10.5 OPERATING MECHANISM AND CONTROL

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

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

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

5.10.4.4 Control cabinet/operating mech. box shall conform to requirements stipulated under auxiliary equipment mentioned elsewhere in the chapter and IS:5039/IS 8623/IEC 60439 as applicable.

5.10.5 OPERATION

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

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

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

5.10.6 TESTS

5.10.6.1 In continuation to the requirements stipulated elsewhere the isolator alongwith operating mechanism shall conform to the type tests and shall be subjected to routine tests and acceptance tests in accordance with IEC 62271-102. During final testing of isolator sequential closing/ opening of earth switch shall also be checked only after isolator is fully open/close.

5.10.6.2 The insulator shall conform to all the type tests as per IEC 60168. In addition to all type, routine and acceptance tests, as per IEC-60168, the following additional routine/ acceptance tests shall also be carried out:

- Bending load test in four directions at 50% min. bending load guaranteed in all insulators.
- Bending load test in four directions at 100% min. bending load guaranteed on sample insulators in a lot.
- Torsional test on sample insulator of a lot.

5.10.7 PARAMETERS

- Type of isolator- Outdoor type
- Rated frequency- 50 Hz
- Number of poles- Three (3)
- Operating time- Not more than 12 sec.
- Control voltage- 110/220V DC
- Auxiliary contacts on Isolator- As required plus 8NO and 8NC contacts per pole/isolator as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 millisecond at 220V dc. Additionally MBB contacts as required shall also be provided.
- Auxiliary contacts on earth switch- Total 6NO and 6NC
- Rated mechanical terminal load- As per table III of IEC 62271-102
- Temperature rise over- As per IEC:62271-102 ambient
- Rated ambient temperature- 50 deg C
- System neutral earthing- Effectively earthed
- Support structure height- Adequate so that lowest part of support insulator of equipment is min. 2550 mm from plinth level
- Rated mechanical terminal- As per table III of IEC 62271-102 Load
- Operating mechanism of Motor operated Isolator and Earth Switch- AC/DC/Universal
- Temperature rise- As per Table III of IEC 60694 for an ambient of 50 deg C

5.10.8 245 kV Class Isolators :

- Rated voltage- 220 kV
- Highest System voltage- 245 kV
- Rated current at 50°C ambient min. temperature- 2000 Amp
- Rated short time withstand current for 1 sec of isolator and earthswitch- 40 kA rms
- Rated dynamic short circuit withstand current of isolator and earthswitch- 100kAp
- Rated Insulation levels

	1.2/50 micro sec. lightning impulse withstand voltage (+ ve or – ve polarity) earth) impulse on one terminal and other terminal earthed	One minute power freq. withstand voltage (Between live terminal and
To earth	+/-1050 kV (Peak)	460 kV (rms)
Across isolating distance	+/-1200 kV peak	530 kV (rms)

g) Phase to phase spacing- 4500 mm (other type tested spacing are also acceptable)

h) Max. Radio interference between 0.5MHz to 2.0 MHz at 156 kV (rms)- 1000 micro volts

5.11 INSTRUMENT TRANSFORMER

5.11.1 CODES AND STANDARDS

Current transformers IEC 60044, BS:3938, IS: 2705 IEC 61869

Voltage transformers IEC 60044 IEC 60358, IS:3156 IEC 61869

Insulating oil IS: 335

5.11.2 GENERAL REQUIREMENTS

5.11.2.1 The instrument transformers i.e. current and voltage transformers shall be single phase transformer units and shall be supplied with a common marshaling box for a set of three single phase units.

5.11.2.2 The tank as well as top metallics shall be hot dip galvanised or painted with Grey color of shade RAL 9002.

5.11.2.3 The instrument transformers shall be hermetically sealed units. The instrument transformers shall be provided with filling and drain plugs.

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

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

5.11.2.6 No Oil shall come into direct contact with Zinc galvanized surface.

5.11.2.7 Metering terminal box shall be provided in a separate compartment for Instrument Transformers (CT & CVT) with separate locking Arrangement.

5.11.3 CURRENT TRANSFORMERS (OIL FILLED CTs) (Metering and protection CTs)

5.11.3.1 The CTs shall have single primary of either ring type or hair pin type or bar type. The Wound Primary type is not acceptable.

In case of "Bar Primary" inverted type CTs, the following requirements shall be met:

The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution. The lowest part of insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage d

uring transportation due to relative movement between insulation assembly and top dome. The insulator shall be one piece without any metallic flange joint

5.11.3.2 The CT shall be provided with oil sight glass which should be clearly visible to maintenance personnel standing on ground.

5.11.3.3 The core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters. The CTs shall be suitable for high speed auto-reclosing.

5.11.3.4 Different ratios shall be achieved by secondary taps only, and primary reconections shall not be accepted.

5.11.3.5 The guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

5.11.3.6 The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CT/reactor is used, then all parameters specified shall be met treating auxiliary CTs/reactors as integral part of CT. The auxiliary CT/reactor shall preferably be in-built construction of the CT. In case it is separate, it shall be mounted in secondary terminal box.

5.11.3.7 The physical disposition of protection secondary cores shall be in the same order as given under CT requirement table(s) given below.

5.11.3.8 The secondary terminals shall be terminated on stud type suitable no's of nondisconnecting and disconnecting terminal blocks as required inside the terminal box of degree of protection IP:55 at the bottom of CT. The CTs shall be suitable for horizontal transportation.

5.11.3.9 The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Contractor shall give his

recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn, and treatment of CT.

5.11.3.10 The CT shall have provision for measurement of capacitance and tan delta as erected at site.

5.11.4 VOLTAGE TRANSFORMERS (CVTs) (Metering and protection CVTs)

5.11.4.1 Voltage transformers shall be of capacitor voltage divider type with electromagnetic unit.

5.11.4.2 The CVTs shall be thermally and dielectrically safe when the secondary terminals are loaded with guaranteed thermal burdens.

5.11.4.3 The electro-magnetic unit (EMU) shall comprise of compensating reactor, intermediate transformer and protective and damping devices. The oil level indicator of EMU with danger level marking shall be clearly visible to maintenance personnel standing on ground.

5.11.4.4 The secondaries shall be protected by HRC cartridge type fuses for all windings. In addition fuses shall also be provided for protection and metering windings for connection to fuse monitoring scheme. The secondary terminals shall be terminated on stud type non-disconnecting terminal blocks via the fuse inside the terminal box of degree of protection IP: 55. The access to secondary terminals shall be without the danger of access to high voltage circuit.

5.11.4.5 The damping device shall be permanently connected to one of the secondary winding and shall be capable of suppressing ferro-resonance oscillations.

5.11.4.6 CVTs shall be suitable for high frequency (HF) coupling for power line carrier communication. Carrier signals must be prevented from flowing into potential transformer (EMU) metering circuit by means of RF choke/reactor suitable for effective blocking the carrier signals over the entire frequency range of 40 to 500 kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. The HF terminal shall be provided with earthing link with fastener.

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

5.11.4.8 The protection cores shall not saturate at about 1.5 times the rated voltage for a min. duration of 30 secs.

5.11.4.9 The accuracy of metering core shall be maintained through the entire burden range upto 75VA on all three windings without any adjustments during operations

5.11.4.10 MARSHALLING BOX

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

5.11.5 PARAMETERS FOR CURRENT TRANSFORMERS

5.11.5.1 General Parameters

- a) One minute power frequency withstand voltage between secondary terminal and earth- 5 kV
- b) Partial discharge level- 10 pico Coulombs max.
- c) Temperature rise- As per IEC 60044
- d) Type of insulation- Class A
- e) Number of cores- As per AC SLD
- f) Installation- Outdoor (up right)
- g) Number of terminals in marshalling box- All terminals of control circuits wired upto marshalling box plus 20 terminals spare.
- h) System Neutral earthing- Effectively earthed

5.11.5.2 220 kV Current Transformers

- a) Highest System voltage- 245 kV

- b) Rated short time thermal current- 40 kA for 1 sec.
- c) Rated dynamic current- 100 kA (peak)
- d) Rated extended primary current- 120% of rated primary current.
- e) Rated insulation level :
 - i) 1.2/50 micro seconds (impulse voltage)- 1050 kV (Peak)
 - ii) 1 minute (dry and wet) power frequency withstand voltage- 460 kV (rms)
- f) Maximum temperature rise at an ambient temperature of 50 deg C- As per IEC-60044
- g) Max. Radio interference voltage at 156kV (rms)- 1000 micro volts
- h) Partial discharge level immediately After p.f. test- 10 picocoulombs (max.)

