

CHAPTER 14: TECHNICAL SPECIFICATION OF CONTROL AND RELAY PANEL

14.1 TECHNICAL SPECIFICATIONS FOR CONTROL & RELAY PANELS:

- a) This Section is intended to cover the design, manufacture, assembly, testing at manufacturer's works and erection, testing & commissioning of Indoor Relay and Control Panels.
- b) The Control and Relay Panels required are for control and protection of the Power Transformers and Feeders according to requirements. The supply shall include all accessories, special tools, supporting steels, spare parts, drawings, relevant software, instruction manuals etc. The panels shall be supplied complete with all accessories as specified and completely assembled and all internal wiring completed.
- c) The sub-stations shall have automation as per IEC 61850 protocol in Bay & Station level. The bidder has to supply the C&R panels to match the requirement of Sub-station Automation System (SAS) as specified in the subsequent chapter, **from the same manufacturer.**
- d) **The manufacturer/supplier of Control and Relay Panels shall necessarily be an OEM (Original Equipment Manufacturer) of Numerical Protective Relays, Bay Control Units and Sub Station Automation System (SAS), having registered servicing unit in India.**
- e) Design and fabrication of Control & Protection Panels for mounting the relay and relay assemblies along with all necessary accessories like switches, indicating lamps etc. and wiring up of the same to provide self contained and ready to use protection as per this specification.
- f) Complete testing at manufacturer's works of the relays and protection schemes **including SAS** after mounting and fully wiring up in the Control & Protection Panels.

14.2 STANDARDS:

All equipment and all component parts supplied under this specification shall conform in all respects to the latest issue of relevant IEC and Indian Standard Specifications except where specified otherwise in this specification. Equipment meeting any other authoritative standards which ensure an equal or better quality may also be acceptable.

14.3 SERVICE CONDITIONS:

The plant and materials supplied shall be suitable for operation under the following climatic and other conditions as mentioned in chapter 2 of this Bid document:

14.4 TYPE TEST REPORTS.

14.4.1 Equipment, which have never been tested for critical performance, shall not be accepted. In such cases, a promise or agreement by a bidder to have the equipment tested after award of a contract is not acceptable.

14.4.2 All Bids must be accompanied by the full Type Test Certificates of equipment offered. Such type test certificates shall be acceptable only if:

- i) Tests are conducted in KEMA/NABL accredited laboratory, *for GOOSE messaging etc as per relevant IEC 61850 Standards.*
- ii) Inter-operability Tests are conducted in manufacturer's own laboratory. In this case (i) the laboratory must have ISO 9000 (or its equivalent) series certification; and (ii) tests

have been witnessed by technically qualified representatives of earlier Indian clients of Central/State Transmission Utilities.

- iii) The Validity of the Type Test Reports of CRP, Relays, BCUs and Energy Meters shall be as per CEA's "Guidelines for the Validity Period of Type Tests Conducted on Major Electrical Equipment in Power Transmission System", File No CEA-PS-14-80/1/2019-PSETD Division-Part (2).

14.5 TYPE OF PANEL

- 14.5.1 All simplex panels shall be swing type with front glass door with locking arrangement. The **Minimum number** of Panels shall be as per Table 1 below:

Table -1

	400kV	220kV	132kV	33kV
Feeder Panel	4 Nos if SWLR	2 Nos	2 Nos	1 No
Bus Coupler/Tie Breaker/Sectionalizer Panel	2 No	1 No	1 No	1 No
Reactor Panel	2 No			
Bus Bar Protection panel	4 Nos	2 Nos		
Transformer Panel	400/220/33kV AT	220/132kV AT	132/33kV PT	
	3Nos (Minimum)	2Nos (Minimum)	2 Nos (Minimum)	

14.5.2 Swing type Simplex Control and Relay Panels shall consist of vertical swing front panels with equipment mounted thereon and having front glass door. As there will be no rear door, manufacturer shall have to keep suitable swing angle, for maintenance & testing of equipment, circuitry inspection etc. Panel front shall have lockable glass door.

14.5.3 These panels shall be of the **Simplex type** with the following approximate dimensions:

- Height: 2250mm + 15mm anti-vibration pad + 50 mm (base)
- Depth: 800mm to 1000 mm
- Width: 800 mm to 1000 mm
- Operating Height: 1800 mm

14.5.4 For 33kV feeder, panel shall be of simplex type and it should accommodate one 33kV feeder in a single cubicle and one BCU will control single 33kV feeder.

14.6 CONSTRUCTIONAL FEATURES:

- The panels shall be completely metal enclosed to ensure a dust, moisture and vermin proof atmosphere. The enclosure shall provide a degree of protection not less than IP 54 in accordance with IS-2147/IEC-60529.
- Panels shall be rigid free standing and floor mounting type and comprise of structural frames enclosed completely with specially selected texture finished, cold rolled sheet steel of thickness not less than 3.15 mm for weight bearing members of the panels such as base frame, front sheet and door frames and not less than 2.0 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation.

- c) All joints shall be made flush and all edges shall be bent at right angles and rounded. All structural members shall be bolted or welded together. Necessary arrangement shall be provided for bolting together the adjacent panels as well as for fastening them to the floor. The opening required for mounting the equipment shall be punched or cut and filed smooth.
- d) All doors, removable covers and panels shall be sealed all around with synthetic rubber gaskets Neoprene/EPDM generally conforming to provision of IS 11149. However, XLPE gaskets can also be used for fixing protective toughened glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.
- e) Panels shall have additional rolled channel plinth at the bottom with smooth bearing surface. The panels shall be fixed on the embedded foundation channels with intervening layers of anti-vibration strips made of shock absorbing materials which shall be supplied by the contractor.

14.7 MOUNTING OF EQUIPMENTS:

- a) All equipment on and in the panels shall be mounted and completely wired to the terminal blocks ready for external connection. All equipment on the front panels shall be mounted flush. Terminal markings shall be clearly visible.
- b) Bay level intelligent electronic devices (IED) BPU for protection and control (BCU) and the Managed Ethernet Switch shall be housed in the C&R panels installed in the local control room.

14.8 INTERNAL WIRING:

- a) Panels shall be supplied completely with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and wiring shall be carried out internally. These adjacent inter panel wiring shall be clearly indicated in the drawing furnished by the supplier.
- b) Bay level intelligent electronic devices (IED) for protection, control (BCU) and the Managed Ethernet Switch shall be housed in the C&R panels installed in the local control room.
 - i) All Circuits except instrument transformers **and incoming AC/DC Supply** circuits: 1.5 sq. mm. per lead.
 - ii) Instrument transformers circuit: 2.5 sq. mm. per lead.
- c) Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panel running throughout the entire length of the panels.
- d) Wire terminals shall be made with solder less clamping type of tinned copper lugs, which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected from blocks.
- e) Interconnections to adjacent panels shall be brought out to a separate set of terminals blocks located near the slots or holes meant for taking the interconnecting wires. Arrangement shall permit easy interconnection to adjacent panels at site and wires for

this purpose shall be provided by the supplier looped and bunched properly inside the panel.

- f) A laminated copy of total schematics is to be fixed on the inside of door.

14.9 TERMINAL BLOCKS:

- a) All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. Terminal blocks shall be of 1100 volts grade and have 10 amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Terminal block designs include a white fibre-marking strip with clear plastic/silicon chip on terminal covers. Marking on the terminal strips shall correspond to block and terminal number on the wiring diagram.
- b) Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. Current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.
- c) At least 20% spare terminals shall be provided on each panel and these terminals shall be uniformly distributed on all terminal blocks.
- d) There shall be a minimum clearance of 250 mm between first row of terminal blocks and associated cable gland plates. Also, the clearance between two rows of terminal blocks shall be a minimum of 150 mm. A steel strip shall be connected between adjacent terminal block rows at 450-mm intervals for support of incoming cables.

14.10 PAINTING:

- a) All Sheet steelwork shall be phosphated in accordance with IS 6005.
- b) Oil grease, dirt and warp shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- c) After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of 2 (two) coats of ready mixed, stoving type zinc chromate primer. The first coat may be 'flash dried' while the second shall be stoved.
- d) After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. Exterior Paint shall be texture finishing with RAL 7032 paint shade.
- e) Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting.
- f) The inside of the panels shall be glossy white.
- g) A small quantity of finishing shall be supplied minor touching up required at site after installation.

14.11 NAME PLATES AND MARKINGS:

- a) All equipment mounted on front and rear side as well as equipment mounted inside the panel shall be provided with individual nameplates with equipment designation engraved. Also, on the top of each panel on front as well as rear side large and bold name plates shall be provided for circuit /feeder designation.

- b) All front mounted equipment shall be also provided at the rear with individual name plates engraved with Tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.
- c) Nameplates shall be made of non-rusting metal or 3 ply lamicord. Nameplates shall be black with white engraved lettering.

14.12 MISCELLANEOUS ACCESSORIES:

- a) A 240 Volts, single-phase plug points shall be provided in the interior of each cubicle with ON-OFF switch for connection of headlamp.
- b) Each panel shall be provided with a LED lighting fixtures for the interior illumination of the panel complete with all fittings, i.e. lamp, switch (controlled by panel door)
- c) Each control panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of D.C. and A.C. supplies of various control, AC & DC supervision, signalling, lighting and space heater circuits. MCBs of requisite capacity with fail indicators shall be used, HRC fuse is not acceptable. The main input A.C. and D.C. circuits will be protected with miniature circuit breakers.
- d) Pistol Grip Trip Switch shall be provided.

14.13 EARTHING:

- a) All panels shall be equipped with an earth bus securely fixed along with inside base of the panels. The materials and the sizes of the bus bar shall be at least **25X6 mm copper**. When several panels are mounted joining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply. Provisions shall be made for extending the earth bus bar to future adjoining panels on either side.
- b) All metallic cases of equipment shall be connected to the earth bus by independent copper wires of size not less than 2.5 sq. mm. Earthing wire shall be connected on terminals with suitable clamp connectors and soldering shall not be permitted.
- c) PT and CT secondary neutrals or common lead shall be earthed at one place only at the terminal blocks, where they enter the panels.

14.14 RECORDING METERS (ABT TRIVECTOR METERS):

14.14.1 General

- a) All meters shall be housed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be accurately adjusted and calibrated at works and shall have means of calibration, check and adjustment at site.
- b) All these instruments and meters shall be flush mounted type and back connected, suitable for front panel mounting.
- c) The ABT meters shall be SAMAST compatible as per specification given in subsequent chapter.
- d) The meters should be compatible to IEC62052-11 and IEC62053-22, IEC62053-24, IS14697, IS15959.
- e) The manufacturer shall provide Performance Certificate from CTU/STU of successful operation of minimum 3 years as on BID Opening.

14.15 RELAYS:

14.15.1 General

- a) All relays shall conform to the requirements of IS 3231/ IEC 60255/ IEC 61000 or other relevant standards. The relay firmware/software shall be of the latest version.
- b) All protective relays shall be numerical type and communication protocol shall be IEC 61850. Further, test levels of EMI as indicated IEC 61850 shall be applicable to these relays.
- c) Two sets of relevant software (latest version) for relay configuration & setting, maintenance etc to be supplied to each station. The numeric relay and software shall be upgradable.
- d) The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay's coils and contacts, including spare contacts.
- e) Relays shall be suitable for flush or semi-flush mounting with connectors from rear.
- f) All draw out cases or plug in type modular cases will have proper testing facilities. The testing facilities provided on the relays shall be specifically stated in the bid. All protective relays shall be with proper online testing facilities without isolation from TB where inputs viz CT/ PT and DC are wired. All main relays shall be provided with test plug to test the relay online & required test handle may be invariably indicated. Necessary test plug shall be in the supplier's scope of supply and shall be supplied loose. Unless otherwise specified all auxiliary relays and timers shall be supplied either in non-draw out cases or plug in type modular cases.
- g) All A.C. relays shall be suitable for operation at 50 Hz. A.C. Voltage operated relays shall be suitable for 110 volts VT secondary and current operated relays for 1Amp. CT secondary. DC auxiliary relays and timers shall be designed for 110 volts/ 220 volts DC and shall operate satisfactorily between 70% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- h) All Protective relays, auxiliary relays and timers except the lockout relays and interlocking relays shall be provided with self-reset type contacts. All protective relays, trip relays and timers shall be provided with externally/ electrically reset positive action operation indicators provided with proper inscription. All protective relays which do not have built-in hand reset operation indicators shall have additional auxiliary relays with operating indicators for this purpose. Similar separate operating indicators (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholz relays, temperature protection etc.
- i) No control relays that shall trip the circuit breaker when the relays are de-energized shall be employed in the circuits.
- j) All relays shall withstand a test voltage of 2.5 kV, 50 Hz rms. voltage for one second. In case of static relays, the Clause 14.28.1.I shall be applicable.
- k) Auxiliary seal-in unit provided in the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

- (i) The operating time of the series seal-in unit shall be sufficiently shorter than that of the trip coil relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
 - (ii) Seal - in unit shall obtain adequate current for operation when one or more relays operate simultaneously.
 - (iii) Impedance of the seal-in unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when D.C. supply is minimum.
 - (iv) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.
 - (v) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).
 - (vi) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.
 - (vii) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).
- I) Whenever solid state auxiliary relays are used the following requirements shall be met with:
- i) The printed circuit cards shall be of fibre glass type and the contact shall be gold plated. All connectors with the connector pegs shall be through wire wrapping. All solder Joints on the printed circuit boards shall be encapsulated or covered with varnish.
 - ii) The components shall be loaded by less than half of their rated values. The resistor shall be of carbon composition or metal oxide type and the capacitors shall be plastic film or tantalum type. Stringent measures including shielding of long internal wiring should be taken to make relays immune to voltage spikes. Relays must withstand 5kW, 1x150 microsecond, 0.5 Joule source energy impulse test or 1.5 MHz damp oscillations with initial value of 2.5 kV decaying to half the initial value in 6 microseconds with internal source impedance of 150 ohms.
 - iii) The supplier shall ensure that the terminals of the contacts of the relays are readily brought out for connectors as required in the final approved scheme.

- iv) DC /DC converter shall be provided in the solid state protective relays wherever necessary in order to provide a stable auxiliary supply for relay operation. Provision of DC cell in the protective relays as relievable stand-by power supplies will however not be acceptable.
- m) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- n) All Spare pair of contacts of all IEDs and Alarm Relays shall be wired to Terminal Blocks exclusively for Employer's use.
- o) All relays and their drawings shall have phase indications as R-Red, Y-Yellow, B-Blue.
- p) The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

14.15.2 General Specification of Numerical Relays

- a) Numerical Relays shall be provided for the following applications:
 - i) Distance Protection (Main I & Main II) of different make and model for 400KV and 220 kV lines.
 - ii) Distance protection for 132 kV lines.
 - iii) Back up directional over current and earth fault relays for 132 kV Lines.
 - iv) Back up non directional over current (3 O/C) and earth fault relays for 33kV lines
 - v) Bus Bar Protection.
 - vi) Integrated Numerical Transformer Differential Protection as Main –I & Main-II of different make **and model** with non-directional overcurrent and earth fault function with high set units for power and autotransformers/ reactors.
 - vii) Reactor Protection.

viii) *Line Differential Protection*

- (viii) 3 winding transformer protection relay for Main-1 & Main-2 shall be provided for all the transformers under the scope of this bid

- b) All Numerical Relays should have following minimum features.
 - i) Relays shall be communicable on IEC61850 protocol without any protocol converter. Certificate from KEMA confirming interoperability, Goose messaging & publishing as per IEC61850 standard shall be submitted along with the tender. The relay shall have suitable communication facility for future connectivity to SCADA.
 - ii) Relays shall have one no. front RJ45 or USB port (for RS 232 port Converter to USB shall be supplied for each substation along with spare) for Local Relay Parameterization and Two nos. rear FO port for connectivity to SAS over IEC61850 protocol.
 - iii) The relay shall have self-communication port monitoring feature and failure shall generate alarm.

- iv) The relay shall have sufficient battery back up to keep the internal clock running for at least 2 years in absence of auxiliary supply. The capacitor discharging power is not sufficient and won't be accepted. Proper battery back must be provided.
 - v) Should have minimum 12 configurable LEDs for 132kV and above voltage class.
 - vi) Should have minimum **24 Binary Inputs and 32 Binary Outputs**. Moreover, the relays shall have minimum 30% BI & BO as spare after fulfilment of scheme requirement.
 - vi) All BI/BOs shall be site configurable
 - vii) Shall have front minimum 3 lines LCD display with Alpha numeric keypad.
 - viii) Numerical relays are to be provided with built in Event / Disturbance / Fault Recorder features.
 - ix) The bidder shall bring out in the bid that the Numerical relays providing different protection features / application in a single unit if any one of the application/ features goes out of service the other feature/application (s) will remain un-effected.
 - x) The relays shall be site configurable (Including logic development)
 - xi) Configured features & set values shall be in non-volatile memory
 - xii) Must have real time clock for time stamping of events/ disturbances with time synchronization inputs (GPRS etc.). Time synchronisation through SNTP compatible.
 - xiii) The major component cards shall be hot swappable and front or rear loading.
 - xiv) The relays should have self-diagnostic features identifying area of fault or failure of a particular component or card.
 - xv) Shall have in built Circuit Breaker Failure protection based on undercurrent detection and/or circuit breaker auxiliary contact status. Provision shall be given to initiate the breaker fail logic using a digital input from external protection devices.
 - xvi) Relay shall have inbuilt PRP ports.
 - xvii) Relays shall have redundant communication channels for Protection Communication.
- c) Hardware based measurement shall not be acceptable.
- d) The relay should have high immunity to electrical and electromagnetic interference.
- e) The same relay shall be provided with both 1A CT inputs and shall be site selectable.
- f) It shall be possible to energise the relay from either AC or DC auxiliary supply. Auxiliary dc supply shall be suitable for both 110 and 220 Volt and shall be site selectable.
- g) Be capable of performing basic instrumentation functions and displaying various instantaneous parameters like Voltage, current, active power, reactive power, phase sequence etc. in primary values. Additionally, all sequence current and voltage values shall be displayed on-line. Also the direction of power flow shall be displayed.

- h) Extensive disturbance recording facility shall be available for at least up to 10 seconds to capture maximum possible information. Necessary software shall be provided for retrieving and analysing the records.
- i) Facility for developing customised logic schemes inside the relay based on Boolean logic gates and timers should be available. Facility for renaming the menu texts as required by operating staff at site should be provided.
- j) Must have additional feature of local breaker back up protection
 - i) The relay shall have built in Circuit Breaker Supervision Functions.
 - ii) The relay shall be able to detect any discrepancy found between NO & NC contacts of breaker.
 - iii) The relay shall monitor number of breaker trip operations.
 - iv) The relay shall also monitor the breaker operating time.
- k) The relays shall have the following tools for fault diagnostics:
 - i) Fault record (shall be function of IED): – The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.
 - ii) Event record (shall be function of IED): – The relay shall have the facility to store time stamped event records with 1ms resolution.
 - iii) Disturbance records (shall be function of IED): – The relay shall have capacity to store disturbance records of at least 10 sec. duration and sampling rate per cycle shall be more than 15.
- l) It shall be possible to preserve stored information in the event of an auxiliary supply failure with the help of a battery backup.
- m) The relay settings shall be provided with password protection.
- n) It shall be possible to change the relay setting from the front panel using the key pads/ Work station of SAS and Laptop.
- o) The relay shall have comprehensive self-diagnostic feature. This feature shall continuously monitor the healthiness of all the hardware and software elements of the relay. Any failure detected shall be annunciated through an output watchdog contact. The fault diagnosis information shall be displayed on the LCD. These records shall also be retrieved from local as well as remote terminal through the communication port.
- p) The Numerical Relays shall be provided with 2 sets of common support software (latest version) compatible with latest version of Windows OS which will allow easy settings of relays in addition to uploading of event, fault, disturbance records, and measurements to Station HMI/ DR Work Station. The relay settings shall also be changed from local or remote using the same software.
- q) In case of line protection and transformer/reactor protection, the features like fault recorder, disturbance recorder and event logging function as available (including if available as optional feature) in these relays shall be supplied and activated **at no extra cost to the owner**.

- r) The manufacturer shall have to provide up-graded support software if any within 10 years span.

14.16 Transmission Line Protection :

14.16.1 Line Differential Protection Relay (If Applicable)

Main I and Main II Line Differential Protection shall be of **different make and model**.

The relay shall have all the features as per Distance protection relay over and above following features

1. It shall be working on phase segregated Current Differential protection principle.
2. It shall have multiple slope characteristic (preferably) to have stability against CT saturation and heavy through faults as well as sensitivity for internal faults.
3. It shall measure Differential as well as restrain current continuously and shall display the same as measurement.
5. It shall communicate to remote end through IEEE C37.94 format.
6. It shall have redundant communication channels for protection communication.
7. It shall communicate analogue as well as digital signals to remote end.
8. It shall have various communication options for remote communication i.e. mono-mode / multi-mode for direct communication / communication through multiplexer.
9. It shall have Line charging current compensation feature for better sensitivity.
10. Distance protection function can be utilized as independent or as back up of Differential protection in case of failure of remote communication. . It shall have a full scheme distance protection scheme to provide independent protection in parallel with the differential scheme in case of a communication channel failure for the differential scheme. The distance protection then provide protection for the entire line including the remote end back up capability either in case of a communications failure or via use of an independent communication channel to provide a fully redundant scheme of protection (that is a second main protection scheme). Eight channels for intertrip and other binary signals are available in the communication between the IEDs. The auto-reclose for single-, two- and/or three phase reclosing includes priority circuits for multi-breaker arrangements. It co-operates with the synchronism check.

11. It shall communicate time coordinated current signals for remote communication to execute Line differential protection algorithm accurately. Time synchronization through GPS shall also be possible.
12. It shall monitor individual communication links continuously and switchover to standby link after preset time in case of failure of one link.
13. It shall supervise individual telegrams.
14. It shall detect reflected telegrams.
15. It shall detect change in communication It shall measure delay time for remote end along with dynamic compensation of the same in differential protection algorithm.
17. It shall also supervise maximum permissible delay time.
18. It shall generate alarm for heavily disturbed communication link. Technical Parameters
 - A. Line Differential Protection setting:
 1. Minimum operating current - 20 to 200% of I_n
 2. Slope (Single/dual) - 10 to 100%
 3. End section (Single/dual) - 20 to 1000% of I_n
 4. Highset operating current - 100 to 5000% of I_n
 5. 2nd Harmonic blocking - 5 to 100 %
 6. Typical operating time - 25 ms
 7. Operating time for high set - 15 to 20 ms
 8. Charging current comp. – Selectable
 - B. Remote communication:
 9. Analogue signal transfer – Minimum 3 Nos.
 10. Binary signal transfer - Minimum 8 Nos
 11. Remote Communication module
 - Dual modules suitable for
 - a) 1300 nm - multi-mode
 - OR
 - b) 1300 / 1550 nm – mono-mode
 - (finalized during detailed engineering)
 12. Synchronization mode - GPS / Echo (finalized during detailed engineering)

13. Time delay alarm - 5 to 500 ms, step 5 ms (for communication fail)
14. Time delay - 5 to 500 ms, step 5 ms (for switching to redundant channel)
15. Asymmetric delay - - 20 to +20 ms, step 1 ms (When echo mode is used)
16. Max. Transmission delay – 0 to 40 ms, step 1 ms

14.16.2 Distance Protection Relay

- i) The distance protection relay shall be fully numerical using microprocessors and be based on a non-switched scheme.
- ii) The distance protection relay shall have at least three completely independent non switched forward directional zones, one extended zone and a reverse directional zone protection.
- iii) Have non-switched measurement, which implies processing of six possible fault loops (six –loop measurement).
- iv) The protection algorithm shall utilize fault voltages and currents, as well as the superimposed voltages and currents to arrive at a secure trip decision in the shortest possible time with reliability, selectivity and full sensitivity to all types of faults online.
- v) Have polygonal characteristics with independently adjustable reactive and resistive reaches for maximum selectivity and maximum fault resistance coverage. The zones shall have independent settable earth fault compensation factors to cater to adjacent lines with different zero sequence to positive sequence ratios.
- vi) Selection shall be so that the first zone of the relay can be set to about 80% - 85% of the protected line without any risk of non-selective tripping.
- ix) The second and third zone elements shall provide backup protection in the event of the carrier protection or the first zone element failing to clear the fault, zone-2 shall cover full protected section plus 50 % of the next section, zone-3 shall normally cover the two adjacent sections completely. The zones must have independent time settings.
- x) Shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)
- xi) All the zones shall have setting such that they can detect the fault online from minimum 0.3 km to 500 km.
- xii) The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current. The starting and measuring relays characteristics should be satisfactory under these extreme varying conditions.
- xiii) The relay shall use the memory voltage for proper directional discrimination at close in 3 phase fault which shall be based on positive sequence voltages. The directional discrimination and phase selection based on negative sequence measurement techniques is not acceptable.
- xiv) Have adequate number of forward zones (minimum three) and a reverse zone. The zone reach setting ranges shall be sufficient to cover line lengths appropriate to each zone. Carrier aided scheme options such as permissive under reach, overreach, & blocking and non-carrier aided schemes of zone 1 extension and Loss of load accelerated tripping schemes shall be available as standard. Weak in feed logic and current reversal guard also shall be provided.
- xv) In case the carrier channel fails, one out of the non-carrier-based schemes cited above should come into operation automatically to ensure high speed and simultaneous opening of breakers at both ends of the line.
- xvi) Shall have suitable number of potential free contacts for Carrier Aided Tripping, Auto Reclosing, CB Failure, Disturbance/Fault recorder and Data Acquisition System.

- xvii) Have a maximum operating time up to trip impulse to circuit breaker (complete protection time including applicable carrier and trip relay time) for SIR 0.01-4: as 40ms at the nearest end and 60ms at the other end of line & for SIR 4-15: as 45ms at the nearest end and 65ms at the other end of line with carrier transmission time taken as 20ms. Isochronic curves shall be provided in support of operating times.
- xviii) Shall have an independent Directional Earth Fault (DEF) protection element to detect highly resistive faults as a built in feature. This element shall have an inverse time/definite time characteristic.
- xix) Has logic to detect loss of single /two-phase voltage input as well as three-phase voltage loss during energisation and normal load conditions. The voltage circuit monitoring logic in addition to blocking the distance protection element, enable an emergency over current element to provide a standby protection to the feeder until the re-appearance of voltage signal.
- xx) The VT fuse failure function shall function properly irrespective of the loading on the line. In other words, the function shall not be inhibited during operation of line under very low load conditions.
- xxi) Have necessary logic to take care of switch-on-to-fault condition. Energisation of transformers at remote line ends and the accompanying inrush current shall not cause any instability to the operation of relay.
- xxii) Have power swing blocking and Out of Step protection feature, with facilities for fast detection of power swing selective blocking of zones settable unblocking criteria for earth faults, phase faults and three phase faults. It shall be on the principle of measurement of the rate of impedance vector change and monitoring of the vector path. It should have the Earth fault detection feature, which shall override power swing blocking and allow the relay to operate for trip as per zone detection. The relay shall be blocked for the set time for the first PS sensed and remain unblocked for the set time for the successive PS.
- xxiii) Be suitable for single pole or three pole tripping. However, relays offered for 132 kV lines provided with mechanically ganged circuit breakers, single pole tripping need not to be provided.
- xxiv) Be suitable for both bus PT or Line PT/ CVT supply.
- xxv) Shall have in built Trip circuit supervision facility to monitor both pre- and post close supervision facilities. An alarm shall be generated.
- xxvi) Shall have in built broken conductor detection by way of level detector or negative sequence measurement.
- xxvii) Shall have df/dt functions.
- xxviii) Shall have multistage under frequency setting options.
- xxix) The sensitivity of the logic shall not be affected during operation under low load.
- xxx) Shall have a fault locator with an accuracy of $\pm 3\%$. The display should be in kilometres and preferably in percentage impedance too. The fault locator should have built in mutual compensation for parallel circuit.
- xxxi) Have mutual zero sequence compensation factor setting. The relay shall have facility to select different group settings to cater for mutual coupling on account of multi circuit line conditions. The minimum no. of group should be four.
- xxxii** Have at least 24 no of programmable BI and 32 no of programmable BO contact to cater for DR/SER carrier aided tripping auto re-closing etc.
- xxxii) The distance relays shall have a built-in auto-reclose function with facilities for single pole / three pole / single and three pole tripping. It shall be possible to trigger the A/R function from an external protection. A voltage check function which can be programmed for deadline charging/dead bus charging / check synchronising shall be included. However, the relay shall support independent A/R scheme.
- xxxiii) Shall have additional features to provide under/ over voltage protection.
- xxxiv) Shall have additional features to provide under frequency protection

- xxxv) Shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault.
- xxxvi) The protective relays shall be suitable for use with capacitor voltage transformers having non electronic damping and transient response as per IEC.
- xxxvii) Shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall be also capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.
- xxxviii) Must have a current reversal guard feature.
- xxxix) Shall have Stub Protection function with current setting minimum range of 1 to 3 pu with definite time delay setting, minimum range of 0 to 100 msec
- xl) Have feature of load encroachment blinder to safeguard the protection trip during heavy line loading condition.

14.16.3 Integrated Numerical Transformer Protection Relay

a) GENERAL REQUIREMENTS:

- i) Shall be stable during magnetising inrush and over fluxing conditions. Stabilization under inrush conditions shall be based on the presence of second harmonic components in the differential currents.
- ii) Shall have saturation discriminator as an additional safeguard for stability under through fault conditions.
- iii) Shall have zero sequence current filtering, which may be deactivated separately for each winding, for special applications.
- iv) Shall have software to take care of the angle & ratio correction of CT inputs.
- v) Shall have all output relays suitable for both signals and trip duties

b) FUNCTIONAL DESCRIPTIONS:

The integrated Numerical Transformer Protection Scheme shall have following functional qualities:

1) Differential protection:

- i) The relay shall be biased differential protection with triple slope tripping characteristics with faulty phase identification / indication. The range for the differential pick-up shall be from 0.1 to 2.5 p.u. Its operating time shall not exceed 30 ms at 5 times rated current.
- ii) The relay shall have two adjustable bias slopes from 20 % to 150 % and slope from 40% to 150 %, to provide maximum sensitivity for internal faults with high stability for through faults
- iii) The relay shall have an unrestrained high set element to back up the biased differential function and the setting range for it shall have a minimum setting of 5pu and a maximum setting of 30pu.
- iv) The relay shall have the second harmonic restraint feature for stability under transformer inrush condition. The setting shall be 15-25%.
- v) Further, the fifth harmonic blocking for stability under transient over fluxing condition shall be provided.
- vi) Have suitable non-linear resistors along with stabilizing resistor for CT Circuit to limit peak voltage during in-zone faults in case of high impedance type.