5.11.6 PARAMETERS FOR CVTs

5.11.6.1 General Parameters

- a) Installation Outdoor
- b) Standard reference range of frequencies for which the accuracies are valid 96% to 102% for protection and 99% to 101% for measurement.
- c) High frequency capacitance for entire carrier frequency range within 80% to 150% of rated capacitance
- d) Equivalent resistance over entire carrier frequency range Less than 40 ohms
- e) Stray capacitance and stray conductance of LV terminal over entire carrier frequency range As per IEC:60358
- f) One minute power frequency withstand voltage
 - a) between LV (HF) terminal and earth 10kV rms for exposed terminals or 4 kV rms for terminals enclosed in a weather proof box.
 - b) For secondary winding 2 kV rms
- g) Temp. rise over an ambient temp. of 50 deg. C As per IEC 60044-2
- h) Number of terminals in control Cabinet All terminals of control circuits wired upto marshalling box plus 10 terminals spare.
- i) Rated total thermal burden 225 VA
- j) Partial discharge level 10 pico Coulombs max.
- k) Number of cores As per details given in Tables below.
- l) Rated Voltage factor 1.2 continuous , 1.5 – 30sec

5.11.6.2 220 kV Voltage Transformers

- a) Rated system voltage 245 kV (rms)
- b) Rated insulation levels
- c) 1.2 micro sec. impulse ± 1050 kV (peak)
- d) 1 min (dry& wet) power frequency withstand voltage 460 kVrms
- e) HF capacitance 8800 pf (nominal)
- f) RIV at 156 kV rms 1000 microvolts (max)

5.11.7 TESTS

The current and voltage transformers shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC.

CTs & CVTs shall also conform to the following additional type tests as applicable:

- (i) Radio Interference Voltage test
- (ii) Thermal withstand test i.e. application of rated voltage and rated current simultaneously by synthetic test circuit(For CT only)
- (iii) Thermal co-efficient test i.e. measurement of Tan-Delta as function of temperature (at ambient and between 80 deg. C and 90 deg. and voltage (at 0.3, 0.7, 1.0 and 1.1 $U_m/\sqrt{3}$)(For CT only)
- (iv) Multiple chopped impulse test on Primary winding.

TABLE – IA

CORE DETAILS OF 220 KV PROTECTION CT (Metering CTs will be as per AC SLD)

Core No	Application	Current Ratio (A)	Output Burden (VA)	Accuracy Class as per IEC 185	Min. knee point voltage (V)	Max. CT Sec. wdg. Resistance (ohms)	Max. exciting current in mA at knee point voltage
1	Bus Diff. Check	2000/1000/1	--	PS	2000/1000	10/5	30/60
2	Bus Diff. Main	2000/1000/1	--	PS	2000/1000	10/5	30/60
3	Metering and synchronizing	200/100/1	20	0.2s	--	--	--
4	Trans. Back up/ Line protection	2000/1000/500/1	--	PS	2000/1000/500	10/5/2.5	30/60/120
5	Trans. Diff./ Line protection	2000/1000/500/1	--	PS	2000/1000/500	10/5/2.5	30/60/120

Note:

The rated extended primary current of the CTs shall be 120% continuous of 2000 A. ISF for metering core should be less than 5.

TABLE-IB

CORE DETAILS OF 220 KV PROTECTION CVTs (Metering CVTs will be as per AC SLD)

	Secondary 1	Secondary 2	Secondary 3
Rated secondary voltage	110 / $\sqrt{3}$	110 / $\sqrt{3}$	110 / $\sqrt{3}$
Application	Protection	Protection	Metering
Accuracy	3P	3P	0.2
Output Burden (minimum)	75 VA	75 VA	75 VA

Note : The accuracy of 0.2 on secondary should be maintained through the entire burden range up to 75 VA on all the three windings without any adjustments during operation.

5.12 SURGE ARRESTOR

5.12.1 GENERAL

5.12.1.1 The surge arrestors shall conform in general to IEC-60099-4 and IS:3070 except to the extent modified in the specification.

5.12.1.2 Arrestors shall be hermetically sealed units, self-supporting construction, suitable for mounting on lattice/tubular type support structures.

5.12.2 DUTY REQUIREMENTS

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

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

5.12.2.3 The SAs shall be fully stabilised thermally to give a life expectancy of one hundred (100) years under site conditions and take care of effect of direct solar radiation.

5.12.2.4 The SAs shall be suitable for circuit breaker duty cycle in the given system. The SAs shall be capable of withstanding meteorological and short circuit forces under site conditions.

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

5.12.2.6 The SAs shall be capable of withstanding meteorological and short circuit forces under site conditions.

5.12.3 CONSTRUCTIONAL FEATURES

5.12.3.1 Each Surge Arrester (SA) shall be hermetically sealed single phase unit.

5.12.3.2 The non-linear blocks shall be sintered metal oxide material. The SA construction shall be robust with excellent mechanical and electrical properties.

5.12.3.3 SAs shall have pressure relief devices and arc diverting ports suitable for preventing shattering of porcelain housing and to provide path for flow of rated fault currents in the event of SA failure.

5.12.3.4 The SA shall not fail due to insulator contamination.

5.12.3.5 Seals shall be effectively maintained even when SA discharges rated lightning current.

5.12.3.6 Porcelain shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to maximum design value for SA. The cantilever strength of the insulator shall be minimum 350kg.

5.12.3.7 The end fittings shall be non-magnetic and of corrosion proof material.

5.12.3.8 The Contractor shall furnish the following:

- a) The heat treatment cycle details with necessary quality checks used for individual blocks along with insulation layer formed across each block.
- b) Metalizing coating thickness for reduced resistance between adjacent discs alongwith procedure for checking the same.
- c) Details of thermal stability test for uniform distribution of current on individual discs.
- d) Detailed energy calculations to prove thermal capability of discs.

5.12.4 FITTINGS AND ACCESSORIES

5.12.4.1 Each SA shall be complete with insulating base for mounting on structure.

5.12.4.2 SAs shall be provided with grading and/or corona rings as required.

5.12.4.3 Self contained discharge counters, suitably enclosed for outdoor use (IP:55 degree of protection) and requiring no auxiliary or battery supply shall be fitted with each SA along with necessary connections to SA and earth. Suitable leakage current meters shall also be supplied in the same enclosure. The reading of milliammeter and counter shall be visible through an inspection glass panel to a man standing on ground. A pressure relief vent/suitable provision shall be made to prevent pressure build up. The earth connection for the Surge Arrester shall be carried out in such a manner so that the discharger current path is diverted to earth and the path through structure is avoided.

5.12.5 PARAMETERS

5.12.5.1 General

- a) System neutral earthing Effectively earthed
- b) Installation Outdoor
- c) i) Nominal discharge current 10 kA of 8/20 microsec. wave
- ii) Discharge current at which Insulation coord. is done 20 kA of 8/20 microsec. wave
- d) Rated frequency 50 Hz
- e) Long duration discharge class 3
- f) Current for pressure relief test 40 kA rms
- g) Prospective symmetrical fault current 40 kA rms for 1 second
- h) Low current long duration test value (2000 micro sec.)As per IEC
- i) Pressure relief class Class A of Table VII of IS:3070 or equiv. IEC.
- j) Partial discharge at 1.05 MCOV (Continuous operating voltage) Not more than 50 p.C.

- k) Siesmic acceleration 0.3 g horizontal
 - l) Reference ambient temp. 50 deg. C
 - 5.12.5.2 220kV class Surge Arrestors**
 - a) Rated system voltage 245 kV
 - b) Rated arrestor voltage 216 kV(not less than)
 - c) Minimum discharge capability 5 kJ/kV (referred to rated arrestor voltage corresponding to min. discharge characteristics)
 - d) Continuous operating voltage (COV) at 50 deg. C 168 kV rms
 - e) Maximum Switching surge residual voltage (1 kA) 500kVp
 - f) Maximum residual voltage at
 - i) 10kA nominal discharge current as per IEC
 - ii) 20kA nominal discharge current As per IEC
 - g) Max. steep current residual voltage at 10 kA 650 kVp
 - h) Long duration discharge class 3
 - i) Current for Pressure Relief test 40 kArms
 - j) High current short duration test value (4/10 microsec. wave) 100 kAp
 - k) One minute dry/wet power frequency 460 kV (rms)
 - l) Impulse withstand voltage of arrestor withstand voltage of arrestor housing (dry & wet) 1050kVp housing with 1.2/50 micro sec. wave.
 - m) Radio interference voltage at 156 KV Not more than 1000 micro volt
 - n) Partial discharge at 1.05 MCOV (continuous operating voltage) Not more than 50 p.c.
- The surge arrestors are provided to protect the following equipment whose insulation levels are indicated in the table I given below. The contractor shall carry out the insulation coordination studies for deciding the location of the surge arrestors.

TABLE – I

S No	EQUIPMENT TO BE PROTECTED	INSULATION LEVEL LIGHTNING IMPULSE (kVp) FOR 220 KV SYSTEM
1	Power Transformer	± 1050
2	Instrument Transformer	± 1050
3	CB/Isolator	± 1050

5.12.6 TESTS

5.12.6.1 Surge Arrestors shall conform to all type tests as per IEC and shall be subjected to routine and acceptance tests in accordance with IEC-60099-4.