- vii) Have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period: **Current in all three windings in nine analogue channels plus three analogue channels for Backup protection in case of 400kV class/ 220kV Class (In case of loaded tertiary) or 9 analogue channels for lower voltage transformers and voltage in three channel.**
- viii) The Disturbance recorder function built in the Differential Protection IED shall have the facility to record the following external digital channel signals associated with transformer which shall be wired to differential relay apart from the digital signals pertaining to differential relay:
 - a) REF Protection Operated
 - b) HV Breaker Status (Main & Tie/Transfer both separately)
 - c) IV/LV Breaker status (Main & Tie/Transfer both separately)
 - d) Bucholz/OLTC/OTI/WTI alarm
 - e) Bucholz/ PRD/ SPR Trip
 - f) Group-A/ Group-B lockout relay trip

Necessary hardware and software, for automatic up loading of the data captured by disturbance recorder to the personal computer (DR Work Station) available in the sub station, shall be included in the scope.
- ix) The Relay shall have Reverse Power Protection feature.
- x) The Differential Relay shall be designed for the protection & control of 3 winding Transformer

2) Restricted Earth fault Protection:

The scheme shall have in-built restricted earth Fault (REF) for both the windings. The REF function shall be configurable to Auto Transformer also. This function should be provided to maximise the sensitivity of the protection of earth faults. **Both the Differential relay shall have inherent high impedance REF element.** The REF function should be able to share Current Transformers with the biased differential function. As in traditional REF protections, the function should respond only to the fundamental frequency component of the currents. For star/star transformer, both the windings shall be protected through REF, as such relay shall have sufficient analogue channels to accommodate the same.

3) Over fluxing Protection:

- i) The over fluxing protection shall be built in the relay. By pairs of V/f and t , it shall be possible to plot the over fluxing characteristics so that accurate adaptation of the power transformer data is ensured.
- ii) In addition, the relay should have a definite time element for alarm.
- iii) The relay should monitor all the three phase voltages for calculation of V/f and should take the highest voltage for V/f calculation.

4) Thermal Overload Protection:

- i) Shall have two stages of thermal overload protection for alarm and trip condition with continuously adjustable setting range of 100-400% of rated current and time constant setting range of 1.0 to 10.00sec continuously.
- ii) Shall be single pole type.
- iii) Shall have a drop off/pick up ratio greater than 95%.

- iv) Shall have separately adjustable time delay relays for alarm having a setting range of 1to 10 seconds continuously.

5) Over Current and Earth fault protection:

- i) The relay shall have three stages of definite time **Directional** over current protection as backup operating with separate measuring systems for the evaluation of the three phase currents, the negative sequence current and the residual current.
- ii) In addition, the relay shall have three stages of Inverse time **Directional** over current protection operating based on one measuring system each for the three phase currents, the negative sequence current and the residual current.
- iii) Shall have additional features to provide under/ over voltage protection.
- iv) Shall have additional features to provide under frequency protection.
- v) The Earth fault relay shall have directional IDMT characteristic with a definitive minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current. (with selectable IEC Curves).
- vi) The Earth fault relay shall have low transient, overreach high set instantaneous unit of continuously variable setting range 200-800 % of rated current.

6) Transformer Neutral Current relay (for 400 KV class transformer only) shall

- i) Have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current. (with selectable IEC Curves)

14.16.4 Over Current and Earth Fault Relays

These relays shall be of numeric, single/multi pole, directional /non-directional type with high set element as specified. These relays shall have the following features/characteristics:

- (i) IDMT characteristic with definite minimum time of 3 second at 10 times setting.
- (ii) Other operating curves such as inverse, very inverse shall be selectable
- (iii) Adjustable setting range of 50-200 % and 20-80% of rated current for over current and earth fault relays respectively.
- (iv) The directional relays shall have a Maximum torque angle of 45° current leading for directional over current unit & 30 lag for directional earth fault. Other MTAs should be settable
- (v) Voltage polarizing coil: 63.5 or 110volt
- (vi) Must have faulty phase, type of fault identification
- (vii) The directional relays shall have over voltage/ under voltage & under frequency built in protection
- (viii) The relay shall have blocking scheme on Reverse Power Flow.
- (ix) Include LED indicators.

14.16.5 Reactor Protection

14.16.5.1 REACTOR DIFFERENTIAL PROTECTION RELAY Shall

- (i). Be triple pole type.

- (ii). Have operation time less than 25 milli-seconds at 5 times setting
- (iii). Be tuned to system frequency.
- (iv). Have an operating current sensitivity of at least 10% of nominal current
- (v). Have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range
- (vi). Be high impedance / biased differential type.
- (vii). Have suitable non-linear resistors along with stabilizing resistor for CT Circuit to limit peak voltage during in-zone faults in case of high impedance type.
- (viii). Be stable for all external faults.

14.16.5.2 REACTOR RESTRICTED EARTH FAULT PROTECTION RELAY shall

- (i). Be single pole type.
- (ii). Be of current/voltage operated high impedance type.
- (iii). Have a current setting of 05-40% of 1 Amp. / have a suitable voltage setting range
- (iv). Be tuned to system frequency
- (v). Have a suitable non-linear resistor to limit the peak voltage to 1000 Volts.

14.16.5.3 REACTOR BACK UP IMPEDANCE PROTECTION RELAY shall

- (i). Be triple pole type, with faulty phase identification/ indication.
- (ii). Be single step polarized 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults
- (iii). Have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable
- (iv). Have an adjustable characteristic angle of 30-80 degree
- (v). Have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds
- (vi). Include VT failure relay which shall block the tripping during VT fuse failure condition.
- (vii). Have Back Up over Current and Earth fault protection as built in function.

14.16.6 Circuit Breaker Protection

a) LOCAL BREAKER BACK-UP PROTECTION SCHEME shall

- (i). Be triple pole type.
- (ii). Have an operating time of less than 15 milli seconds
- (iii). Have a resetting time of less than 15 milli seconds
- (iv). Have three over current elements
- (v). Be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections
- (vi). Have a setting range of 10-80% of rated current
- (vii). Have a continuous thermal withstand two times rated current irrespective of the setting
- (viii). Have a timer with continuously adjustable setting range of 0.1-1 seconds
- (ix). Have necessary auxiliary relays to make a comprehensive Scheme
- (x). Shall have re-trip feature for tripping its own CB after initiation with a set time delay.
- (xi). Be acceptable as Built-in protection function of distributed bus bar protection scheme only; however in that case separate LBB relay shall be provided for tie bays.

- b) **NUMERICAL AUTO RECLOSING FUNCTION** (where specified) shall be an in built feature of Main-I and Main-II protection relay. The Auto Reclose shall
- (i). Have single phase and three phase reclosing facilities.
 - (ii). Have a continuously variable single-phase dead time range of 0.1-2 Seconds
 - (iii). Have a continuously variable three phase dead time range of 0.1-2 Seconds
 - (iv). Have a continuously variable reclaim time range of 5-300 seconds
 - (v). Incorporate a four-position selector switch/ from which single phase/three phase/single and three phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through HMI of the relay or BCU & SAS.
 - (vi). Have facilities for selecting check synchronizing or dead line charging features. It shall be possible at any time to change the required feature by reconnection of links.
 - (vii). Be of single shot type
 - (viii). Have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers
 - (ix). Include check synchronizing relay which shall
 - Have a time setting continuously variable between 0.5-5 seconds with a facility of additional 10 seconds
 - Have a response time within 200 milli seconds with the timer disconnected.
 - Have a phase angle setting not exceeding 35 degree
 - Have a voltage difference setting not exceeding 10%
 - Include deadline charging relay, which shall
 - Have two sets of relays and each set shall be able to monitor the three-phase voltage where one set shall be connected to the line CVTs with a fixed setting of 20% of rated voltage and the other set shall be connected to the bus CVTs with a fixed setting of 80% of rated voltage.
 - Incorporate necessary auxiliary relays and timers to give comprehensive scheme.

Auto Reclose function shall be an in-built feature of the BCU and the signal exchange for auto-reclose function from BCU to main relays and vice versa shall be achieved through hard wiring and GOOSE parallely.

14.17 Bus Bar Protection Relay

- a) These relays shall also be of numeric type.
- b) Redundant (1+1) numerical low impedance biased differential Bus Bar protection scheme for each bus system (Bus1 +Bus2) for 400kV shall be provided. The scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to main faulty bus shall result in tripping of the same.
- c) Single bus bar protection scheme shall be provided for each main bus (**Main I/Main II**) and transfer bus (as applicable) for 220KV and **132kV** voltage level.
- d) Each Bus Bar protection scheme shall
 - i) Have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.
 - ii) Operate selectively for each bus bar
 - iii) Give hundred percent security up to 63 KA for fault level for 400 KV , 50kA for 220 KV and 40 KA for 132 KV

- iv) Incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm
- v) Not give false operation during normal load flow in bus bars
- vi) Incorporate clear zone indication
- e) It shall have End fault Protection & LBB function
- f). Be of phase segregated and triple pole type. The bus bar scheme may be Centralized or De-Centralized type and it must accommodate all future bays as per Project along with tripping relays.
- g) Provide independent zones of protection (including transfer bus if any). If the bus section is provided, then each side of bus section shall have separate set of bus bar protection schemes
- h) Include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.
- i) Be transient free in operation
- j) Include continuous D.C. supplies supervision
- a) Not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.
- b) Shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm
- c) Include protection 'IN/OUT' switch for each zone
- d) Shall include trip relays, CT switching relays (if applicable) , auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However, for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.
- e) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

14.18 Tee Differential Protection Relays (If Applicable)

- 1) **TEE-1 DIFFERENTIAL (BIAS) PROTECTION RELAY** shall
 - (a) be triple pole type
 - (b) have an operating time less than 30 milliseconds at 5 times the rated current
 - (c) have three instantaneous high set over current units
 - (d) have an adjustable bias setting range of 20-50%
 - (e) have an operating current setting of 15% of 1 Amp or less
- 2) **TEE-2 DIFFERENTIAL (HIGH IMPEDANCE) PROTECTION RELAY** shall
 - (a) be triple pole type
 - (b) have operating time less than 25 milliseconds at 5 times setting
 - (c) be tuned to system frequency

- (d) have current setting range of 20 to 80% of 1 Amp
- (e) be voltage operated, high impedance type
- (f) be stable for all external faults
- (g) be provided with suitable nonlinear resistors across the relay to limit the peak voltage to 1000 volts

14.19 Trip Circuit Supervision Relay

- Trip circuit supervision relay shall be provided for each pole of the breaker for both trip coils with separate DC source.
- The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.
- The relay shall have adequate contacts for providing connection to alarm and event logger.
- The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase.

14.20 Master Trip Relay

- High Speed Tripping Relay shall be instantaneous (operating time not to exceed 10 milli-seconds)
- The relays shall reset within 20 milli seconds
- The relay shall be re-settable/configurable from local SCADA.
- The relays shall be D.C. operated
- The relays shall have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.
- The relays shall be provided with operation indicators for each element/coil.

14.21 Other Trip Relays

- For transformer protection other trip relays for Buchholz, winding & oil temperature high, PRD etc. shall be provided as per requirement.
- These High-Speed Tripping Relays shall be instantaneous (operating time not to exceed 10 milli-seconds)
- The relays shall have adequate contacts to meet the requirement of scheme

14.22 DC Supply Supervision Relay

- The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.
- It shall have adequate potential free contacts to meet the scheme requirement.
- The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and the relays shall be provided with operation indicator/flag.

14.23 TIME SYNCHRONISATION EQUIPMENT:

- The equipment must be Type tested for Shock, Vibration, Dry heat, Radiated Emission, Electromagnetic field immunity, Electrostatic discharge immunity test in a Standard Laboratory. Type test report shall be submitted along with the bid. Type tests shall be more than five years as on opening of this bid.

- The equipment shall be compliant to IEC 61850 Protocol. It shall also support the network protocols like NTPv4, SNTP, SNMPv1,2,3, SNMP Trap, SSH2, Ipv6, DHCP, HTTP (S), eMail, FTP, TELNET and Syslog
- The Time synchronisation equipment shall receive the coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipment to the Indian Standard Time in a substation.
- Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.
- It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.
- Equipment shall operate up to the ambient temperature of 50 degree centigrade and 100% humidity.
- The synchronisation equipment shall have 20 nano second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc.) including communication time for satellite link to achieve real time signal.
- Equipment shall meet the requirement of IEC 60255 for storage & operation.
- The system shall be able to track the satellites to ensure no interruption of synchronisation signal.
- The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following:
 - 1) Voltage signal: Normally 0-5V with 50 milli Seconds minimum pulse duration. In case any other voltage signal required, it shall be decided during detailed engineering.
 - 2) Potential free contact (Minimum pulse duration of 50 milli Seconds.)
 - 3) IRIG-B
 - 4) RS232C
 - 5) RJ 45
 - 6) SNTP
 - 7) Optical
 - 8) IEEE 1588 PTP (Applicable only for process bus automation station)
- The equipment shall have a periodic time correction facility of one-second periodicity.
- Time synchronisation equipment shall be suitable to operate from 80V-250V DC supply available at the sub-station with voltage variation of + 10% and -15%.
- . Equipment shall have real time digital display in hour, minute, second (24-hour mode) & have a separate time display unit to be mounted on the top of control panels/SAS Panels having display size of approx. 100 mm height.
- The cable connecting Antenna and Time Synchronising unit should be run through HDPE pipe or GI pipe from the location of Antenna fixing to Time Synchronising panel with suitable fixtures and no provision to enter rainwater and should not be affected by atmospheric conditions.
- Time Synchronisation software shall be window base and it should be provided free of cost after commissioning.

14.24 BAY CONTROL UNIT (BCU)

- The BCU must be type tested at KEMA/Internationally or nationally accredited other testing laboratories for IEC 61850 and other tests as per relevant IEC standards. The

bidder is to submit type test reports along with the bid. The validity of type test report shall be as per Clause 14.4.2(iii).

- The bay unit shall use industrial grade components. The BCU shall be modular type. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. These shall incorporate select- before-operate control principles as safety measures for operation via the HMI. These shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. These shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, these shall receive the operation commands from station HMI and SLDC. The bay unit shall have the capability to store all the data for at least 24 hours even if there is any power off conditions during the day. **The BCU shall have Auto Reclose, LBB, U/O voltage and Synchronization function. The BCU shall have redundant power supply card i.e. in case of failure of one source/Card fail, the redundant shall pick up instantly. Power supply card failure shall generate necessary alarm to local SCADA.**
- The BCU must have metering functions like phase current, phase voltages, active & apparent power, power factor, frequency etc. The metering functions shall be accurate for a minimum of 1% of rated current.
- BCU HMI shall display complete mimic of the respective bay, and operator shall be able to select the equipment in the mimic diagram for which operation of equipment is required. The control operation shall be password protected. For 33kV, the HMI should display one bay and control thereof.
- The mimic diagram shall indicate the live & dead portion of the Bay.
- The BCU shall be capable to generate password for maintenance shutdown.
- One Bay level unit shall be provided for supervision and control of each 400KV, 220KV, 132kV and 33kV bay (a bay comprises of one circuit breaker and associated disconnectors, earth switches and instrument transformer). If the 33kV bus section comprises isolator only, then the isolator shall be controlled from the transformer LV side bay and same is the case for Bus PT Isolator which shall be controlled by Transformer LV side BCU. The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.
- The BCU shall have sufficient number of BI/BO as per the scheme requirement with additional 30% spare BI/BO.
- The Bay level units shall be installed in the control and relay panels located in the control room.
- The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.
- **Input / Output (I/O) modules**

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data

coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear.