5.12.6.2 The resistive current drawn by the arrestor at rated voltage shall be indicated in the routine test report.

5.13 POST INSULATOR

5.13.1 GENERAL

The post insulators shall conform in general to latest IS:2544 and IEC – 60815, 60168.

5.13.2 CONSTRUCTIONAL FEATURES

5.13.2.1 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators shall be accepted. Height of post insulator shall be preferably as given under parameters of this part.

5.13.2.2 The other requirements of insulator as given under auxiliary requirements shall also be applicable.

5.13.3 TESTS

5.13.3.1 In accordance with the stipulations elsewhere the post insulators shall conform to type tests and acceptance, sample and routine tests as per IS:2544, IEC-60168 shall be carried out.

5.13.3.2 In addition to acceptance/sample/routine tests as per IS:2544, IEC-60168, the following tests shall also be carried out.

- Ultrasonic tests on all cutshells as routine check.
- Visual examination and magnaflux test on all flanges prior to fixing.
- Check for uniformity of thickness and weight of zinc coating as a sample test from each lot of flanges prior to fixing.
- Bending load test shall be carried out at 50% minimum failing load in four directions as a routine test.
- Bending load in four directions at 100% minimum bending load guaranteed on samples as per clause-2.3 of IEC. Subsequently this post insulator shall not be used.
- Tests for deflection measurement at 20, 50, 70% of specified minimum failing load on sample.

5.13.3.3 The post insulator shall conform to following type tests as applicable according to voltage class :

- Switching Impulse withstand test (dry & wet)
- Lightning Impulse withstand test (dry)
- Power frequency withstand test (dry & wet)
- Test for deflection under load.
- Test for mechanical strength
- Measurement of RIV

5.13.4 PARAMETERS

220 kV class Bus Post Insulators

- Type Solid core
- Voltage class (kV) 245
- Dry and wet one minute power frequency withstand voltage (kV) 460
- Dry impulse withstand positive and negative(kVp) 1050
- Max. radio interference voltage (Microvolts) for any frequency between 0.5 MHz to 2 MHz at voltage of 156 kV (rms) between phase to ground 1000
- Total min. cantilever strength (Kg) 800
- Min. torsional moment (Kg m) As per IEC
- Total height of insulator (mm) 2300
- Top p.c.d. (mm) 127
Bottom p.c.d. (mm) 254
- No. of bolts : Top 4 : Bottom 8
- Diameter of bolt holes (mm) : Top M16 : Bottom M16
- Pollution level as per IEC-815 Class III, Heavy

5.14 METERING SYSTEM

As per AC SLD, Bidder has to supply and connect 1 no of ABT Meter (for internal NTPC metering network) and 3 Nos of TEM meters (for Commercial metering- Main, Check and Standby meters) with metering panels.

Supply of ABT meter and necessary interface with the existing ABT metering network are in the scope of Bidder. All required hardware shall be provided by the bidder. ABT meter shall be similar to the existing ABT meters of other 220kV bays. AT Gandhar Project, For ABT meter integration purpose, Bidder shall provide the following hardware:

- MOXA convertor- 01 No.
- 16-port Ethernet switch-01 No.
- LAN Cable-200 meters

5.14.1 Energy meter (0.2s accuracy class suitable for ABT-TOD requirement with metering panel as required conforming to STU/PGCIL requirement.

5.14.2 Meter shall be suitable for interfacing for synchronizing the built-in clock of the meter by GPS time synchronization equipment. Bidder shall synchronize the meter using GPS time synchronization equipment.

5.14.3 The ABT meters supplied under this contract shall also meet the requirement of respective RLDC/State power Utilities.

5.14.4 This metering system shall have following features:

- Meters shall be microprocessor-based MWH meters having an accuracy class of 0.2S or better. MVARh meters shall have accuracy class of 0.5 or better.
- These meters shall have provision for downloading of data through an optical port and /or through RS 232/485 port.
- Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meters.

5.14.5 Technical Requirements of Energy Meters for ABT Requirement

Contractor shall supply energy meters along with metering station, 4 Nos. machine Clients, 20 nos web client license. MRI or lap top (as applicable) as per the technical specification given below:

- Shall be microprocessor-based conforming to IEC 62052-11, IEC 62053-22, IS 14697
- Shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4 wire principle suitable for balanced/ unbalanced 3 phase load.
- Shall have an accuracy of energy measurement of at least Class 0.2S for active energy and at least Class 0.5 for reactive energy.
- The active and reactive energy shall be directly computed in CT & VT primary ratings.
- The reactive energy shall be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (Lag) when active import, MVARh (lead) when active export, MVARh (Lead) when active import.
- Two separate registers shall be provided to record MVARh when system voltage is >103% and when system voltage is < 97%.
- Shall compute the net MWh and MVARh during each successive 15-minute block metering interval along with a plus/minus sign, instantaneous MWh, instantaneous MVARh, average frequency of each 15 minutes, net active energy at midnight, , net reactive energy for voltage low and high conditions at each midnight.
- Each energy meter shall have a display unit. It shall display the net MWh and MVARh with a plus/minus sign and average frequency during the previous metering interval; peak MWh demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with a plus/minus sign, date and time; and instantaneous current and voltage on each phases.
- All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable.

All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.

j) At least the following data shall be stored before being over-written for the following parameters.

Parameters	Details	Min No of days
Net MWH	15 min block	40days in meter
Aver Freq	15 min block	40days in meter
Net MVARH for V > 103%	15min block	40days in meter
Net MVARH for V < 97%	15min block	40days in meter
Cumulative Net MWH at every midnight		10 days in meter/40 days in PC

Cumulative Net MVARH for $V > 103\%$ at every midnight		10 days in Meter/40 days in PC
Cumulative Net MVARH for $V < 97\%$ at every midnight		10 days in Meter/40 days in PC
Date and time blocks of VT failure on any phase		

k) Shall have a built in clock and calendar with an accuracy of less than 15 seconds per month drift without assistance of external time synchronizing pulse.

l) Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment being supplied by the contractor.

m) The voltage monitoring of shall be inbuilt feature provided to signal failures to the Substation Automation System, The meter shall be suitable to operate with power drawn from the VT supplies. The burden of the meters shall be less than 2 VA.

n) The power supply to the meter shall be healthy even with a single-phase VT supply. An automatic backup, in the event of non-availability of voltage in all the phases, shall be provided by a built in long life battery and shall not need replacement for at least 10 years with a continuous VT interruption of at least 2 years. Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meter.

Incase data downloading is not possible in absence of VT supply, meter with provision of 220V DC auxiliary power shall be provided. Date and time of VT interruption and restoration shall be automatically stored in a non-volatile memory.

o) Shall have an optical port on the front of the meter for data collection from either a hand held meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software . The contractor shall supply the MRI and/or notebook complete with all optical interface unit required.

p) The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ and test terminal blocks shall be provided for the same.

q) Each meter shall have a unique identification code provided by the Owner and shall be permanently marked on the front of the meter and stored in the non-volatile memory of the meter.

5.14.6 Type Test requirement for Energy Meter

All Type Test Reports shall be provided as per IEC 62052-11, IEC 62053-22, IS 14697.

5.15 FIRE PROTECTION SYSTEM

The Switchyard bay shall be equipped with suitable fire protection & fire fighting systems for protection of entire equipment switchyard & Switchyard control room as per CEA/ CEIG requirements.

The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

The fire fighting system for the proposed installation for fire protection shall be consisting of:

- Sand buckets
- Portable fire extinguishers
- Extension of existing Automatic fire detection cum High Velocity Water (HVW) Spray System.

5.15.1 Portable Fire Extinguishers and Sand Buckets

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

DCP Type (ABC type) (10 Kg. Capacity)- 2 nos

CO2 Type 9 kg capacity- 2 nos

Sand Buckets- 1 set

5.15.2 EXTENSION OF EXISTING AUTOMATIC FIRE DETECTION CUM HIGH VELOCITY WATER (HVW) SPRAY SYSTEM

5.15.2.1 SCOPE OF SUPPLY & SERVICES

5.15.2.1.1 Automatic Fire Detection cum high velocity water (HVW) spray system for the following equipment(s) as per technical specification and required Quantities shall be supplied, erected and commissioned for 33/220 kV Tie Transformer at Switchyard bay.

5.15.2.1.2 The scope of equipment to be furnished and erected under this specification shall cover all the systems and equipments as indicated hereunder.

i) Hydrant System

Bidder shall suitably extend the existing Fire hydrant in switchyard area as per technical specification in required Quantities for HVW spray system and connection of fire hose.

ii) Civil work

Construction of Deluge Valve Housings/Pipe Pedestals and supply of Hume Pipes as per requirement and associated civil work is included in bidder scope.

iii) General

a) Supply and installation of other system and equipment including cables, structural supports, hanger, valves, fastener, packing, gasket and all accessories required to complete erection and commissioning shall be in bidder's scope.

b) Supply & application of protective coatings and wrapping for buried pipes and pipes in RCC trenches, and painting for above ground piping, valves, pipe supports, etc. as per specifications.

c) Any other item and services, needed to make the system complete, safe and sound in operation shall be included under the scope of work by the Bidder at no extra to BHEL.

d) All pylons required for transformers shall be anchored to soak pit base slab using anchor fasteners of adequate capacity. Subsequent to fixing the pylons, lower part of pylon which would be within filled up gravel portion shall be encased with concrete for corrosion protection.

5.15.2.2 GENERAL DESIGN CRITERIA

5.15.2.2.1 The existing main fire protection system consists of a fire water hydrant system and fire water spray system serving the whole station including NTPC's plant/ facilities/ buildings.

5.15.2.2.2 All major equipments/system components of complete fire detection & protection system shall have the approval from one of the following :

a) Underwriters Laboratories of USA

b) LPCB –UK

c) VDS

d) FM-USA

e) BIS (For the approval of pumps and valves).

5.15.2.2.3 Design of fire detection & protection system shall be done as per the guidelines of TAC.

5.15.2.2.4 Any other additional equipment not specifically mentioned in the technical specification for the scope of works identified under this package but are found necessary to meet the requirements of TAC and also for safe and sound operation of the plant shall deemed to be included in the total package cost quoted by the Bidder.

5.15.2.3 Fire Water Source

For fire hydrant protection system, tap-off shall be taken from the existing ring main in the switchyard. Further, for spray protection system tap-off shall be taken from the existing nearby spray line. Necessary taps off shall be taken from the existing fire water hydrant headers and spray headers by the bidder in consultant with Engineer-In-Charge.

Isolation valves (gate valves) shall be provided at the point from where taps for the proposed system shall be taken.

5.15.2.4 HVW SPRAY SYSTEM FOR INTERCONNECTING TRANSFORMERS

5.15.2.4.1 General

a) System shall be pressurized continuously to normal working pressure up to the Deluge valves and spray nozzles.

b) It shall consist of water mains network, Deluge valves, Isolation valves, Y-type strainers, spray nozzles/projectors / spray nozzles piping network, detection system, instrumentation, local control panels, cables etc.

c) The system shall be automatic and shall be activated by a dedicated detection system to be provided for each of the equipment/area.

5.15.2.5 Design Philosophy (Minimum Requirements)

a) Minimum running water pressure at any projector/spray nozzle shall maintained for HVW spray system as per site available pressure without much drop.

b) Design discharge density shall be as per the rules of water spray system of Tariff Advisory Committee (TAC) and/or NFPA standards.

c) An isolation valve shall be provided at both upstream and downstream of each of the deluge valve and alarm valve. The size shall be same as that of the deluge valve and alarm valve.

d) Deluge valves shall be of diaphragm design type. Deluge valve along with trims shall be UL/FM or equivalent approved / listed. The deluge valve (auto resetting type) assembly shall consist of accessories such as pressure gauge (two nos.), water motor gong, alarm test valves, drain valves, strainers for these valves, hydraulic releasing system, etc. Solenoid valve for remote operation shall also be provided.

e) A strainer ('Y' type) shall be provided at upstream of deluge valve.

f) Strainer wire shall be SS (AISI 316), 30 SWG, 30 mesh. Strainer area shall be at least 4 times the pipe cross section at the pipe inlet. Pressure drop across strainer in clean condition shall not exceed 1.5 kg/cm² at design flow of deluge valve.

g) Pressure gauges and pressure switches at upstream and downstream of deluge valves shall be provided.

h) The design features and make of all the projectors/ spray nozzles shall be UL/FM or equivalent approved / listed. Material of construction for projectors / spray nozzles shall be Stainless Steel.

i) Pressure switches shall be provided in spray and detector piping to exhibit "FIRE" and "SPRAY ON" annunciations and interlock for tripping of respective equipment wherever applicable.

j) Wet type detector network shall be provided for spray system using quartzoid bulb detectors.

k) Remote manual operation of the deluge valves shall be possible from the existing fire alarm cum control panel through the available existing operator interface if such fire alarm cum control panel exist at site. To achieve this, necessary hardware modules (for interfacing of pressure switches, limit switches and solenoids of Deluge valves) shall be provided by the contractor. These modules must be compatible to the existing Fire Alarm Panel located at Switchyard. Apart from the automatic operation of the deluge valve, the system shall have provision for manual operation of the deluge valve by means of hand operated lever close to the deluge valve assembly. There shall also be a provision to operate deluge valve electrically from a nearby local panel.

l) Each outdoor deluge valve housing shall be provided with brick wall housing on three sides and RCC roof. The fourth side of the enclosure shall be in a direction away from protected equipment.

m) All pylons required for transformers shall be anchored to soak pit base slab of individual transformer etc. using anchor fasteners of adequate capacity. No separate foundation / pedestal for pylon shall be provided by Employer. Subsequent to fixing the pylons, lower part of pylon which would be within filled up gravel portion shall be encased with concrete by contractor for corrosion protection.

5.15.2.6 PIPING AND VALVES

5.15.2.6.1 GENERAL

a) Inserts / Embedment required for all pipe / valve / equipment supports, clamps, channels, bolts, nuts, etc. to support / mount piping / valves / equipments shall be supplied and erected by the Contractor.

b) Piping for all fire protection systems shall generally be laid over ground

5.15.2.6.2 Material of Construction

a) Mild steel as per IS:1239 (Part-I) medium grade (upto 150 NB) & as per IS:3589 Gr 410 (above 200 NB) or Equivalent for pipes normally filled with water.

b) Mild steel as per IS:1239 (Part-I) medium grade (upto 150 NB) & as per IS:3589 Gr.410 (above 200 NB) or Equivalent and galvanised as per IS:4736 for pipes normally empty and periodically charged with water and foam system application.

c) Pipe thickness:

i) For Pipe sizes upto 150 NB and above: As per IS:1239 Part-I medium grade

ii) Pipes for size 200 NB & above shall conform to IS: 3589 Grade 410 with wall thickness not less than 6.3 mm below 350 NB. For pipe size 350 NB and above, wall thickness shall be 8.0 mm.

d) All valves shall be as per applicable IS/BS codes and shall be provided with locking arrangement (with locks) in open or close condition. Further, all gate/butterfly valves of size 200 mm & above shall be provided with spur gear reduction unit.

e) Unless otherwise specified all elbows / bends shall be long radius type and all the flanges and counter flanges shall conform to ANSI B 16.5 CI 150.

f) For pipe fittings the material shall conform to ASTM A 234 Gr WPB or ASTM A 105 or equivalent and dimensional standard conforming to ANSI B16.11 (socket & threaded type), ANSI B 16.9 (for butt welded fittings) and ANSI B16.5 (for flanges and flanged fittings) as the case may be. Further, Galvanised malleable Cast Iron fittings as per IS 1879 or Cast Iron fittings as per BS-1641 are also acceptable.

g) Grooved coupling : Vendor may also use mechanical grooved couplings type fittings in GI pipe lines for HVW / MVW spray system. All materials and products shall be either Underwriters Laboratories (UL) Listed or Factory Mutual (FM) Approved and installed in accordance with NFPA Standard 13 / equivalent Standard.

h) Fabricated fittings shall not be acceptable up to pipe size of 300 NB. For sizes 350 NB and above, fittings may be fabricated as per BS:2633 / BS:534. Set on set in type fittings shall not be acceptable. The fittings shall be galvanized as per IS:4736 for galvanized pipe application.

i) Welding of Galvanised iron pipes/fittings would be permitted provided the same is carried out by means of electrodes suitable for the above application and the same shall be approved by Employer. After welding, welded portions shall be applied with three coats of Zinc silicate treatment /rich paint over one coat of suitable primer. Further the Contractor shall provide proper zinc paint at the point of welding.

5.15.2.6.3 PAINTING

All the Equipments shall be protected against external corrosion by providing suitable painting. The surfaces of stainless steel, Gunmetal, brass, bronze and non-metallic components shall not be applied with any painting.

All Steel Surfaces (external) exposed to atmosphere (outdoor installation)

i) Surface Preparation : The steel surfaces to be applied with painting shall be thoroughly cleaned before painting by wire brushing, air blowing, etc.

ii) Painting: One (1) Coat of red oxide primer of thickness 30 to 35 microns followed up with three coats synthetic enamel paint, with 25 microns as thickness of each coat.

Painting of all equipments shall be as per manufacturer's standard practice or as detailed below whichever is superior in quality. However after erection, painting shall be done at site as per relevant clause as mentioned above in this section.

Environment	Paint scheme	Total DFT
Normal / Mild Corrosive Environment	Primer- zinc filled epoxy Finish – Aliphatic Polyurethane (shade RAL3000)(P.O Red)	Min 125 microns

5.15.2.7 Quartzoid bulb heat detection system

For equipments protected by HVW spray system. Upon detection of fire by QB detectors, the spray system shall be initiated.