The measured values of SF6 Gas Pressures, Operating Mechanism Pressures, WTIs, OTI etc. are received through transducers to Bay Level Unit

The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state.

- **Operator Interface**

The HMI of BCU shall display the following informations

- i) the bay name
- ii) the date and time
- iii) the Local / Remote/Maintenance bay mode
- iv) the auto-recloser function status (on / off),
- v) the synchrocheck function status (on / off),
- vi) the interlock function status (on / off),
- vii) a list of measurements (in real value)
- viii) the bay graphical representation
- ix) the bay events classified in a chronological order
- x) the bay alarms
- xi) the list of disturbance records available
- xii) Bay interlock diagram

In addition, it shall be possible to plug a PC laptop on the Bay and get the full substation operator interface.

14.25 SWITCHED ETHERNET COMMUNICATION INFRASTRUCTURE:

The bidder shall provide the redundant managed switched optical Ethernet communication infrastructure for SAS against PRP architecture. The necessary switches are provided for communication infrastructure as follows.

14.25.1 One switch shall be provided to connect all IEDs for 1 Bay in LAN –I and the second optical port of Bay IEDs shall be connected to other Ethernet Switch in LAN-2. The maximum number of bays may be connected to these Ethernet Switch shall be two bays for 400KV, 220kV and 132kV. However, for 33kV, 3 numbers bay may be connected to one Ethernet Switch in this PRP architecture. The exact no of Ethernet switches required for complete implementation of the scheme shall decided during detailed engineering.

14.25.2 The managed Ethernet switch shall have minimum 20% port redundancy (Both Fibre & Copper ports).

14.25.3 Ethernet Switches shall have redundant power card.

14.25.4 Port monitoring softwares for Ethernet Switches are to be provided.

14.25.5 The make of the Ethernet switches shall be Ruggedcom/Hirschman/ABB.

14.26 FAULT RECORDER:

- 14.26.1 The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.
- 14.26.2 Fault recorder shall be capable to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.
- 14.26.3 The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit (as described in section sub-station automation through bus conforming to IEC 61850) which is common for the entire Substation. Necessary hardware and software shall also be supplied for online transfer of data from all acquisition units to Evaluation unit.
- 14.26.4 Fault recorder shall have at least 8 analogue and 16 digital channels for each feeder.
- 14.26.5 Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.
- 14.26.6 The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.
- 14.26.7 The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.
- 14.26.8 The evaluation unit hardware shall be as described in clause no. 4.0 of section sub-station automation.
- 14.26.9 Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner's PLCC/VSAT/LEASED LINE shall be provided.
- 14.26.10 Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)
- 14.26.11 The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.
- 14.26.12 Fault recorder acquisition units shall be suitable to operate from 220V DC as available at sub-station Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Distance recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in section sub-station automation clause no. 8.0 and DR evaluation unit.
- 14.26.13 The acquisition unit shall have the following features:

- i) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc. and same shall be wired to annunciation system.
 - ii) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.
 - iii) Scan rate shall be 1000 Hz/channel or better.
 - iv) Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds.
 - v) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.
 - vi) The acquisition unit shall be typically used to record the following digital channels:
 - 1. Main CB R phase open
 - 2. Main CB Y phase open
 - 3. Main CB B phase open
 - 4. Main-1 carrier received
 - 5. Main-1 protection operated
 - 6. Main/Tie /TBC Auto reclosed operated
 - 7. Over Voltage -Stage-1 /2 operated
 - 8. Reactor / Stub/TEE-1/2/UF protection operated
 - 9. Direct Trip received
 - 10. Main-2 carrier received
 - 11. Main- 2/ Back Up protection operated
 - 12. Bus bar protections operated
 - 13. LBB operated of main /tie/TBC circuit breaker
 - 14. Tie/TBC CB R phase open
 - 15. Tie/TBC CB Y phase open
 - 16. Tie/TBC CB B phase open
 - vii) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.
 - viii) Any digital signal can be programmed to act as trigger for the acquisition unit. Analogue channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.
- 14.26.14 The printer shall be compatible with the desktop PC and shall use Plain paper. The printout shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of paper (500 sheets in each packet) suitable for printer shall be supplied.
- 14.26.15 Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to +0.5 seconds/day, if allowed to run without synchronization. Further, Fault recorder shall have facility to synchronize its time generator from Time Synchronization Equipment having output of following types.
- i) Voltage signal: (0-5V continuously settable, with 50m Sec. minimum pulse duration).
 - ii) Potential free contact (Minimum pulse duration of 50 m Sec.)
 - iii) IRIG-B/SNTP
 - iv) **RS232C/RS485/RJ 45/Optical port.**
- The recorder shall give annunciation in case of absence of synchronizing within a specified time.

14.27 DISTANCE TO FAULT LOCATOR:

- 14.27.1 The Distance to Fault Locator shall be provided for transmission line and the fault locator as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.
- 14.27.2 Distance to Fault Locator shall be electronic or microprocessor based and 'Online' type with built-in display unit.
- 14.27.3 The display shall be directly in percent of line length or kilometers without requiring any further calculations.
- 14.27.4 It shall have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays. The accuracy should not be impaired under the following conditions:
- i) presence of remote end in-feed
 - ii) predominant D.C. component in fault current
 - iii) high fault arc resistance
 - iv) severe CVT transients
- 14.27.5 It shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

14.28 PROTECTION SCHEME FOR PANELS:

- **400KV Line Panel**

The following protections scheme shall be provided for Panels for 400 KV Transmission lines:

Main Protection Scheme I & II:

Distance protection scheme using Numerical Relay as specified in detail in Clause 14.15 and 14.16.2 shall be implemented. The summary of the scheme detailed in the above clauses have the following feature:

- (i) Permissive under reach/over reach/ blocking communication mode.
- (ii) Suitable for single cum three phase tripping.
- (iii) Power swing blocking and out of step protection.
- (iv) Single shot single-cum-three phase auto re-closing with check synchronising and deadline charging features.
- (v) Fuse failure protection.
- (vi) Weak end in feed feature.
- (vii) Over/Under Voltage Protection
- (viii) Directional Over current and Earth Fault protection
- (ix) Current reversal guard feature
- (x) Stub protection function
- (xi) Load encroachment blinder feature.
- (xii) Switch on to fault feature.
- (xiii) In built Broken Conductor detection feature.
- (xiv) Shall have df/dt functions
- (xv) Under frequency protection

(xvi) Carrier Aided Tripping

(xvii) Main 1 and Main 2 relay shall of different make **and model**.

- **220 KV Line Panel**

The following protections scheme shall be provided for Panels for 220 KV Transmission lines:

- a) **Main Protection Scheme I & II:**

Distance protection scheme using Numerical Relay as specified in detail in Clause 14.15 and 14.16.2 shall be implemented. The summary of the scheme detailed in the above clauses have the following feature:

- (i) Permissive under reach/over reach/ blocking communication mode.
- (ii) Suitable for single cum three phase tripping.
- (iii) Power swing blocking and out of step protection.
- (iv) Single shot single-cum-three phase auto re-closing with check synchronising and deadline charging features.
- (v) Fuse failure protection.
- (vi) Weak end in feed feature.
- (vii) Over/Under Voltage Protection
- (viii) Directional Over current and Earth Fault protection
- (ix) Current reversal guard feature
- (x) Stub protection function
- (xi) Load encroachment blinder feature.
- (xii) Switch on to fault feature.
- (xiii) In built Broken Conductor detection feature.
- (xiv) Shall have df/dt functions
- (xv) Under frequency protection
- (xvi) Main 1 and Main 2 relay shall of different **make and model**.

- **132 KV Line Panel**

The following protections scheme shall be provided for Panels for 132 kV Transmission lines:

- a) Main Protection Scheme I:

Distance protection scheme using Numerical Relay as specified in Clause 14.15 and 14.16.2.

- b) Backup Protection:

The backup protection shall be provided with directional single/ multi pole relays as specified in Clause 14.16.4. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults without high set elements shall be provided.

- **33KV Feeder Protection Panel**

The 33kV Feeder Panels shall be provided non directional single/ multi pole relays as specified in Clause 14.16.4. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults with high set elements shall be provided.

- **Power and Auto Transformer Protection Panel**

Integrated Transformer protection scheme as detailed in Clause 14.16.3 of the BID shall be provided for Panels for all Power and Auto Transformers:

(a) Main Protection -1

Biased transformer differential protection employing relay type specified in Clause 14.32. The scheme shall include also following:

- (i) Second and fifth harmonic restraint feature.
- (ii) The relay shall also provide Restricted Earth Fault Protection
- (iii) The scheme shall have suitable input and output for transformer auxiliary protection like Buchholz, oil temperature, winding temperature etc.
- (iv) Over-fluxing protection
- (v) The relay shall have Back up protection features i.e Directional over current and earth fault with high set element. The high set unit should not operate due to transformer in-rush current.

(b) Main Protection - 2

Protection function shall be same as Main Protection – I.

(c) Backup Protection: The backup protection shall be provided with Directional relays as specified in Clause 14.16.3. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults with high set elements shall be provided. The high set unit should not operate due to transformer in-rush current.

- **Bus Bar Differential Protection Panel:**

- The Bus Bar Protection shall be provided as detailed in Clause 14.17 of the BID for 400kV, 220kV and 132kV Voltage Level.

- **Reactor Protection Panel:**

The Reactor Protection shall be provided as detailed in Clause 14.16.5 of the BID.

14.29 RELAY MAINTENANCE TOOL KIT

MAINTENANCE TOOL KIT

- The bidder shall supply a complete maintenance tool kit set. The tool kit shall have generally current jack, card extender, card puller, required crimping tool, screw drivers, pliers etc.
- The tool kit shall contain test plugs, test leads, clips for maintenance and testing of relays supplied. Further detailing will be done during detail engineering.
- The Maintenance Tool Kit shall be of Universal type.

14.30 TESTS

- The supplier shall carryout all tests as per relevant standards as all associated equipment including relays, meters, instruments etc. The supplier shall submit all that reports to Employer for approval before despatching the control and relay panels. The Bidder shall also submit along with the bid type test reports for relays instruments, meters and other devices of the type and class being offered. Bidder has to submit KEMA test certificate for Numeric relay on interoperability compliance of IEC 61850 in general and GOOSE messaging and publishing in particular along with the bid.
- Control and relay panels shall be subjected to the following tests:
 - a. Mechanical operation test.
 - b. Verification of degree of protection.
 - c. High voltage test (2000 volts for 1 minute)
 - d. Electrical control interlock and sequential operation test.
 - e. Verification of wiring as per approved schematic.
 - f. Interoperability test as per IEC 61850 (interoperability with ABB, AREVA, SIEMENS, GE and SEL)

14.31 PRE-COMMISSIONING TESTS

- The contractor shall have to perform following minimum Pre-commissioning tests for commissioning of the C&R panels. For this purpose, the contractor shall arrange all required tools and testing equipment at site
 - (i). IR values of all circuits
 - (ii). Measurement of burden in CT & PT circuits
 - (iii). Primary current injection of CT circuits with connected burden
 - (iv). Energisation of PTs at suitable low voltage and measurement of PT inputs at all measuring points
 - (v). Secondary ac current injection of relays, dynamic testing of all numeric relays. Tracing of zone curves, limits. Checking of relay timings, inherent or set values. For this testing, the contractor shall bring 'Omicron' or equivalent test kit.
 - (vi). Testing of voltage related elements like directional element, over fluxing, over/ under frequency, over/ under voltage features, tracing of curves and checking limits of set values and associated timings
 - (vii). Checking of Boolean logic gates, BI/BO points of the numeric relays, checking conformity to specification and checking of set logics
 - (viii). Checking of stability and sensitivity of differential zones by suitably applying 3-phase low voltages and shorting of primary circuits. Measurements of voltage and current inputs to all relays.
 - (ix). Checking stability & sensitivity of bus differential relay zones by suitably injecting current
 - (x). Primary injection of REF connected CTs, measurements of relay inputs and checking of stability and sensitivity of REF scheme
 - (xi). Checking registration of event and disturbance records in the numeric relays and downloading
 - (xii). Testing of carrier aided protection schemes and simulation with regard to transmission and receipt of protection signalling
 - (xiii). Testing of AR schemes
 - (xiv). Checking of healthiness of each dc circuit of panels
 - (xv). Simulation of faults like Buchholz, OTI, WTI and other relays and checking of tripping of breaker and connected annunciation
 - (xvi). Operation of master trip relays, tripping of breaker through each trip coil and checking of interlocks

- (xvii). Simulation of faults like low gas, air pressure and checking operation of interlocks.
Checking anti pumping scheme of CB
- (xviii). Simulation to Check Checking of PT selection schemes
- (xix). Simulation to Check interlocks of all CB and isolator interlocks
- (xx). Simulation to Check annunciation of all events in BCU (Bay control unit) as well as SAS (Sub-station Automation System)
- (xxi). Simulation to Check of logic of BCU
- (xxii). Operation of tap changing of transformer through SAS
- (xxiii) The pre-commissioning checklist will be further developed by the contractor and will seek approval prior to commencement of pre-commissioning tests from the DGM, MRT Circle, AEGCL. The tests will be witnessed and approved by him or by his authorized officers.

14.32 TECHNICAL DATA SHEET FOR THE RELAY AND CONTROL PANELS

- Features to be provided in various Relay and Control panels are indicated below. Description below are only indicative; the Contractor shall ensure that all items are included in their offer to complete the schemes described in the Specification whether such items are specifically mentioned or not.