5.15.2.8 SPECIFICATION FOR PRESSURE GAUGE

S No	FEATURES	ESSENTIAL/MINIMUM REQUIREMENTS
1	Sensing Element and material	Bourdon for high pressure, Diaphragm/Bellow for low pr. Of 316 SS
2	Body material	Die-cast aluminium
3	Dial size	150mm
4	End connection	1/2 inch NPT (F)
5	Accuracy	±1% of span
6	Scale	Linear, 270° arc graduated in metric units
7	Range selection	Cover 125% of max. of scale
8	Over range test	Test pr. for the assembly shall be 1.5 to the max. design pr. at 38 deg C.
9	Housing	Weather and dust proof as per IP-55
10	Zero/span adjustment	Provided
11	Accessories	Blow out disc, siphon, snubber, pulsation dampener, chemical seal (if required by process) gauge isolation valve
12	Material of Bourdon/ movement	316 SS / 304 SS

5.15.2.9 PROCESS ACTUATED SWITCHES

FEATURES	ESSENTIAL/MINIMUM REQUIREMENTS
Sensing Element	Piston actuated for high pressure and diaphragm or bellows for low pr./ vacuum
Material	316 SS
End connection	½ inch NPT (F)
Over range proof pressure	150% of max. design pr.
Repeatability	+ 0.5% of full range
No of contacts	2 No.+2NC. SPDT snap action dry contact
Rating of contacts	60 V DC, 6 VA (or more if required by or PLC)*
Elect connection	Plug in socket
Set point/ Dead band adjustment	Provided over full range
Enclosure	Weather and dust proof as per IP-55

Accessories	Syphon, snubber, chemical seal, pulsation dampeners as required by process
Mounting	Suitable for enclosure/ rack mounting or direct mounting

5.15.2.10 SOLENOID VALVES

Solenoid valves shall fulfill the following requirements: -

- Type 2/3/4 way SS 316/ forged brass (depending on the application subject to Employer's approval during detailed engg.)
- Power supply – As available at site or offered by bidder.
- Plug in connector connection.
- Insulation : Class “H”

5.15.2.11 DATA SHEET FOR HYDRANT VALVE

S No	FEATURES	ESSENTIAL/MINIMUM REQUIREMENTS
1	Type	Oblique female type as per IS: 5290
2	Size	63 mm
3	Dimensional specification	Conforming to IS: 5290 Type A
4	Working Pressure (Kg/cm ²)	Max. 7.0 Min. 3.5
5	Construction Features:	
5.1	Bonnet	Screwed / Bolted
5.2	Stem	Rising
6	Material of Construction	
6.1	Body & Bonnet	SS-304 / SS-316 (for corrosive environment)
6.2	Stop valve, valve seat, trim, etc.	SS-304 / SS-316 (for corrosive environment)
7	Operation	Hand wheel.
8	Direction of Hand wheel to open	As indicated by an arrow head on the hand wheel
9	Ends	
	a) Inlet	Flanged (flat faced) drilled as per ANSI B16.5, Cl.150.

5.15.2.12 DATA SHEET FOR BUTTERFLY VALVE

1	Size Range	50 MM & Above
2	Design Code & Rating	Double flanged or lugged wafer type of low leakage rate confirming to AWWA C-504/BS:EN:593/API 609/equivalent
3	Pressure Rating	PN 16
4	End Connection	Flanged as per ANSI B.16.5 Class 150 / BSEN 1092
5	Operating Condition	

5.1	Working Pressure	12 Kg/cm ²
5.2	Working Temperature	ambient (50°C)
5	Service	Water
6	Material of Construction	
6.1	Body & Disc	Cast Iron
6.2	Shaft	SS 410 / SS 420
6.3	Seat Rings	EPDM

Accessories Required

- Position Indicator
- Draining arrangement for Valve Seat
- Locking Facility with lock
- Spur gear reduction unit for valve size 200 NB and above.

Notes:-

- The body shall be permanently marked with an “arrow” inscription indicating the direction of flow of the fluid.
- Manufacturer’s catalogue and dimensional Drg. for the valves shall be furnished by the Contractor.
- Valve shall be approved by BIS.
- Inspection and Testing shall be as per NTPC approved QAP & TAC regulation if any.

5.16 33 kV OUTDOOR EQUIPMENT

5.16.1 ISOLATORS

The isolators and accessories shall conform in general to IEC 62271-102 (or equivalent Indian standard) except to the extent explicitly modified in specification.

Earth switches shall be provided on isolators wherever called for.

Operating mechanism of Isolator and earth switch	Manual/Electrically Operated
Nominal system voltage	33kV
Highest system voltage	36kV
Type	Outdoor
Rated continuous current	Min. 630A at rated ambient temperature current capacity
Rated short time current of isolator and earth switch	12.5 kA for 1 sec
Rated dynamic short time withstand current of isolator and earth switch	31.25kA (peak)
Impulse withstand voltage with 1.2/50 micro sec. wave	170kVp to earth 195 kVp across isolating distance
One minute power frequency withstand Voltage	70 kV (rms) to earth & 80 kV (rms) across isolating distance
Temperature rise	As per Table-IV of IS: 9921
Rated mechanical terminal load	As per 62271-102
Creepage distance (Total)	1260 mm
Line charging breaking capacity	6.3 A
Transformer off-load breaking capacity	6.3 A

Isolator shall be gang operated for main blades and earth switches. The operation of the three poles shall be well synchronised and interlocked.

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

They shall be constructed such that they do not open under influence of short circuit current and wind pressure together. The earth switches wherever provided shall be constructional interlocked so that the earth switches can be operated only when the isolator is open and vice-versa. The insulator of the isolator shall have a min. cantilever strength of 350 kg.

In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in relevant section. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for 'DC' control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

5.16.2 INSTRUMENT TRANSFORMER

a) General Requirement

The instrument transformers i.e. current and voltage transformers shall be single phase transformer units and shall be supplied with a common marshaling box for a set of three single phase units.

The tank as well as top metalics shall be hot dip galvanised or painted Grey color as per RAL 9002. No oil shall come in contact with zinc galvanized surface.

The instrument transformers shall be oil filled hermetically sealed units. The instrument transformers shall be provided with filling and drain plugs.

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

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

b) MARSHALLING BOX

The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box in such a manner so that it is visible and it does not deteriorate with time. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.

c) CURRENT TRANSFORMERS (CTs)

The CTs shall have single primary of either ring type or hair pin type or bar type. In case of "Bar Primary" inverted type CTs, the following requirements shall be met:

The secondaries shall be totally encased in metallic shielding providing a uniform equi-potential surface for even electric field distribution.

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

The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly and top dome.

The insulator shall be one piece without any metallic flange joint. The CT shall be provided with oil sight glass/oil level indicator.

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

Different ratios shall be achieved by secondary taps only, and primary reconnections shall not be accepted.

The guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CT/reactor is used, then all parameters specified shall be met treating auxiliary

CTs/reactors as integral part of CT. The auxiliary CT/reactor shall preferably be in-built construction of the CT. In case it is separate, it shall be mounted in secondary terminal box. The secondary terminals shall be terminated on stud type suitable no's of nondisconnecting and disconnecting terminal blocks inside the terminal box of degree of protection IP:55 at the bottom of CT.

The CTs shall be suitable for horizontal transportation.

The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Contractor shall give his recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn, and treatment of CT.

The CT shall have provision for measurement of capacitance and tan delta as erected at site.

d) PARAMETERS FOR CURRENT TRANSFORMERS

GENERAL PARAMETERS

Highest system Voltage(Um)	36 kV
Rated frequency	50 Hz
System neutral earthing	effective earthed
Installation	Outdoor
Rated short time thermal current	12.5 kA for 1 sec
Rated dynamic current	31.25kA (peak)
Rated min power frequency withstand voltage (rms value)	70kV
Rated lightning impulse withstand voltage (peak value)	170kV
Partial discharge level	10 pico Coulombs max.
Minimum Creepage distance	35 mm/kV of highest system voltage
Temperature rise	As per IEC 60044
Type of insulation	Class A
Number of cores	Tariff CTs shall be single metering core with 0.2S accuracy class.
Number of terminals in marshalling box	All terminals of control circuits wired upto marshalling box plus 20 terminals spare

VOLTAGE TRANSFORMERS (VTs)

Voltage transformers shall be of Outdoor type, Oil filled, bottom and dead Tank type electromagnetic, with sealing arrangement as per IS-316-1992. It is also to be equipped with protective and damping devices Oil level indicator with danger level marking is also to be provided. They shall be of the oil immersed, self-cooled type and provided alternatively with an inert gas cushion or with metallic bellows above the-insulating oil level. A pressure relief device valve type may also be provided if permitted to design.

The VTs may be built up of high-grade non ageing cold rolled grain oriented silicon steel lamination, conforming to IS: 3024, of low hysteresis losses and high permeability to ensure high accuracy at both normal rated and above rated voltages.

The limits of temperatures rise shall not exceed the values specified in Table 3 of IS: 3156 (Part-1) 1998. However, if the voltage transformers has an inert gas cushion above the oil at the top of the tank or housing shall not exceed 50° C. The oil shall be mineral insulating oil conforming to IS: 335-1983.

The HV neutral end terminal shall not be earthed directly to the metal body of the VT but shall be brought out through a porcelain 2 KV class bushing. A tinned copper link of the bolted type shall be provided to connect the HV neutral end terminal and the earth bushing. Both the HV neutral end bushing and the earth bushing shall be housed in a. dust tight, vermin proof box with a front access bolted type gasketed cover.

The secondaries shall be protected by HRC cartridge type fuses for all windings. In addition fuses shall also be provided for protection and metering windings for connection to fuse monitoring scheme. The secondary terminals shall be terminated on stud type non-disconnecting terminal blocks via the fuse inside the terminal box of degree of protection IP55. The access to secondary terminals shall be without the danger of access to high voltage circuit.

The accuracy of metering core shall be maintained through the entire burden range upto 50VA on all three windings without any adjustments during operations.

f) PARAMETERS FOR VOLTAGE TRANSFORMERS

GENERAL PARAMETERS

Highest System Voltage(Um)	36 kV
System neutral earthing	effective earthed
Installation	Outdoor
System Fault level	12.5 kA for 1 sec
Rated min power frequency withstand voltage (rms value)	70kV
Rated lightning impulse withstand voltage (peak value)	170kV
Standard reference range of frequencies for which the accuracy are valid	96% to 102% for protection and 99% to 101% for measurement
Rated voltage factor	1.2 continuous & 1.5 for 30 sec
Class of Accuracy	For tariff metering VT - 0.2 Other VTs – 0.2
Stray capacitance and stray conductance of LV terminal over entire carrier frequency range	As per IEC:358
One Minute Power frequency Withstand voltage for secondary winding	2 kV rms
Temp. rise over an ambient temp. of 50 deg. C	As per IEC 60044
Number of terminals in control spare.	All terminals of control circuits wired Cabinet upto marshalling box plus 10 terminals
Min Creepage distance	35mm/kV of Highest voltage
Rated total thermal burden	150 VA
Partial discharge level	10 pC max.

5.16.3 SURGE ARRESTOR

The surge arrestors (SAs) shall conform in general to IEC 60099-4 or IS: 3070 except to the extent modified in the specification. Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on lattice type support structures. Bidder shall furnish the technical particulars of Surge arrester. The SAs shall be of heavy duty station class and gapless Metal Oxide type without any series or shunt gaps. The SAs shall be capable of discharging over-voltages occurring during switching of unloaded transformers, and long lines.

Arrestors shall be complete with insulating base for mounting on structure. Selfcontained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit with necessary connection. Suitable leakage current meters should also be supplied within the same enclosure. The reading of millimeter and counters shall be visible through an inspection glass panel The surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC-60099-4

Rated System Voltage 36 kV

Rated Arrester Voltage 30 kV

Nominal discharge current 10 kA of 8/20 micro-sec wave

Minimum discharge capability 5 kilo joule/kV(referred to rated arrester voltage corresponding to minimum discharge characteristics)

Maximum continuous operating 24 kV rms

Max. residual voltage (1 kA) 70 kVp

Max. residual voltage at 10 kA nominal discharge current (8/20 micro sec wave) 85 kVp

Max. switching impulse residual Voltage at 500A peak 70 kVp

Max. steep current residual voltage 93 kVp at 10kA

High current short duration test Value (4/10 micro-sec-wave) 100 kAp

Current for pressure relief test 12.5kA rms

One minute power frequency withstand voltage of arrestor housing (dry and wet) 70 kV (rms)

Impulse withstand voltage of arrestor housing with 1.2/50 micro sec. Wave 170 kV (Peak)

Partial discharge at 1.05 MCOV (continuous operating voltage) Not more than 50 p.c

15.16.4 POST INSULATOR

The post insulators shall conform in general to latest IS:2544 and IEC – 60815, 60168.

Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators shall be accepted. Height of post insulator shall be preferably as given under parameters of this part.

Other requirements of insulator as given under auxiliary requirements shall also be applicable.

In accordance with the stipulations elsewhere the post insulators shall conform to type tests and acceptance, sample and routine tests as per IS:2544, IEC-60168 shall be carried out.

Type Solid core

Voltage class 36kV

Rated one minute power frequency withstand Voltage 70 kV (rms)

Rated Lightning Impulse withstand voltage with 1.2/50 micro sec. wave 170kVp

Total min. cantilever strength As per IEC 60273

Min. torsional moment (Nm) As per IEC 60273 Creepage distance (Total) min. 1260 mm

i) Top p.c.d (mm) 76

ii) Bottom p.c.d (mm) 76

No. of bolts : Top : 4

Bottom : 4

Diameter of bolt holes (mm)

Top : M12

Bottom : M12

15.16.5 HT CABLES

15.16.5.1 CODES & 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 the cables shall conform to the requirements of the following standards and codes:

IS:7098 Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV upto & including 33 KV .

IS : 3961 Recommended current ratings for cables

IS : 3975 Low Carbon Galvanized steel wires, formed wires and tape for armouring of cables.

IS : 4905 Methods for random sampling.

IS : 5831 PVC insulation and sheath of electrical cables.

IS : 8130 Conductors for insulated electrical cables and flexible cords.

IS : 10418 Specification for drums for electric cables.

IS : 10810 Methods of tests for cables.

ASTM-D -2843 Standard test method for density of smoke from the burning or decomposition of plastics.

ASTM-D-2863 Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.

IEC-754 (Part-I) Test on gases evolved during combustion of electric cables.

IEEE-383 Standard for type test of Class IE Electric Cables.

IEC -332 Tests on Electric cables under fire conditions. Part-3 : Tests on bunched wires or cables (category -B)

15.16.5.2 TECHNICAL REQUIREMENTS

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

Cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions as specified elsewhere in this specification.

Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be multi stranded.

XLPE insulation shall be suitable for continuous conductor temperature of 90 deg.C and short circuit conductor temperature of 250 deg C. For single-core armoured cables, the armouring may constitute the metallic part of insulation screening.

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. In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.

For single core armoured cables, armouring shall be of aluminum wires. For multi core armoured cables armouring shall be of galvanized steel as follows: -

Calculated nominal dia. of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire /3.15mm dia GS wire
Above 70mm	1.4 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-sq. mm/ mtr. at 20 deg.C. The types and sizes of aluminium armouring shall be same as indicated for galvanised steel. The gap between armour wires / formed wire 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 wires/formed wires.

Distinct extruded PVC inner sheath of black colour as per IS:5831 shall be provided for the cables as follows:

a) For all multicore cables.

b) For single core armoured cables, where armouring is not being used as metallic screen Outer sheath shall be of PVC black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.

(a) Oxygen index of min. 29 (to ASTM D 2863)

(b) Acid gas emission of max. 20% (to IEC-754-I).

(c) Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTM-D-2843.

Cores of the cables of upto 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.

In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath:

- (a) Cable size and voltage grade - To be embossed
- (b) Word 'FRLS' at every 5 metre - To be embossed
- (c) Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated)
- (d) Sequential marking of length of the cable in metres at every one metre. -To be embossed / printed

The embossing / printing shall be progressive, automatic, in line and marking shall be legible and indelible.

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

Allowable tolerances on the overall diameter of the cables shall be +\ -2 mm maximum over the declared value in the technical data sheets.

In plant repairs to the cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.

The eccentricity shall be calculated as

$$\frac{t_{max} - t_{min}}{t_{max}} \times 100$$

t max

and the ovality shall be calculated as

$$\frac{d_{max} - d_{min}}{d_{max}} \times 100$$

d max

Where t-max/t-min is the maximum/minimum thickness of insulation and dmax/ d-min is the maximum / minimum diameter of the core.

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%

Cable selection & sizing

HT cables shall be sized based on the following considerations:

- a) Rated current of the equipment
- b) As per protection time grading requirement subject to min. of 0.5 sec. For final power evacuation feeder connecting to the GCP, the time shall be min. 1.0 sec.

De rating Factors

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

- a) Variation in ambient temperature for cables laid in air
- b) Grouping of cables
- c) Variation in ground temperature and soil resistivity for buried cables.

Cable lengths shall be considered in such a way that straight through cable joints are avoided. Cables shall be armoured type if laid directly buried.

15.16.5.3 CONSTRUCTIONAL FEATURES OF 11 KV AND ABOVE GRADE CABLES

Cables shall conform to IS: 7098 Part - II. These cables shall have mutli-stranded, compacted circular, aluminium conductors, XLPE insulated, metallic screened suitable for carrying the system earth fault current, PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces.

Method of curing for cables shall be “dry curing / gas curing”. The metallic screen of each core shall consist of copper tape with minimum overlap of 20%. However for single core armoured cables, the armouring shall constitute the metallic part of the screening.