400kV and 220kV Feeder Panels:

SL NO	ITEM	RATINGS AND PARTICULARS	
		400KV Panel with 1 ^{1/2} Breaker Scheme	220KV Panel with Main I & Main II
I	II	III	IV
A	LINE PANELS		
1	Protection and relays:		
	(a) Distance Protection Scheme I	1 No.	1 No.
	(b) Distance Protection Scheme II	1 no	1 no
	(c) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coils per pole or phase)	Supervision for 6 trip coils (2 trip coils per pole or phase)
	(e) DC Supply healthy monitoring scheme for two separate DC source	2 No.	2 No.
	(e 1) DC Changeover Relay	2 Nos	2 Nos
	(f) AC Supply healthy monitoring scheme	1 No.	1 No.
	(g) High Speed Trip relay (1 & 3 pole)	2 sets.(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)	2 sets.(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)

	(h) PT-CVT Selection Scheme with PT1-PT2-CVT selection relay	1 Set. Complete Bus PT1-Bus PT2-CVT Selection Scheme	1 Set. Complete Bus PT1-Bus PT2-CVT Selection Scheme
	(i) Auxiliary relay, timer relay for healthiness of relays, auto reclose communication link etc.	As required (Can be function of BCU)	As required (Can be function of BCU)
	(j) Trip Transfer Relay	-	2 sets
	(j) Fault Recorder	1 set (shall be function of IED)	1 set (shall be function of IED)
	(k) Distance to fault locator	1 set (shall be function of IED)	1 set (shall be function of IED)
	(l) Under Voltage protection relay for isolator/earth switch Interlock	2 nos	2 nos
	(m) Over Voltage Protection Scheme	1 set (maybe function of IED)	1 Set (maybe function of IED)
2	Meters		
	(a) ABT tri-vector Meter (SAMAST Compliant) with TTB	1No	1No
3	Controls/ Status indication/ Annunciation		
	Bay control unit (IED)	1No. (Function of BCU/ SAS)	1No. (Function of BCU/ SAS)

132kV and 33kV feeder Panels:

SL NO	ITEM	RATINGS AND PARTICULARS	
		132 kV Panel with Main & Transfer Bus Scheme	33 kV feeder panel with single bus system
		V	VI
A	LINE PANELS		
1	Protection and relays:		
	(a) Distance Protection Scheme	1 No.	-.
	(b) Back up directional over current and earth fault scheme	1 Set	-
	(c) Back up non directional over current and earth fault scheme	-	1 set
	(d) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(e) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 2 trip coils	Supervision for 2 trip coils
	(f) DC Supply healthy monitoring scheme, for two DC source	2 No.	2 No.

	(f 1) DC Changeover	2 Nos	2 Nos
	(g) AC Supply healthy monitoring Scheme	1 No.	1 No.
	(h) High Speed Trip relay	2 No.	2 No.
	(h1) High Speed Trip Relay for LBB	1 No	1 No
	(i) Auxiliary relay, timer relay for healthiness of relays, auto reclose communication link etc.	As required (Can be function of BCU)	As required (Can be function of BCU)
	(j) Trip Transfer Relay	2 sets	2 sets
	(j) Line CVT-Bus PT selection relay	1 No	-
	(k) 33kV Incomer PT selection	-	-
	(l) Distance to Fault Locator	1 set (shall be function of IED)	-
	(m) Fault Recorder	1 set (shall be function of IED)	
	(l) Under Voltage protection relay for isolator/earth switch Interlock	2 nos (function of IED)	
	(m) Over Voltage Protection Scheme	1 set (maybe function of IED)	
2	Meters		
	(a) ABT tri-vector Meter (SAMAST Compliant) with TTB	1 No	1 No
3	Controls/ Status indication/ Annunciation		
	Bay Control Unit (IED with HMI)	1No. (Function of BCU/ SAS)	1No.

Transformer Protection Panels

SL NO	ITEM	RATINGS AND PARTICULARS			
		400/220/33 kV Transformer Panel	220/132 kV Transformer Panel	220/33 kV Transformer Panel	132/33kV Transformer Panel
		VII	VIII	IX	X
B	TRANSFORMER PANELS				
1	Protection and Relays:				
	(a) Differential Protection Scheme	2 No.	2 No.	2 No.	2 No.
	(b) Restricted Earth Fault Protection Scheme	(inherent High imp REF)	(inherent High imp REF)	(inherent High imp REF)	(inherent High imp REF)

(c) Back up directional over current scheme and earth fault scheme for HV side.	Could be feature of relay	Could be feature of relay	Could be feature of relay	Could be feature of relay
(d) Back up directional over current and earth fault scheme for MV/LV Side.	Could be feature of relay	Could be feature of relay	Could be feature of relay	Could be feature of relay
(e) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs	Can be function of BCU/IEDs	Can be function of BCU/IEDs
(f) Over Fluxing Protection scheme	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
(g) Overload protection scheme	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
(g.1) Tertiary Side O/C and Open Delta Voltage Protection	1 set	1 set	-	-
(h) Trip Circuit Supervision Relay Scheme for ascertaining pre and post-closing healthiness.	Supervision for 4/12 trip coils (2 trip coils per pole/ breaker on each side)	Supervision for 4/8 trip coils (2 trip coils per pole/ breaker on each side)	Supervision for 4/8 trip coils (2 trip coils per pole/ breaker on each side)	Supervision for 4 trip coils (2 trip coils per breaker on each side)
(i) DC Supply healthy monitoring scheme	2 No.	2 No..	2 No.	2 No.
(i1) DC Changeover Relay	2 No.	2 No.	2 No.	2 No.
(j) AC Supply healthy monitoring scheme	1 No.	1 No.	1 No.	1 No.
(k) High Speed Trip relay (HV Side)	2 No.	2 No.	2 No.	2 No.
(l) High Speed Trip relay (MV/LV Side)	2 No.	2 No.	2 No.	2 No.
(m) Trip Transfer Relay	2 sets	2 sets	2 sets	2 sets
(m) PT Selection Scheme on HV / MV/LV Side as applicable	1 No. Complete Bus PT Selection Scheme (Can be function of BCU)	1 No. Complete Bus PT Selection Scheme (Can be function of BCU)	1 No. Complete Bus PT selection scheme (can be function of BCU)	1 No. Complete Bus PT selection scheme (can be function of BCU)
(m1) PT Selection Relay	3 Nos for HV/ 2 Nos for LV	2 Nos for HV/ 2 No for MV	2 Nos for HV/ 2 No for LV	1 No for HV/ 2 No for LV
(n) Tripping relay for Bucholtz, PRD, WTI, OTI, OSR etc.	As required	As required	As required	As required
(o) Alarm auxiliary for Bucholtz, PRD, WTI, OTI, MOG, Air Cell	As required (Can be a	As required (Can be a	As required (Can be a	As required (Can

	leakage etc.	function of BCU)	function of BCU)	function of BCU)	be a function of BCU)
	(p) Transformer tap position status/raise & lower	Can be a function of BCU	Can be a function of BCU	Can be a function of BCU	Can be a function of BCU
	(q) Reverse Power Protection	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
2	Meters				
	(a) ABT tri-vector Meter (SAMAST Compliant) With TTB	2 No. (on 400kV and 220 kV side)	2No. (on 220 kV and 132 kV side)	2No. (on 220 kV and 33kV side)	2 Nos. (132 kV & 33 kV side)
3	Controls / interlocks / Status indication/ Annunciation				
	Bay Control Unit (IED), one no each for HV & LV side.	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)

Reactor Protection Panel

The Reactor Protection Panel shall consist of following protection features/schemes:

SL. NO	Description	400 kV
		XI
1	Reactor Differential Protection scheme	1 No
2	Restricted Earth fault Protection scheme:	1 No
3	Reactor back up impedance protection scheme	1 Set
4	Three phase trip relays (Only for Bus Reactor)	2 Nos.
5	CVT selection relay as per scheme requirement	Lot

400kV, 220 kV and 132 kV Bus Coupler / Bypass Breaker Panel

SL NO	ITEM	RATINGS AND PARTICULARS	
		220 kV Panel with Main I & Main II Scheme	132 kV Panel with Main I & Transfer Bus Scheme

		XII	XIII
A	BUS COUPLER PANEL		
1	Protection and relays:		
	(a) Back up directional over current and earth fault scheme	1 Set	1 Set
	(b) Bus Bar differential protection	Main I and Main II	Applicable, where specified in BoQ
	(c) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coil for each Phase)	Supervision for 2 trip coils
	(e) DC Supply healthy monitoring scheme	2 No.	2 No.
	(e) DC Changeover Relay	2 No.	2 No.
	(f) AC Supply healthy monitoring scheme	1 No.	1 No.
	(g) High Speed Trip relay	2 Sets. .(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)	2 No.
	(h) PT Selection Scheme	1No. Complete Bus PT Selection Scheme (Can be function of BCU)	Not applicable
	(i) Auxiliary relay, timer relay scheme	As required	As required
2	Metering	Function of BCU/ SAS	Function of BCU/ SAS
3	Controls/Annunciation/Status indication		
	Bay control unit (IED)	1 No. (Function of BCU/ SAS)	1 No. (Function of BCU/ SAS)

400kV Tie Breaker Panel

SL NO	ITEM	Ratings and Particulars	
		4000 kV Panel with 1 ^{1/2} Breaker Scheme	
		XIV	

B	TIE PANEL	
1	Protection and relays:	
	(a) Back up directional over current and earth fault scheme	
	(b) Bus Bar differential protection	
	(c) LBB Relay.	1 No
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coils per pole or phase)
	(e) DC Supply healthy monitoring scheme	2 No.
	(f) DC Changeover Relay	2 No
	(f) AC Supply healthy monitoring scheme	1 No.
	(g) High Speed Trip relay	2Sets. (each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)
	(h) Auxiliary relay, timer relay scheme	As required
2	Metering	Function of BCU/ SAS
3	Controls/Annunciation/Status indication	
	Bay control unit (IED)	1 No.

14.33 Monitoring, Control & Protection for Auxiliary Transformer

Suitable monitoring, control (operation of associated Circuit breaker and isolator) and protection for LT Auxiliary Transformer, connected to tertiary winding of auto transformer for the purpose of auxiliary supply shall be provided by the contractor. Overcurrent and open delta protection is required to be provided for the auxiliary transformer. These control and protection shall also be acceptable as built in feature either in the bay controller to be provided for the auxiliary system or in the control and protection IEDs to be provided for the auto transformer.

NOTE: 1) The relays (main / auxiliary) not covered within the above table shall be considered for complete commissioning of the protection scheme.

2) In Case of incomplete Diameter (D and I type layouts), control panel shall be equipped fully as if the Diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3) Relay setting template (in editable document format) shall be provided by the Contractor for each typical protection IEDs for relay setting purpose.

4)For GIS Sub Stations, GIS Gas Zone trip signals, if provided, for each gas tight compartments (gas zone) in the GIS LCC shall be integrated in the protection schematics to provide electrical isolation of faulty Gas Zone by tripping/ inter tripping its adjacent circuit breakers. The scheme shall be implemented through protection IEDs and auxiliary relay as required.

CHAPTER 20: TECHNICAL SPECIFICATION FOR XLPE CABLE WITH TERMINATION

TECHNICAL SPECIFICATION OF 33KV, 66KV, 132KV, 220KV & 400KV XLPE CABLE AND TERMINATION

20.1 SCOPE

The specification covers Design, Engineering, Construction, Supply & Delivery, Erection, Laying, Testing & Commissioning including Transportation & Insurance, Storage of XLPE Cable of different ratings and their associated works.

20.2 STANDARD & CODES

The works covered by the specification shall be designed, engineered, manufactured, tested and commissioned in accordance with the Standards as specified in the table below.

Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards referred shall also be accepted. Copies of such standards shall be submitted by the bidder along with the bid.

IS 7098 : Part 3 : 1993	Cross-linked polyethylene insulated thermoplastic sheathed cables: For working voltage from 66KV up to and including 220KV.
IS 8130 : 1984	Conductors for insulated electric cables and flexible cords
IS 5831 : 1984	PVC insulation and sheath of electric cables.
IS 1255 : 1983	Code of practice for installation and maintenance of power cables upto and including 33KV rating.
IS 3975 : 1999	Mild steel wires, formed wires and tapes for armouring of cables.
IS 5831 : 1984	PVC insulation and sheath of electric cables.
IS 6380 : 1984	Elastomeric insulation and sheath of electric cables.
IS 8130 : 1984	Conductors for insulated electric cables and flexible cords.
IS10418 : 1982	Drums for electric cables
IS 5 : 1994	Colours for ready mixed paints and enamels.
IS 617 : 1994	Aluminum and aluminium alloy ingots and castings for general engineering purposes (Superseded IS 20: 1977)
IS 3043 : 1987	Code of practice for earthing.
IS 5578 : 1984	Guide for marking of insulated conductors.
IS 11353 : 1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals.
IS 5216 : Part I : 1982	Recommendations on Safety Procedures and Practices in Electrical Work.
IS 2071 : 1993	High voltage test techniques.
IEC-60540	Power cables with extruded insulation and their accessories and cords
EC 60060 : 1989	High Voltage Test Techniques
IEC-60502	Extruded solid dielectric insulated power cables for rated voltages from 1KV up to 30KV
IEC-60754 : 1991	Tests on gases evolved during combustion of electric cables
IEC-60183 : 1990	Guide to the Selection of High Voltage Cables.
IEC-60230 : 1996	Impulse tests on cables and their accessories.
IEC-60840 / IEC-62067	Testing
IEC-60287 : 1995	Calculation of the continuous current rating of cables (100%load factor).
IEC-60304 : 1982	Standard colours for insulation for low-frequency cable and wires
IEC-60331 : 1970	Fire resisting characteristics of Electric cables.
IEC-60332 : 1992	Tests on electric cables under fire conditions.
BS-5468	Cross-linked polyethylene insulation of electric cables
IEC-60228 : 1978	Conductors of insulated cables
IEC-60332 : 1993	Test on electric cables under fire conditions

IEC-60066	Environmental Test
IEC-60117	Graphical Symbols
IEC-60270 : 2000	Partial Discharge Measurements
CSA-Z299.1-1978h	Quality Assurance Program Requirements
CSA-Z299.2-1979h	Quality Control Program Requirements
CSA-Z299.3-1979h	Quality Verification Program Requirements
CSA-Z299.4-1979h	Inspection Program Requirements
ASTMD-2863	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)

20.3 COMPLIANCE TO SPECIFICATION & DEVIATION:

Normally the offer should be as per Technical Specification without any deviation. But any deviation felt necessary to improve performance, efficiency and utility of equipment must be mentioned in the Deviation Schedule with reasons duly supported by documentary evidence. Such deviations suggested may or may not be accepted by the purchaser.

As a mark of technical conformance, all sheets of the specification shall be furnished by each bidder with the signature and company seal affixed thereon. In case of any deviations, the same shall be carried out in the deviation schedule only. Deviations not mentioned in Deviation schedule will not be considered.

The bidder shall also submit the GTP as per Annexure-1 duly signed with date & company seal for acceptance of the Technical Bid unless which the bid may be considered as non-responsive.

20.4 CONSTRUCTION

1. **For 66KV and above:** The cable shall be of applicable EHV grade as per requirement according to price schedule, single core, armored, stranded compacted circular Copper conductor in case of cross section less than or equals to 800 sq.mm or segmental compacted circular (Miliken) Copper conductor in case of cross section over 800 sq.mm, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, crosslinked polyethylene (XLPE) tree-retardant/ super clean dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non-woven tape with water swellable absorbent over insulation screen, followed by radial sealing of corrugated & seamless aluminum & overall HDPE sheathed (conforming to IEC 60840/ IS 7098 Part III) & graphite coated and conforming to the technical particulars of specification.

For 33KV: Untinned annealed Aluminium conductor of class 2 as per IS 8130/1984 and any latest amendments to it. The shape of conductor shall be compacted, stranded, and circular/ sector shaped, shielded with conductor screen of black extruded semi-conducting compound, XLPE insulation, shielded with insulation screen of black extruded semi-conducting compound, black semi-conducting tape and metallic screen of Aluminium tape, Inner sheath extruded PVC type ST2, single layer of strip/ round steel, round hard drawn aluminium wire armoured and black extruded HDPE (Type ST-7) overall sheathed, conforming generally to IS:7098 (Part II)

20.5 COMPOSITIONS OF CABLES

20.5.1 CONDUCTOR

For the cable sizes having cross section over 800 sq.mm, the segmental compacted circular conductor having minimum four (4) segments should be constructed for the supply under the scope of bid. When the conductor's cross-section is less than 400 sq.mm, the compacted circular is applied generally.