15.16.5.4 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. 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 stencilled 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.

The standard length for HT power cables shall be 1000 meter for all single core cables and 750 meters for 3 core cables. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. One drum length of each cable size can be of non standard length (not less than 250 meter) so as to match the ordered quantity. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/-2% and the payment shall be made based on the actual cable length supplied within this limit.

15.16.5.5 TYPE, ROUTINE AND ACCEPTANCE TESTS

All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

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.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and “No design Change”. Minor changes if any shall be highlighted on the endorsement sheet.

All types and sizes of cables being supplied shall be subjected to type tests, routine tests and acceptance tests as specified below and according to relevant standards.

The following type tests shall be carried out at no extra cost to NTPC, if the relevant reports are not available, on one cable of each size and/or design of HT Cables.

Size of the cable shall be decided by the employer during detailed engineering.

Type Test	Remarks
Conductor	
Resistance test	
For Armour Wires / Formed Wires	
Measurement of Dimensions	
Tensile Test	
Elongation test	For GS wires
Torsion test	For GS round wires only
Wrapping test	
Resistance test	
Mass & uniformity of Zinc Coating tests	For GS wires/formed wires only
Adhesion test	For GS wires/formed wires only
For XLPE insulation & PVC Sheath	
Test for thickness	
Tensile strength and elongation test before ageing and after ageing	
Ageing in air oven	
Shrinkage test	
Hot set test	For XLPE insulation only
Water absorption test	For XLPE insulation only
Loss of mass test	For PVC outer sheath only.
Hot deformation test	For PVC outer sheath only.
Heat shock test	For PVC outer sheath only
Thermal stability test	For PVC outer sheath only
Oxygen index test	For PVC outer sheath only
Smoke density test	For PVC outer sheath only
Acid gas generation test	For PVC outer sheath only
Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only
Insulation resistance test- Volume Resistivity method	
High voltage test	
Partial discharge test	
Bending test	
Dielectric power factor test	
a) As a function of voltage	
b) As a function of temperature	
Heating cycle test	
Impulse withstand test	

Indicative list of tests/ checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of H.T. Cables enclosed with this chapter.

15.16.6 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.

5.17 REQUIREMENT OF AUXILIARY ITEMS (FOR BOTH 220 kV & 33 kV)

5.17.1 ALUMINIUM TUBULAR CONDUCTOR

5.17.1.1 The aluminium tube shall be grade 63401 WP(range2) as per IS 5082.

5.17.1.2 There shall be no negative tolerance on OD and thickness of the tube. Other tolerances shall be as per IS:2678 and 2673.

5.17.1.3 Tests: In accordance with stipulations of specification routine tests shall be conducted on tubular conductor as per IS:5082. Also, the wall thickness and ovality shall be measured by ultrasonic method. In addition 0.2% proof tests on both parent material and aluminium tube after welding shall be conducted.

For 220kV

- a) Size 4" IPS (EH type),
- b) Outer diameter 114.20mm with no negative tolerance
- c) Thickness of tube 8.51 mm with no negative tolerance
- d) Cross-sectional area 2825.61 sq. mm.
- e) Weight 7.7 kg/m
- f) Aluminum grade 63401 WP(range 2) conforming to IS:5082

ACSR CONDUCTOR

The conductor shall be Aluminium Core Steel Reinforced (ACSR) type. The conductor shall confirm to IS:398 (Part-II) except where otherwise specified herein

MOOSE CONDUCTOR (For 220 kV Switchyard)

- a) Code and standard IS 398
- b) Name MOOSE ACSR
- c) Overall diameter 31.77 mm
- d) Weight 2.004 kg/m
- e) Ultimate tensile strength 161.2 kN minimum
- f) Strands and wire diameter of
 - Aluminium 54 / 3.53 mm
 - Steel 7 / 3.53 mm

DOG CONDUCTOR (For 33 kV ACSR Connections)

- a) Code and standard IS 398
- b) Name DOG ACSR
- c) Overall diameter 14.15 mm
- d) Weight 0.394 kg/m
- e) Ultimate tensile strength 32.41 kN minimum
- f) Strands and wire diameter of
 - Aluminium 6 / 4.72 mm
 - Steel 7 / 1.57 mm

RABBIT CONDUCTOR (For 33 kV ACSR Connections)

- a) Code and standard IS 398
- b) Name RABBIT ACSR
- c) Overall diameter 10.05 mm
- d) Weight 0.214 kg/m

e) Ultimate tensile strength 18.25 kN minimum

f) Strands and wire diameter of

- Aluminium 6 / 3.35 mm

- Steel 1 / 3.35 mm

5.17.2 CLAMPS AND CONNECTORS

5.17.2.1 The material of clamps and connectors shall be Aluminium alloy casting conforming to designation A6 of IS:617 for connecting to equipment terminals and conductors of aluminium. In case equipment terminals are of copper, the same clamps/connectors shall be used with 2mm thick bimetal.

5.17.2.2 The material of clamps and connectors shall be Galvanised mild steel for connecting to G.S.shield wire.

5.17.2.3 Bolts, nuts and plain washers shall be hot dip galvanised mild steel for sizes M12 and above. For sizes below M12, they shall be electro-galvanised mild steel. The spring washers shall be electro-galvanised mild steel.

5.17.2.4 All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be rounded off to meet specified corona and radio interference requirements.

5.17.2.5 They shall have same current rating as that of the connected equipment. All current carrying parts shall be at least 10 mm thick. The connectors shall be manufactured to have minimum contact resistance.

5.17.2.6 Flexible connectors, braids or laminated strips shall be made up of copper/aluminium.

5.17.2.7 Current rating and size of terminal/conductor for which connector is suitable shall be put on a suitable sticker on each component which should last atleast till erection time.

5.17.3 INSULATORS & INSULATOR STRING HARDWARES

5.17.3.1 Porcelain insulator shall comply IS: 731-1976 or equivalent international standard and shall be homogenous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Hollow porcelain should be in one integral piece in green & fired stage

5.17.3.2 Pin insulators shall be used on all poles in straight line and disc or shackle insulators on angle and dead end poles.

5.17.3.3 Strain insulators shall be used at line sectionalizing locations, dead end locations, major crossings and locations where the angle of deviation of line is more than 10 deg.

5.17.3.4 For 33KV, Ball & Socket type strain insulators with fittings shall be used.

5.17.3.5 The pins for insulators shall be fixed in the holes provided in the cross-arms and the pole top brackets. The insulators shall be mounted in their places over the pins and tightened. In the case of strain or angle supports, where strain fittings are provided for this purpose, one strap of the strain fittings is placed over the crossarm before placing the bolt in the hole of cross-arms. The nut of the straps shall be so tightened that the strap can move freely in horizontal direction.

5.17.3.6 The insulator hardware shall be of bolted type and shall be of forged steel except for insulator cap, which can be of malleable cast iron. It shall also generally meet the requirements of clamps and connectors as specified above.

5.17.3.7 In one span, Tension string assembly at one end shall be supplied with suitable turn buckle.

5.17.4 DISC INSULATOR

The disc insulator shall meet the following parameters:

a. Type : Antifog type insulator

b. Size of insulator : 255x145

c. Electro mechanical strength : 120kN

d. Leakage distance (mm) : 430mm minimum or as required to meet the total creepage.

e. Power frequency withstand voltage: 85 kV (dry), 50kV (wet)

5.17.5 INSULATOR STRING

The insulator string shall meet the following parameters

		220 KV	33KV
	Type	Porcelain type	Porcelain type /composite type
a	Creepage distance	8575 mm	1260 mm
b	PF withstand voltage	460 KV(rms) 1 min (dry and wet)	130 kV & 80 kV rms (dry and wet)
c	L / I withstand voltage	+/- 1050 KV	+/-170KV
d	No. of disc insulator (min.) (Porcelain type)	15 nos	4 nos.
e	Electro mechanical strength	120 KN / string-porcelain 160kN for composite type	
f	Pollution Level (as per IEC 71)	Class-III, Heavy	

5.17.6 EARTHING CONDUCTOR

a) The main conductor buried in earth shall be 40mm dia MS rod for main and auxiliary mat. The earthing conductors over the ground shall be of 75x12 mm GS flat. The earthing leads for columns and auxiliary structures, cable trenches shall be of 75x12 mm GS flat. The earthing of the lighting fixtures shall be carried out by 16 SWG wire.

b) All earthing conductors above the ground level shall be galvanised steel only.

c) Earthing terminal of each surge arrester, capacitor voltage transformer and lightning down conductors shall be directly connected to rod electrode which in turn, shall be connected to station earthing grid.

d) Earthing mat comprising of closely spaced (300mm x 300mm) conductors shall be provided at 300 mm below ground the operating handles of the isolators/earthswitch.

e) Earthing conductor shall be buried 2000mm outside the switchyard fence. Every post of the fence and gates shall be connected to earthing loop.

5.17.7 LIGHTNING PROTECTION

Direct stroke lightning protection (DSLPL) shall be provided in the switchyard by LM/shield wires. Lightning protection System down conductors shall not be connected to other conductors above ground level. Also, no intermediate earthing connection shall be made to Surge arrester, Voltage Transformer, earthing leads for which shall be directly connected to earth electrode.

Every down conductor shall be provided with a test joint at about 1000mm above ground level. The test joint shall be directly connected to the earthing system.

Down conductors shall be cleated on the structures at 2000mm interval.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

Lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

5.17.8 Earthwire for Lightning Protection

a) Number of strands 7 of steel

b) Strand diameter 3.66 mm

c) Overall diameter 10.98 mm

d) Weight 583 kg/km approx.

e) Ultimate tensile strength 68.4 kN minimum

f) Total cross-sectional area 73.65 sq.mm.

g) Calculated d.c. resistance 2.5 ohms/km at 20 deg.C.

h) Direction of lay of outer layer Right hand

i) Protective coating for storage Boiled linseed oil to avoid wet storage stains (white rust)

The earth wire shall be preformed and post formed quality.

5.17.9 Earthwire Compression type tension Clamp & Flexible Copper Bond

5.17.9.1 TENSION CLAMP FOR EARTHWIRE

The details shall be as per IS:2121 part-3. Compression type tension clamp shall be used to hold 7/3.66 mm galvanised steel earthwire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates. The strain plates supplied with the towers will have a minimum thickness of 8 mm with a hole of 17.5 mm diameter. Suitable lugs for jumper connection shall also be supplied alongwith necessary bolts and nuts.

The dimensions and the dimensional tolerance of the tension clamp shall be as given below:

Item	Dimensions before compression		Dimension after Compression	
	Inner Dia.(mm)	outer Dia. (mm)	Corner to Corner width (mm)	Face to face Width (mm)
Steel Dead-end	11.1±0.2	21±0.5	20.2±0.5	17.5±0.5

5.17.9.2 Flexible copper bond: as detailed in IS: 2121 Part 3. The flexible copper bond shall be fitted with 2 nos. Tinned copper connecting lugs which will be pressed jointed to either ends of the bond. One lug shall be suitable for 12 mm dia bolt and other for 16 mm dia bolt. The complete assembly shall also include one 16 mm dia 40 mm lug with MS bolt hot dip galvanised with nut and lock washer.

5.17.10 BUSHINGS, HOLLOW COLUMN INSULATORS, SUPPORT INSULATORS, AND DISC INSULATORS

5.17.10.1 Bushings shall be manufactured and tested in accordance with IS:2099& IEC:60137 while hollow column insulators shall be manufactured and tested in accordance with IEC 62155/IS 5284. The support insulators shall be manufactured and tested as per IS:2544 / IEC 60168/IEC 60273. The insulators shall also conform to IEC 60815 as applicable having alternate long and short sheds.

Support insulators/ bushings/ hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

5.17.10.2 Porcelain used shall be homogenous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

5.17.10.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burns and other similar defects.

5.17.10.4 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanised.

5.17.10.5 Post type insulators shall consist of a porcelain part permanently secured in metal base to be mounted on supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand all shocks to which they may be subjected to during operation of the associated equipment.

5.17.10.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps, the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

5.17.10.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued, porcelain parts by grinding and metal parts by machining. Insulator/ bushing design shall be such as to ensure a uniform compressive pressure on the joints.

5.17.10.8 In accordance with the requirements stipulated elsewhere, bushings, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests and acceptance test/ sample test in accordance with relevant standards.

5.17.11 SPACERS

5.17.11.1 Spacers shall conform to IS: 10162. They shall be of non-magnetic material except nuts and bolts, which shall be of hot dip galvanised mild steel.

5.17.11.2 Spacers shall generally meet the requirements of clamps and connectors as specified above. Its design shall take care of fixing and removing during installation and maintenance.

5.17.11.3 In addition to the type tests as per IS:10162, clamp slip test should have been conducted. In this test the sample shall be installed on test span of twin/quad bundle string at a tension of 44.2 kN (4500 kg). One of the clamps when subjected to a longitudinal pull of 2.5 kN (250 kg) parallel to the axis of conductor shall not slip, i.e. permanent displacement between conductor and clamp after the test shall not exceed 1.0 mm. This test should have been performed on all other clamps of the sample.

5.17.12 CABINETS, BOXES, KIOSKS, PANELS, ETC.

5.17.12.1 All types of control cabinets, junction boxes, marshaling boxes, lighting panels, terminal boxes, operating mechanism boxes, Kiosks etc. shall generally conform to IS:5039, IS:8623 and IEC:439 as applicable.

5.17.12.2 They shall be of Stainless steel or Aluminium. The thickness of Stainless steel sheet shall be 1mm. The thickness of aluminium shall be 3mm and shall provide rigidity. Top of the boxes shall be sloped towards rear of the box. However, the junction and switch boxes shall be of hot dip galvanised sheet steel of 1.6mm thickness. The paint shade shall be grey RAL 9002 outside and glossy white inside.

5.17.12.3 The cabinets/boxes/kiosks/panels shall be free standing or wall mounting or pedestal mounting type. They shall have hinged doors with padlocking arrangement. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets.

5.17.12.4 The degree of protection of all the outdoor boxes shall not be less than IP 55 as per IS 2147.

5.17.12.5 The cable entry shall be from bottom, for which removable gasketed cable gland plates shall be provided.

5.17.12.6 Suitable 240V, single phase, 50Hz ac heaters with thermostats controlled by switch and fuse shall be provided to maintain inside temperature 10deg. above the ambient.

5.17.12.7 The size of enclosure and the layout of equipment inside shall provide generous clearances. Each cabinet/box/kiosk/panel shall be provided with a 15A, 240V ac, 2 pole, 3 pin industrial grade receptacle with switch. For incoming supply, MCB of suitable rating shall be provided. Illumination of each compartment shall be with door operated incandescent lamp. All control switches shall be of rotary switch type.

5.17.12.8 Each cabinet/box/kiosk/panel shall be provided with two earthing pads to receive 75mmx12mm/50mmx6mm GS flat. The connection shall be bolted type with two bolts per pad. The hinged door shall be connected to body using flexible wire. The cabinets/ boxes/ kiosks/ panels shall also be provided with danger plate, and internal wiring diagram pasted on inside of the door. The front label shall be on a 3mm thick plastic plate with white letters engraved on black background.

5.17.13 BAY MARSHALLING BOX

5.17.13.1 Bay Marshaling Box located at a convenient location to receive and distribute cables shall be provided as required. It shall meet all the requirements as specified for cabinets/boxes.

5.17.13.2 It shall have three separate distinct compartments for following purposes:

- To receive two incoming 415V, three phase, AC supplies controlled by 100A four pole MCBs with auto changeover provision, and to distribute five (5) three phase ac supplies controlled by 32A four pole MCBs. It shall also be provided with 63A, 3 phase 4 pin industrial grade receptacle with rotary switch.

- To receive three phase incoming from first compartment and to distribute ten (10) single phase ac supplies controlled by 16A two pole MCBs.
- 200 nos. terminal blocks in vertical formation for interlocking facility.

5.17.14 AUXILIARY SWITCH

The auxiliary switch shall conform of following type tests:

- a) Electrical endurance test - A minimum of 1000 operations for 2A. D.C. with a time constant greater than or equal to 20 milliseconds with a subsequent examination of mV drop/ visual defects/ temperature rise test.
- b) Mechanical endurance test - A minimum of 5000 operations with a subsequent checking of contact pressure test/ visual examination
- c) Heat run test on contacts
- d) IR/HV test, etc.

5.17.15 TERMINAL BLOCKS

5.17.15.1 They shall be non-disconnecting stud type of extensible design equivalent to Elmex type CAT-M4.

5.17.15.2 The terminal blocks shall be of min. 650 V grade, and rated to continuously carry maximum expected current. The conducting part shall be tinned or silver plated.

5.17.15.3 They shall be of moulded, non-inflammable thermosetting plastic. The material shall not deteriorate with varied conditions of temperature and humidity. The terminal blocks shall be fully enclosed with removable covers of transparent, nondeteriorating plastic material. Insulating barriers shall be provided between the terminal blocks so that the barriers do not hinder the wiring operation without removing the barriers.

5.17.15.4 The terminals shall be provided with marking tags for wiring identification.

5.17.15.5 Unless otherwise required (expected current rating) or specified, terminal blocks shall be suitable for connecting the following conductors on each side:

All CT & VT circuits - Min. four 2.5 sq.mm. copper flexible conductor

AC & DC power supply -Two 16 sq.mm. aluminium conductor Circuits

Other control circuits - Min. two 2.5 sq.mm. copper flexible conductor

5.17.15.6 The terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall also be provided with short circuiting and earthing facilities.

5.17.16 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).

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
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire /3.15mm dia GS wire
Above 70mm	1.4 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 mm² 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 ASTM-D-2843).