20.5.2 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE.

20.5.3 INSULATION

The insulation material shall be extruded cross-linked polyethylene for 33kV and tree- retardant/ super clean XLPE for 66kV and above. In order to ensure that the screen and insulation are intimately bonded together and free from all possibilities of voids between layers, the conductor screen, the insulation and the insulation screen should be extruded simultaneously in one process in single cross-head. The extrusion process should be carried out under strictly controlled atmospheric conditions.

The thickness of the insulation layer should be maintained as the maximum value figured out from the design of the impulse voltage and A.C. voltage. The cross-linking process by N2 gas should be preferred instead of conventional cross-linking process by saturated steam.

20.5.4 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

20.5.5 MOISTURE BARRIER

The longitudinal water barrier shall be applied over insulation screen by a layer of non-woven synthetic tape with suitable water swellable absorbent.

20.5.6 METALLIC SCREEN:

The metallic screen shall be of Aluminium wire or corrugated aluminium as per IS. The metallic screen shall be designed to meet the requirement of the system short circuit rating of 31.5KA for 3 sec (for 33KV and 66KV), 40KA for 3Sec (for 132KV) and 50KA for 3 sec (for 220KV). Aluminium wire screening may be used if required to meet the above ratings.

ARMOURING (FOR 33KV CABLE)

- i. The armoring shall be of non-magnetic material.
- ii. Armoring shall be applied over the insulation or protective barrier or non-metallic part of insulation screening, in case of single core cables or inner sheath in case of screened and armoured single core cables.
- c) The armour wires/strips shall be applied as closely as practicable the direction of lay of the armour shall be left hand. For double wires/strips armoured cables, this requirement shall apply to the inner layer of wires/strips. The outer layer shall, except in special cases, be applied in the reverse direction to the inner layer, and there shall be a separator of suitable non-hygroscopic material; such as plastic tape, bituminized cotton tape, bituminized hessian tape, rubber tape, proofed tape between the inner and outer layers of armour wires strips.
- d) A binder tape may be applied on the armour.
- e) The joints in armour wires of strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm from the nearest joint in any other armour wire/strip in the completed cable, Number of joint in a single wire to be limited.

20.5.7 OUTER SHEATH

The outer sheath shall consist of Extruded black HDPE (TypeST7) grade. The outer sheath shall be designed for protection against termite and rodent attack and shall be coated with graphite.

20.6 RATING

A complete set of calculation made in arriving at the current rating shall be furnished for laying condition and cable sheath bonding system adopted. Short circuit temperature shall be limited to 250-degree C.

20.7 CABLE DRUMS

Cables shall be supplied in wooden or steel drums of heavy construction of suitable size and packed conforming to IS 10418 or applicable internationally accepted standards. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stenciled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. A narrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with hermetically sealed by means of water blocking compound followed by heat shrinkable caps totally coated inside with mastic so as to prevent to cable for moisture penetration during transit, storage and laying.

The bidder shall consider supply of cable on returnable drums basis. Contractor shall take back all the cable drums from site after successful laying, testing and commissioning of cables. If any length of cable remains unused, the same shall be adjusted by the employer.

Embossing of outer sheet: the following details on the other sheet of cable at a regular interval of 1(one) meter.

- (a) **Name of Customer i.e. AEGCL**
- (b) **Conductor size, type of insulation and voltage grade.**
- (c) **Manufacturer's name.**
- (d) **Year of manufacturing**

20.8 TESTS

All routine and acceptance tests shall be conducted as per IEC60840/IEC62067. All type tests conducted during last five years from the date of NIT as per IEC 60840:1999/ IEC 62067:2001 including its amendments on the XLPE insulated HT cable should be submitted. The diameter of test cylinder during bending test shall be as per IS:7098 (Part3) or the diameter of drum barrel to be used for dispatch of cables whichever is lower. For accessories type test reports should be submitted as per Clause 11.3.2 IEC 60840:1999/ Clause12.4.2 IEC62067:2001 & including amendments.

Following additional type tests shall be carried out on outer sheath of XLPE insulated HT cable.

- a. Oxygen index and temperature index test as per ASTM D-2863.
 - b. Chemical composition test for verifying lead sheath composition.
- All tests as prescribed in IEC-60840 shall be performed after installation of cable.

TESTS AFTER INSTALLATION

All tests as prescribed in IEC-60840:1999/IEC 62067:2001 shall be performed after installation of cable.

20.9 TRENCHING

The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.

The trench shall be excavated using manual/ mechanical modes as per field conditions.

Where paved foot paths are encountered, the pavements shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored.

The sides of the excavated trenches shall wherever required be well shored up.

Suitable barriers should be erected between the cable trench and pedestrian/motor way to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.

The excavated material shall be properly stored to avoid obstruction to public and traffic movement.

The bottom of the excavated trench should be levelled flat and free from any object which would damage the cable. Any gradient encountered shall be gradual.

20.10 LAYING OUT

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before laying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The laying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being laid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension loading shall be by tension indicator and shall not exceed the permissible value for the approved cable pulling tension calculation.

The cable end seal shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

20.11 LAYING OF CABLES

The installation, testing and commissioning work for laying of cable in the entire route within the substation, through the outside cable laying corridor as per designated approved route shall mainly consist of:

- a) Route survey for the entire route length under the scope of work. This is also to finalize drum wise cable length with their tolerances.
- b) Clearances from relevant authorities for laying of cables.
- c) Formation of buried cable trenches for cables as per specification including supply and installation of warning tape, protective tiles / brick layer of minimum class designation 50 (50kg./sq.cm.) cable protection covers for entire route, construction of jointing bays, back filling of trenches and restoration as per specification.

- d) Road crossings shall be through HDPE pipe embedded in concrete duct for each cable and restoration as per specification. Rail and canal crossings shall be through direct drilling with steel drum.
- e) Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 500 meters and other important locations. Also the location of underground cable shall be clearly indicated on the marker.
- f) Supply and installation of straight through joints for complete route.
- g) Design, supply and installation of suitable hangers and other necessary structures for running the cable at overhead road bridge.
- h) Supply and installation of all critical installation materials like trefoil clamps, neoprene cushions, support brackets etc. as required for complete route to avoid damages of the cable. Neoprene cushion shall be provided at road and rail bridge crossings to avoid damage of cable due to vibrations during movement of trains and vehicles.
- i) Termination of cables, bonding of screen/sheath to the earth station through disconnecting type link boxes and SVL (sheath voltage limiter) at cable conductor junction-point etc. Bidder shall adopt cable sheath bonding for route under scope as per detailed Engineering calculation in line with IEEE 575. Earthing stations/ Earthing pits, earthing materials and earthing conductors wherever applicable for complete route including outdoor equipment, structure, cable terminating structure and earth link box at the locations mentioned above shall be in contractors' scope.
- j) Design, fabrication, supply and erection of galvanized steel structures (including its civil foundation) for cable end terminations (with all necessary accessories) for cable sat cable–conductor junction point. At cable-conductor junction point terminal connectors offered by bidder shall be suitable to terminate with ACSR conductors.
- k) For termination at GIS substation end the cable should be laid up to GIS module inside the GIS building. Necessary design construction of cable duct/ trench/ cellar etc. in the GIS Sub-Station including all supply is within the scope of this contract.
- l) Design, supply and installation of LA sat cable–conductor junction points for both the circuits including its mounting structure and Las & Isolator sat Sub-Station.
- m) Termination, bonding, earthing etc. at GIS sub-station end is not within the scope of this work.
- n) All EHV cable routes shall be provided with one linear heat sensing cable to detect any fire and provide alarm.

20.12 LAYING OVER PRE-CONSTRUCTED TRENCH

For laying of the cable on a pre-constructed trench below the road in any planned township area, Bridge, switchyards etc., cable shall have to be accommodated in the space allotted in the trench for laying the cables. Sufficient clamping arrangement shall be done for fixing the cable properly. Cables may be placed in trefoil arrangements as per allotted width of the trench. The clearances between the cable trays shall be minimum 330mm for cables up to 132kV and 400mm for cables of 220kV and 400kV. For 66kV cables, maximum two bends are allowed in 20 mtr span and for 132kV, 220kV and 400kV cables, not more than one bend shall be provided in 20 mtr span. Any damages occurred in the trench during lay of the cable shall have to be repaired properly. Wherever there is crossing with any utility line, the utility line will cross the cable route/ jointing bays at minimum separation distance of 500mm below cable route/ jointing bays.

20.13 CLAMPS

Clamps shall be pressure die cast aluminium (LM-6) or Nylon-6 or fiber glass and shall include neoprene rubber lining wherever the cable touches the clamps and below the clamp base and necessary fixing non magnetic nuts, bolts, washer etc. The thickness of neoprene rubber shall not be less than 10 mm inside around the inner surface of the trefoil clamp and minimum 20 mm thick below the base of trefoil clamp. The neoprene shall be tested as per ISIII49-1984. Clamps shall be provided at every one meter

of cable runs. The contractor shall submit drawings of trefoil clamps and arrangements for Employer approval.

Self-supported Aluminium Spring load clamp shall be provided for Cable termination structure at every 1 metre of cable run. The contractor shall submit the drawings of spring load clamp for employer's approval.

20.14 CABLE HANDLING

The inspection of cable on receipt, handling of cables, laying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surface, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in general conform to IS1255- 1983 or its equivalent.

CABLE JOINTING BAYS

Cable jointing bays shall be provided for single core EHV cables in a staggered manner along the cable route with adequate space for bonding of sheaths and link boxes as well as for testing. The jointing bays shall have adequate number of cable ducts entry and exits including spare ducts with fire seals. The jointing bays shall have chequered covers of minimum 6mm thickness

DAMAGE TO PROPERTY

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damages caused shall be immediately repaired and brought to the notice of the concerned and to the Employer.

- The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.
- At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength using HDD technology.

20.15 CABLE ROUTE MARKERS / CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per drawings approved by AEGCL.

Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 30 meters and at all turning points and other important locations.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible above ground surface.

The marker should incorporate the relevant information, The name of the owner, voltage, circuit and distance of cable from the marker.

20.16 DEPTH OF LAYING OF CABLES

Depth of lay shall be normally at 1.5 m. below ground but variation of depth of lay to 1 meter may be considered at the time of detailed engineering on the characteristics of the laying zone.

20.17 SAND BEDDING

The cable shall be completely surrounded by well-compacted cables and to such a thickness and of such size that the cable is protected against damage. The thickness of the cable sand should normally be a minimum of 10 cm in all directions from the cable surface.

20.18 THERMAL BACK FILL

Based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal back fill surrounding the cables.

20.19 IMMEDIATE ENVELOPE TO CABLE

The option on the use of the material that immediately envelopes the cable viz., thermal back fill or sand or sieved native soil rests with the Employer. The contractor shall seek prior approval on the use of the envelop material from the Employer before execution of the works.

20.20 BACKFILLING

Normally back filling shall consist of the material earlier excavated. However, bigger stores or pieces of rock should be removed.

20.21 WARNING TAPE

A pre-warning, Red colour plastic/ PVC tape, 250 mm wide 100 microns thick, shall be laid at approx. 0.4m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under

CAUTION: AEGCL KV CABLES.

20.22 PREVENTION OF DAMAGE DUE TO SHARP EDGES

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench.

Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable.

While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

20.23 ROAD, RAIL & CANAL CROSSINGS

The road cutting, whether cement concrete asphalt or macadam road surface, rail crossing and canal crossing shall be taken after obtaining approval from the concerned authorities i.e. Railway authorities, irrigation deptt, civic authorities traffic police, telephone authorities etc. and work should be planned to be completed in the shortest possible time. Where necessary, the work shall be planned during night or light traffic periods. HDPE pipes shall be used for cable. HDPE pipes diameter should not be less than 1.5 times the cable diameter.

20.24 TRENCHLESS DIGGING

It is envisaged that trenchless digging shall be used for crossing National highways, Rail line and canal and this shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T 1.38. The various methods of trenchless digging such as hand/ manual auguring (upto 15m.) impact moulding (from 16m to about 40-50m.) HDD (above 40-50m) shall be adopted based on the soil/ site conditions and the requirement and exact method for trenchless digging shall be finalized during detail engineering as per actual site/ soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

1. Guided boring/drilling technology is to be used.
2. Radio or any detection system should be used for avoiding damage to existing underground utilities.

3. The depth of boring should be such as to clear any underground utilities/obstacles. However in no case the depth of boring shall be less than 1.65m from the road surface.
4. In horizontal and vertical boring, the system should be capable of going up to 10 meter below ground.
5. The span of HDD will be decided in charge as per site requirements.
6. Excavation and back filling of trial pits and verification of soil condition.
7. Excavation of entry and Exit pits.
8. Erection of drill machined. Drilling of pilot hole.
9. Placement and driving hand augur.
10. Placement and carrying out impact moling.
11. Reaming and widening of bore holes in steps (if required).
12. Pulling of product pipe.

20.25 FOOTPATH CUTTING

The slabs, curb stones on the roads shall be removed and reinstated without damage. For laying of cables, the specified approved corridor shall be followed below footpath.

20.28 TOOLS AND PLANTS

The successful bidder shall have all necessary tools, plant and equipment to carry out the survey and cable installation work.

The bidders are instructed to give all the details of equipment at their disposal to carryout the work successfully and speedily.

20.29 BENDING RADIUS:

The minimum bending radius of XLPE insulated cables are as follows :

Cable Bending radius Single Core $25 \times D$

"D" means the overall diameter of the completed cable.

This bending radius is applicable for direct buried cable route and cable trench.

20.30 CABLE END TERMINATIONS & JOINTING

- i) The cable jointing accessories shall include the end terminating kits, straight through joints and also any special tools and tackles required for making these joints.
- ii) The straight through joints shall be either Pre-molded Heat Shink type complete with all accessories. The joint shall preferably be built up as per the construction of the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for tropical climatic conditions. All straight through joints and cable terminations shall have field proven experience of minimum five (5) years without any latent design defects.
- iii) The outdoor end termination up to 245 KV XLPE Cable shall be Anti-fog, Pre-molded type Silicon Rubber stress cone. Torque controlled mechanical shear head bolted connector with polymeric composite housing (resin cast body with silicon shed housing), dry/fluid filled (silicon oil) type self-supporting with Plug-in / Plug-out facilities. The termination base plate and the cable's metallic sheath shall be electrically insulated from the self supporting structure by means of stand-off epoxy insulators designed to withstand both mechanical and electrical stresses in services. The Polymeric insulator in grey colour shall be used. In addition upon, arcing horn and shield ring shall have to be supplied as required for 245 & 420 KV XLPE cables. 10%etra silicon oil shall be supplied with termination if fluid filled is supplied.
- iv) The outdoor end termination for 400kV shall be based on the Silicon / EPR-based stress relief cone with the epoxy housing and the oil-impregnated cylindrical capacitor cone (so called condenser cone type) to secure the uniform longitudinal voltage distribution all along the termination. Pre-molded type Silicon Rubber sleeve outdoor end termination for 400kV may be offered by the manufacturer if the same is available.
- v) The outdoor terminals should be suitable for heavily polluted atmospheric conditions with total creepage distance of 31 mm/ kV and protected creepage distance of not more than 50% of the total creepage distance. The cable end terminals for terminating the cables shall be fully compatible with the cables to be supplied.

- vi) The Indoor Termination at GIS SF6 Housing shall be based on the Silicon Rubber based stress relief cone and the epoxy resin housing. There shall be mechanical devices to maintain the interface pressure. Stress relief cone and mechanical devices shall be designed to fit with controlled interference over the cable insulation and shall follow the cable's diameter variations still guaranteeing under any service condition a sufficient positive pressure to control the electric field concentration. There shall be epoxy insulating plate to isolate between cable sheath and GIS chamber. The SVLs (Sheath Voltage Limiter) shall be installed to protect epoxy insulating plate from switching impulse. Plug-in type leading conductors shall be supplied though at the time of detailed engineering confirmation shall be given for selection of plug-in type. Design and scope of delivery shall be fully complying with IEC-60859, IEC-62271-209 and possibly adjusted to various needs of project. The main insulation components shall be fully examined and tested in the factory.
- vii) For jointing and terminations, one qualified Engineer and required trained EHV jointers with supporting staff should be deputed. The engineer and EHV jointers shall possess valid certificate from the manufacturer of the Accessories, for erection.
- viii) The detailed description on jointing procedure shall be furnished during detailed engineering.
- ix) The details of the performance of end terminations / straight through joints as offered with the period in service in reputed Indian Utility should be furnished for 145 KV & 245 KV and reputed International/ Indian utility for 420 KV Cable accessories for evaluation of the techno-commercial offer.
- x) The accessories shall be Type Tested as per relevant IEC 60840 & Type test report shall have to be furnished for technical evaluation.

20.31 WORKING PROCEDURE FOR TERMINATION

- (i) At cable terminating end sufficient length of spare cable shall be left in the ground and at cable tray also at GIS, for future needs.
- (ii) The rise of the cable immediately from the ground shall be enclosed in PVC/ PE pipe of suitable diameter to protect against direct exposure to the sun.
- (iii) The cable shall be properly fastened using non-metallic clamps.
- (iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.
- (v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.
- (vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fiber shroud.
- (vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS-3043:1987 (Code of practice for earthing).

20.32 WORKING PROCEDURE FOR JOINTING

- (i) The cable jointing personnel and his crew shall have good experience and with HT license in the type of jointing and terminations that are used. The jointing works shall commence as soon as two or three lengths of cable have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends and the cable end shall be sealed whenever the end is exposed for tests.
- (ii) Jointing of cables in carriage ways, driveways under costly paving, under concrete or asphalt surfaces and in proximity to telephone cables and was mains should be avoided wherever possible.
- (iii) Sufficient overlap of cables shall be allowed for making the joints.
- (iv) The joint bay should be sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed. **3 ph link box for cross bonding to be placed inside the bay with provision for easy access for maintenance purpose.**
- (v) The joints of different phases shall be staggered in the jointing bay.
- (vi) Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.
- (vii) The materials used in the joints like ferrules, screen/ sheath continuity bonds, lugs etc. shall be of good quality and conform to standards.
- (viii) The jointing tools shall be appropriate and as per the requirement of jointing HVXLPE cables.
- (ix) **SUMP HOLES**

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or drained out by buckets, without causing interference to the jointing operation.

(x) TENTS/COVERS

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

(xi) PRECAUTIONS BEFORE MAKING A JOINT

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions which might become uncontrollable.

If the cable end seals of cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

(xii) MEASUREMENT OF INSULATION RESISTANCE

Before joining, the insulation resistance of both sections of cables shall be checked.

(xiii) The identification of each phase shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

20.33 BONDING OF SCREEN/ SHEATH

The screens at both ends, shall be brought out and bonded to the earth station through disconnecting type link boxes or through SVL wherever applicable. On the basis of the length of the cable and current carrying capacity, the bonding maybe required **as per IEEE 575** as follows:

1. Single End Bonding
2. Double End Bonding
3. Cross Bonding
4. Midpoint bonding

All accessories and consumables used in the termination should be of good quality and compatible with the cable. At the time of single end bonding parallel Aluminium earth continuity conductor along the length of the cable shall have to be provided between the two ends of the cable. Bonding cable of **1.1KV Aluminium** XLPE insulated shall be provided for bonding of metallic sheath/ Screen.

The screens at both ends, shall be brought out and bonded to the earth station through disconnecting type link boxes or through SVL wherever applicable. On the basis of the length of the cable and rise of sheath Voltage the bonding maybe required as follows:

1. Single End Bonding
2. Double End Bonding
3. Cross Bonding
4. Mid point bonding

All accessories and consumables used in the termination should be of good quality and compatible with the cable. At the time of single end bonding parallel Aluminium conductor along the length of the cable shall have to be provided between the two ends of the cable. Bonding cable of 6.6KV Aluminium shall be provided for bonding of metallic sheath/ Screen.

20.34 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

20.35 STATUTORY APPROVAL OF WORKS

Contractor shall make an application on behalf of the owner for submission to the Electrical Inspectorate along with copies of required certificates complete in all respects and submit to the engineer-in-charge for onward transmission well ahead of time so that the actual commissioning of system/ equipment is not delayed for want of inspection by the Inspector. Contractor shall arrange the actual inspection of work by the Electrical Inspector. Necessary coordination and liaison work in this respect shall be the responsibility of the contractor.

The Inspection and acceptance of work as above shall not absolve the Contractor from any of his responsibilities under this contract.

Any other statutory approval of works required for the electrical installation (such as Factory Inspector, CCOE, etc.) is also included in contractor's scope.

Supply & execution of job is subjected to regulations time to time framed by the AERC; approval Govt. Of Assam, and NOC from Assam Pollution Control Board. Contractor shall complete the entire job in compliance with the same.

20.36 INSPECTION, TESTING AND COMMISSIONING

- 20.36.1 Inspection of Supplied materials and Site works time to time during execution: Inspection of AEGCL and clearance from AEGCL will be in Contractor responsibility. Expenditure related to this inspection will be in contractor account. Site inspection, testing and commissioning of electrical installation shall be carried out as per enclosed Specification and Inspection and Test Plans included or referred in this BID. All the equipment installed by the contractor shall be tested and commissioned, as required and no separate payments shall be made unless otherwise specified in the Schedule of Rates. Contractor shall carefully inspect all equipment and submit the manufacturer's Certificate before installation. Any damage or defect noticed shall be brought to the notice of the engineer-in-charge at that time and same shall be rectified or replaced by CONTRACTOR on his OWN RISK AND COST within TIME FRAME. Complete testing of power transmission system would be carried out under the supervision of the Employer.
- 20.36.2 Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the contractor shall carry out the rectification at his own cost.
- 20.36.3 The contractor shall carry out all the tests as enumerated in the tender and technical specifications and technical documents which may be furnished to him during performance of the work.
- 20.36.4 Before the electrical system is made live, the electrical contractor shall carry out suitable tests to establish to the satisfaction of the Employer that the installation of equipment, cabling/ wiring and connections have been correctly done and are in good working condition and that the system/ equipment will operate as intended.
- 20.36.5 All tests shall be conducted in the presence of Employer/ Engineer-in-Charge or his authorized representative unless he waives this requirement in writing. Contractor shall arrange testing equipment, as required to carry out the tests. Test results shall be recorded on approved Performa and certified records of the tests shall be submitted to the Employer/ Engineer-in-Charge.
- 20.36.6 Prior intimation to be given to the Employer before finalizing of date of scheduled inspection at least 15 days in advance.
- 20.36.7 Clearance in favour of contractor for dispatch of equipment/material from respective works of manufacturer will be covered by the Employer after physical inspection and witnessing satisfactory routine and acceptance tests. Contractor will have to arrange physical inspection and witnessing of Routine and Acceptance Test of materials/equipments at respective manufacturer's works by two engineer of the Employer and cost of such inspection shall have to be borne by contractor. Clearance for dispatch of equipments & materials from respective works of manufacturers will be conveyed by the Employer after verification and acceptance thereafter.
- 20.36.8 After the completion of all tests and rectification of all defects pointed out during final inspection, plant start-up trials shall commence. During the start-up trials, contractor shall provide skilled/ unskilled personnel and supervision round the clock at his own cost. The engineer-in-charge/Employer will decide the number and the category of workmen and their duration. Any defects noticed during the start-up trials relating to the equipment supplied and work carried out by the contractor, shall be rectified by the contractor at his own cost.
- 20.36.9 The Employer shall have the right to get the defects rectified at the risk and cost of the contractor if he fails to attend to the defects immediately as desired.
- 20.36.10 Contractor shall also inform the Employer/ Engineer-in-charge, well in advance in case services of any OEM (Equipment manufacturer) are required and same shall be arranged by Contractor at the time of commissioning on his own cost.

- 20.36.11 Contractor shall furnish site acceptance test (SAT) procedures from the equipment supplier and get it approved from the Employer/ Engineer-in-charge before carrying out the same at site.
- 20.36.12 Contractor shall prepare detailed testing, pre-commissioning and commissioning procedures for the entire installation. These shall include Performa for defining activities and recording of test results.
- 20.36.13 It is the responsibility of the contractor to coordinate and provide all necessary assistance to other contractors / agencies/ vendors involved in the complex for proper and timely execution of the works. Further contractor shall do all the liaisoning, documentation or other related formalities with respective authorities/agencies for successfully charging/commissioning of system.
- 20.36.14 The following equipment/ items as included in Contractor's scope of supply shall be tested and inspected by AEGCL or his authorized representative before dispatch at the manufacturer's works. Test certificates duly signed by AEGCL or his authorized representative shall be submitted by the contractor as part of the final document:
- a) EHV cable & optical fiber cables and Linear Heat sensing cable.
 - b) Jointing & termination kits for above items.

20.37 ENGINEERING DATA AND DRAWINGS

The Bidder shall necessarily submit all the drawings/ documents unless anything is waived. The Bidder shall submit 4(four) sets of drawings/ design documents/ data/ test reports as may be required for the approval of the Employer.

All drawings submitted by the Bidder including those submitted at the time of bid shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal and the external connections, fixing arrangement required and any other information specifically requested in the specifications.

All engineering data submitted by the Bidder after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

20.38 INSTRUCTION MANUAL

- (i) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.
- (ii) If after the commissioning and initial operation, the instruction manuals require any modifications/ additions/ changes, the same shall be incorporated by the bidder in the final submission.
- (iii) The Bidder shall furnish to the Employer catalogues of spare parts.

20.39 QUALITY ASSURANCE PROGRAMME

- a. To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Bidder's Works or at his sub-bidder's premises or at the Employer's site or at any other place of work are in accordance with the specifications, the Bidder shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be outlined by the Bidder and shall be finally accepted by the Employer after discussions before the award of Contract.
- b. Quality Assurance Documents

The Bidder shall be required to submit the following Quality Assurance Documents within three weeks before laying/ erection of the equipment.

- (i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication and reports including radiography interpretation reports.

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- (ii) Welder and welding operator qualification certificates.
 - (iii) Welder's identification list, listing welder's and welding operator's qualification procedure and welding identification symbols.
 - (iv) Raw material test reports on components as specified by the specification and/or agreed to in the quality plan.
 - (v) Stress relief time temperature charts/ oil impregnation time temperature charts.
 - (vi) Factory test results for testing required as per applicable codes/ mutually agreed quality plan/ standards referred in the technical specification.
 - (vii) The quality plan with verification of various customer inspection points (CIP) as mutually agreed and methods used to verify the inspection and testing points in the quality plan were performed satisfactorily.

20.40 EQUIPMENTS & STRUCTURES FOR CABLE TERMINATION

1. The terminating structure being provided should be designed as per the requirement of the cable end sealing, porcelain bushing etc. The mounting structure shall be fixed on the cement concrete foundation, the design and drawings of which shall be submitted to Employer for review and acceptance during the course of detailed engineering.

After fixing the end termination, the cable shall be fixed to the support, with non- magnetic material clamps to the required height securely. The mounting structure includes the supports for cable end boxes, link boxes and any other structure required for the intent of the contract. All steel sections used shall be free from all imperfections, millscales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer.

2. Suitable fencing should be provided at the cable terminating yard at cable conductor junction point. The fencing will consist of galvanized steel XPM structure over a brick wall of 2(two) feet meeting electrical requirement (IE). A suitable entry point (gate) has to be provided.
3. Outdoor type lightning arresters for each cable of both the circuits are to be provided at cable-conductor junction point. The technical specification of lightning arresters is given separately in this volume.
4. It is recognized that the Bidder may have standardized on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to the Employer. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification and the catalogues or the bid, if not clearly brought out in the specific requisite schedule will not be considered as valid deviation.
5. Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the work unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/ parts of similar standard equipment provided shall be inter-changeable with one another.
6. STEEL STRUCTURES (GANTRY, EQUIPMENTS ETC.):

- A) The contractor shall assume full responsibility for supply, fabrication and detailing, if required of the steel structures and for their satisfactory performance. All detail drawings for the structures shall be

supplied to the successful bidder by the Employer/Engineer. However, the contractor shall have to submit the construction drawings to the Engineer/Employer solely prepared on the basis of these supplied drawings. Equipment Structure drawings, supplied by the employer, shall have to be modified to suit to the approved GA drawings of the equipment and electrical layout drg. And to be submitted to Engineer for approval. Employer/ Engineer shall have the right to instruct the contractor to make any changes in details necessary to make the construction conform to the requirement of the Contract Document.

- B) The contractor shall supply all materials, deliver the same to site, and provide all labour, erection plant and equipment, fixtures, fitting and all temporary and permanent works necessary for satisfactory completion of the job in all respects.
- C) No omissions or ambiguities on the drawings or in specifications will relieve the contractor from furnishing best quality of materials and workmanship. Should any inaccuracies be found, the contractor shall promptly notify the Employer/Engineer without carrying out the job and no further work shall be done before these discrepancies are corrected. Continuation of further work shall be done only after such discrepancies are rectified at contractor's risk and responsibility.
- D) MATERIALS: The materials shall conform to the following requirements:

All Structural Steel Materials to be used in construction within the purview of the specification shall comply with :IS:2062 –Structural Steel (Grade-A) (fusion welding quality) and manufactured by Prime Rollers e.g. SAIL/ TISCO/ IISCO/ RINL. In case of MS sections not manufactured by prime rollers or such sections are not available with prime rollers the same is to be procured from approved conversion agents of prime manufacturer(s).In such case, prior approval of the Engineeris to be obtained by the contractor.

Successful bidder on receipt of structural drawing from department shall submit within 15 days, a detailed raw material procurement plan indicating MS sectionwise producers name to the Engineer for approval. On according approval in this aspect, work for fabrication protos shall be taken up in hands.

Entire fabrication job of MS structural shall not be entrusted to more than two sub- vendors. Further, a list of bonafide fabricators, not exceeding 6 (six) shall be furnished to the Engineer for according approval within 15(fifteen) days from the date of handing over of drawings.

All electrodes to be used under the contract shall comply with any of the following Indian Standard Specifications as may be applicable.

- i) *IS:814: Covered electrodes for metal arc welding of Structural Steel.*
- ii) *IS:815: Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.*
- iii) *IS:144: Covered electrodes for the metal arc welding of high tensile structural steel.*

All bolts and nuts shall be of grade 5.6HRH and shall conform to the requirements of IS:6639 and IS:1367 and galvanizing quality shall be as per IS:1367. All bolts and nuts shall be of minimum diameter of 16mm unless otherwise stated. All mildsteel for bolts and nuts when tested in accordance with the following Indian Standard specification shall have a tensile strength of not less than 44Kg/Sq.mm. and a minimum elongation of 23 percent on a gauge length of 5.6A, where 'A' is the cross sectional area of the test specimen-

- i) *IS:1367: Technical supply conditions for threaded fasteners.*
- ii) *IS:1608: Method for tensile testing of steel products other than sheet, strip, wire and tube.*

Washers shall be made of steel conforming to IS:226, IS:961 as may be applicable under the provisions of the contract and shall be electrogalvanized.

7 FASTNERS & CONNECTIONS:

- a) BOLTS: All connections shall be bolted with 16mm bolts.
- b) SPLICES: Splicing shall be avoided unless the length of a member exceeds 6.0 m or so. The member of splices shall be limited to a practical minimum. No credit shall be allowed for bearing on a butting

areas. Lap joints in leg members shall be preferred to butt joints.

- c) STEP BOLTS: Step bolts shall be of 16mm diameter and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125mm respectively. Step bolts shall not be used as connection bolts. The step bolts shall be spaced alternately on the inner gauge line on each face of the angle about 40cm centers. They shall be furnished for one leg of each steel structure column from its base elevation.
- d) U – BOLTS: U-Bolts shall be suitable furnished for steel structures to suspend or terminate insulator strings or ground wire assemblies. Size of U-bolt shall withstand all loads acting on it.
- e) BILL OF MATERIAL: Bill of material shall give the size, length and weight of each member and the total weights of steel structures. It shall also include the number of bolts, nuts and washers per structure.

20.41 MATERIAL/ WORKMANSHIP

Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new of highest grade of the best quality of their kind conforming to best engineering practice and suitable for the purpose for which they are intended.

In case where the equipment, materials or components are indicated in the specification as “similar” to any special standard, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Bidder shall submit, for approval, all the information concerning the materials or components to be used in manufacture, Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Bidder.

The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.

Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, leveling, aligning, coupling of or bolting down to previously installed equipment bases/ foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification.

Provision for Exposure to Hot and Humid climate: Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew.

20.42 PACKAGING & PROTECTION

- a. All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or

deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Bidder shall also submit packing details/ associated drawing for any equipment/ material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Bidder shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharf age and other such charges claimed by the transporters, railway etc. shall be to the account of the Bidder. Employer takes no responsibility of the availability of the wagons.

- b. All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damaged. The parts which are likely to get rusted, due to exposure to weather should also be properly treated and protected in a suitable manner.

20.43 FINISING OF METAL SURFACES

- a. All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed shall be hot-dip galvanized after fabrication. High tensile steel nuts and bolts and spring washers shall be electro galvanized to service condition. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to IS:2629.
- b. HOT DIP GALVANISHING
The minimum weight of the zinc coating shall be **900gm/sq.m** and minimum thickness of coating shall be **130 microns for outdoor and minimum thickness of coating shall be 85 microns for indoor for all items thicker than 6mm**. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface, which shall be embedded in concrete the zinc coating shall be 610gm/sqm minimum.
- c. The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

After galvanizing no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

The galvanized steel shall be subjected to six one minute dips in copper sulphate solution as per IS-2633.

Sharp edges with radii less than 2.5mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant Indian Standards

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

Galvanized material must be transported properly to ensure that galvanized surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

d. PAINTING

- i) All sheet steel work shall be degreased, pickled, phosphate in accordance with the IS-6005 "Code of practice for phosphating iron and sheet". All surfaces which will not be easily accessible after shop assembly shall be forehand be treated and protected for the life of the equipment.
- ii) ~~The surfaces, which are to be finished painted after installation or require corrosion protection until installation shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be~~

- thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- iii) After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.
 - iv) After application of the primer, two coats of finishing synthetic enamel paint shall be applied each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.
 - v) The exterior color of the paint shall be as per shade no: 697 of IS-5 and inside shall be glossy white for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective sections of the equipments. Each coat of primer and finishing paint shall be slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.
 - vi) In case the Bidder proposes to follow his own standard surface finish and protection procedures or any other established painting procedures like electrostatic painting etc. the procedure shall be submitted along with the Bids of Employer's review and approval.

20.44 HANDLING, STORING AND INSTALLATION

- a. In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Bidder shall unload, store, erect, install, wire, test and place in to commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workman like manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energization at rated voltage.
- b. Bidder may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Bidder shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.
- c. In case of any doubt/ misunderstanding as to the correct interpretation of manufacturer's drawings or instruction, necessary clarifications shall be obtained from the Employer. Bidder shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings / instructions correctly. Where material/ equipment is unloaded by Employer before the Bidder arrives at site or even when he is at site. Employer by right can hand over the same to Bidder and there upon it will be the responsibility of Bidder to store the material in an orderly and proper manner.
- d. The Bidder shall be responsible for making suitable indoor storage facilities to store all equipment, which require indoor storage.
- e. The words 'erection' and 'installation' used in the specification are synonymous.
- f. Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.
- g. The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.7.1 the Bidder shall immediately proceed to correct the discrepancy at his risks.

20.45 QUALITY CONTROL:

- a. The contractor shall establish and maintain quality control procedures for different items of work and materials to ensure that all work is performed in accordance with the specifications and best modern practice.
- b. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer. As far as possible all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at site or elsewhere. The contractor shall cooperate with the Engineer in permitting access for inspection to all places where work is being done and in providing free of cost of all necessary help in respect of tools and plants, instrument, labour and material required to carry out the inspection. Materials or workmanship not in reasonable conformance with the provisions of this specification may be rejected at any time during the

progress of the work.

c. The quality control procedure shall cover but not be limited to the following items of work :

d. Steel: Quality, manufacturer's test certificates, test reports including procurement in-voice of representative samples of materials from unidentified stocks if permitted to be used.

e. Bolts, nuts & Washers: Manufacturer's certificate, dimension check, material testing

f. Electrodes: Manufacturer's certificate, thickness and quality of flux coating.

g. Welds: Inspection, X-ray, ultrasonic test, magnetic particle tests as required

h. Paints: Manufacturer's certificate, physical inspection reports.

i. Galvanizing: Tests in accordance with IS:2633 – Method of testing uniformity of coating on zinc coated articles and IS:2629 Recommended practice for hot - dip galvanizing of iron and steel. Raw zinc & samples collected from bath shall be tested at third party laboratory as per direction of the Engineer.

j. The contractor shall submit a detailed material inspection plan on the basis of various IS codes & standard practices in respect of structural fabrication, galvanization, bolts, nuts, anchor bolts etc. much prior to commencement of the job.

20.44 FABRICATION WORKMANSHIP:

- 20.44.1 All workmanship shall be equal to the best practice in modern structural shop and shall conform to the provisions of IS:800/ IS:802.
- 20.44.2 Rolled materials before being laid off or worked, must be clean free from sharp kinks, bends, or twists and straight within the tolerances allowed by IS:1852. If straightening is necessary it may be done by mechanical means or by the application of a limited amount of localised heat not exceeding 600°C.
- 20.44.3 Cutting shall be effected by shearing, cropping or sawing. Use of mechanically controlled Gas Cutting Torch may be permitted for mild steel provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. To determine the effective size of members cut by gas, 3mm shall be deducted from each cut edge.
- 20.44.4 The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2mm at each end. The erection clearance at ends of beams without cleats shall not be more than 3mm at each end, but where for practical reasons greater clearance is necessary, suitably designed clearance shall be provided.
- 20.44.5 All members shall consist of rolled steel sections.
- 20.44.6 Holes for bolts shall not be more than 1.5mm larger than the diameter of the bolt passing through them unless otherwise stated.
- 20.44.7 All members shall be cut to jig and all hole shall be punched and drilled to jig. All parts shall be carefully cut and holes accurately located after the members are assembled and tightly clamped or bolted together.
- 20.44.8 Drifting or rimming of holes shall not be allowed. Holes for bolts shall not be formed by gas cutting process.
- 20.44.9 Punching of holes will not be permitted for M.S. members upto 8mm thick and in no case shall a hole be punched where the thickness of the material exceed the diameter of the punched hole.
- 20.44.10 Minimum bolt spacing and distances from edges of members shall in accordance with the provisions in the relevant Indian Standard Specification.
- 20.44.11 Built members shall, when finished, be true and free from all kinds of twists and open joints and the material shall not be defective or strained in any way.
- 20.44.12 All bolts shall be galvanized including the threaded portion except the foundation bolts for which galvanizing work shall be done for a length of 100mm (min) to 175mm (max) measured from the tip of the treaded portion. The threads of all bolts shall be cleared of smelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Engineer. All nuts shall be galvanized with the exception of the threads which shall be oiled. In case of foundation bolts the same shall be galvanized excepting the length of embedment.
- 20.44.13 When in position all bolts shall project through the corresponding nuts but not exceeding 10 mm. The nuts of all bolts attaching insulator sets and earth conductor clamps to the structure shall be carefully positioned as directed by the Engineer.
- 20.44.14 Bolts and nuts shall be placed in such a way so that they are accessible by means of an ordinary spanner.
- 20.44.15 Foundation bolts shall be fitted with washer plates or anchor angles and flats, nuts etc. and shall be manufactured from mild or special steel.

20.44.16 Washers shall be tapered or otherwise suitably shaped, where necessary to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least by 3mm. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut. In addition to the normal washer, one spring washer or lock nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified in the drawings.

20.44.17 The thickness of spring washer shall be 3.5 mm for bolt diameter 16 mm and 4 mm for bolt diameter 20 mm.

20.45 CLEANING & GALVANIZING:

20.45.1 CLEANING:

After fabrication has been completed and accepted, all materials shall be cleared off rust, loose scale, dirt, oil grease and other foreign substances.

20.45.2 GALVANIZING:

All materials shall be hot-dip galvanized after fabrication and cleaning. Re tapping of nuts after galvanizing is not permitted.

Galvanizing for structural mild steel products shall meet the requirements of IS:4759. All holes in materials shall be free of excess spelter after galvanizing.

Galvanizing for fasteners shall meet the requirements of IS:1367. The spring washers shall be electrogalvanized as per IS:1573.

Finished materials shall be dipped in to the solution of dichromate after galvanizing for white rust protection during transportation.

All galvanizing shall be uniform and of standard quality. Quantity of zinc shall meet the requirement of IS:209.

Mass of Zinc Coating:

The mass of zinc coating for different class of materials, as given in Table below, shall be followed:

MASS OF ZINC COATING

Sl. No.	Product	Electro meter reading (micron)	Minimum value of average mass of coating
i)	Casting - gray iron, malleable iron		610 (gm/m ²)
ii)	Fabricated steel articles :		
a)	5 mm thick and over	86	610
b)	Under 5 mm, but not less than 2 mm	65	460
c)	Under 2 mm, but not less than 1.2mm	48	340
iii)	Threaded work other than tubes and tube fittings :		
a)	10 mm dia and over	43	300
b)	Under 10 mm dia	39	270
iv)	All Outdoor structures	130	900

20.46 SPECIFIC TECHNICAL PARTICULARS FOR 66KV, 132 KV & 220KV XLPE CABLE

Sl.No.	ITEMS	PARTICULARS
1	Description of Cable	Stranded single core compacted Aluminium core screening by a layer of semi conducting tape followed by a layer of semiconducting compound as conductor screen, XLPE insulation, insulation screening with semiconducting compound extruded directly over the insulation, (semiconducting conductor screen, XLPE insulation, semiconducting insulation screen-all in one triple extrusion process), longitudinal sealing by a layer of water swellable semiconducting non woven tape over insulation screen, followed by radial sealing (metal sheath of Corrugated Aluminum),and overall extruded black HDPE Sheathed (TypeST7).
2	Highest system voltage	72.5KV 145KV 245KV
3	Voltage Grade	36/66KV 76/132KV 127/220KV
4	Voltage variation	+10% and -12.5%
5	Frequency	50 Hz
6	Frequency variation	±3%
7	Power frequency withstand voltage	90KV rms for 30 minutes 190 KV rms for 30 minutes 318KV for 30 minutes
8	Lightning impulse withstand voltage	±325KVpeak 650KVpeak 1050peak
10	No of phase per Ckt	3
11	Earthing system	Effectively earthed
12	Size of Cable	As per BoQ
13	Max. in Conductor Temp.	90°C at maximum continuous current.

14	Fault level	31.5KA for 3 second 40Ka for 3 second 50KA for 3 second (considering parallel path of lead sheath and screen Aluminium for metallic screen)
15	Maximum permissible short ckt temperature.	250°C for one second.
16	CABLE DETAILS : CONDUCTORS	
16.1	Conductor material	Plain un-tinned annealed Aluminium.
16.2	Conductor Shape	Compacted circular.
16.3	Conductor Screen	Extruded, Cross-linked, semi conducting compound of suitable thickness. Semi conducting separator tapes with 50% overlap to be applied between conductor and conductor screen.
16.4	Resistivity of the semiconducting screen	Maximum 1000 ohm-meter
16.5	Insulation	
	a)material	XLPE
	b)specified insulation resistance at 90°C	1×10^{12} ohm cm
16.6	Insulation Screen: Type & Material	Extruded semi conducting compound.
16.7	Resistivity of the semiconducting compound	Max 500 Ohm-meter
16.8	Longitudinal water barrier Material	Layer of semiconducting tape with suitable water swellable absorbent with 50% overlap.
16.9	Radial moisture barrier Material	Seamless or seam welded Corrugated Aluminum sheath with anti-corrosive material.
16.10	Overall sheath	Extruded black HDPE (TypeST7) with anti termite and anti rodent treatment.
16.11	Coating of outer sheath	A hard baked layer of graphite or semi conducting layer shall be applied over the outer sheath as outer electrode for testing the sheath.
17.	Approximate Length of cable in a drum	500 metres with a tolerance range of $\pm 5\%$ or as per requirement.
18	Bending Radius	The minimum bending radius of XLPE insulated cables as follows: Cable: Bending radius Single Core: $25 \times D$ D – diameter of overall conductor.
19	TESTS Applicable standards	IEC60840 IEC62067
19.1	Type Test	All tests as per specifications IEC

	a)whether previous test reports will be sufficient b)whether sample to be Type tested against this order.	Standards Yes, if done on identical cable. No, if done on identical cable.
19.2	Routine Test	All tests as per specifications IEC Standards.
19.3	Acceptance Test	All tests as per specifications IEC Standards.
19.4	Whether test will be witnessed by purchaser or his representative	Yes. Acceptance test will be witnessed.
20	INSTALLATION, TERMINATION AND JOINTS	
21	Ambient temperature Ground temperature Thermal resistivity of soil	45°C 30°C 150°C cm/Km
22	Laying Configuration	Trefoil formation.
23	Depth	1.5 m below ground level.
24	Termination	
25	Type	AS per requirement
26	Joints Required	No
27	Earth Link Boxes Required	Yes. In both end and at joints as per cable bonding system
28	Surge Suppressor Required	Yes
29	Type Bonding ‘	Single end bonding/ cross bonding