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TECHNICAL SPECIFICATION

CONTROL AND RELAY PANEL , SAS ,AC KIOSK

PROTECTION AND CONTROL PANELS

1.0 Panels

General

Simplex and/or duplex panels shall be provided to suite the substations site. Bidder shall be fully responsible for his bids to match the dimensions, colour and fittings with those in the existing control rooms where the extensions are required. In no case any proposal for increase in price at a later date shall be entertained by the Employer. However panels not matching those already installed may be acceptable to the Project Manager. Specific approvals will be required on a case by case basis.

Panels shall be free standing mounted on floors fitted with embedded channels, insert plates or foundation bolts. The panels shall be made vibration and shock proof by providing anti vibration strips.

The base frame of all panels shall have a smooth bearing surface such that when fixed on the embedded foundation channels/insert plates it shall be free standing and provide a level surface.

The panels shall be completely metal enclosed, dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IS 13947

The design, materials selection and workmanship shall be such that it provides a neat appearance both inside and outside without signs of welds, rivets or bolt heads from outside. The exterior surfaces shall be smooth and sleek.

Relay panels of modern modular construction in 19 inch hinged racks would also be acceptable.

Cable entry to the panels shall be from the bottom. The provision of all cable glands and shrouds of the panel shall be part of the scope of supply. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor.

1.1 Simplex Panel

Simplex panels shall be provided with equipment mounted on front panel vertically. The wiring access shall be from rear for control panels and either from front or rear for relay panels. Where panel width is more than 800 mm, double leafed doors shall be provided. Doors shall be fitted with either built-in locking facility or with padlock.

1.2 Duplex Panel

Duplex panels shall be walk-in, tunnel type comprising of two vertical front and rear panels connected back to back by formed sheet steel roof as tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. Where a number of duplex panels are located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall be fitted with either built-in locking facility or with padlock. Separate bottom cable entries shall be provided for the front and rear panels. The inter-connections between front and back panels shall be established by providing wiring at the top of the panel.

IMP: Only Relay panel front side should be provided with protective front door with PRESPEX cover with flush type handle with locking facility to protect the relays from the external.

1.3 Constructional Features

It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes can be properly accommodated in the panels without congestion. Panels shall be free standing, floor mounting type and shall comprise of structural frames completely enclosed with smooth finished, cold rolled sheet steel of thickness not less than 3 mm for all weight bearing members such as base frame, front panel, door frames. All other parts may be provided with 3.0 mm thick steel sheet. There shall be sufficient reinforcement to provide level surfaces, resistance

to vibration and rigidity during transportation and installation. All doors, removable covers and panels shall be gasketted all around with neoprene or superior material. Ventilating louvres, where provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

1.4 Mounting

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices. Equipment shall be readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible. The Contractor shall carry out cut-out, mounting and wiring of all equipment and items which are to be mounted in his panel. Cut-outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plates. The center lines of switches, push buttons and indicating lamps shall be not less than 750 mm from the bottom of the panel. The center lines of relays, meters and recorders shall be not less than 450 mm from the bottom of the panel. The center lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. The top lines of all meters, relays and recorders etc. shall be matched. No equipment shall be mounted on the doors. All the equipment connections and cabling shall be designed and arranged to minimise the risk of fire and damage which may be caused by fire.

1.5 Terminal Blocks

Terminal blocks and boards shall conform to the requirements of the relevant sections of this Specification. De-link type terminal blocks shall be provided in all the circuits and Terminals.

1.6 Supporting steel

All necessary embedded levelling steel, sills, anchor bolts, channels and other parts for supporting and fastenings the panels and vibration damping shall be supplied by the Contractor.

Instruments, Meters, Recorders and Transducers

2.0 General

All instruments, meters, recorders and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All indicating instruments and recorders shall be digital type and provided with individual transducers and shall be calibrated along with the transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have a means of calibrations check and adjustment at site. The Contractor shall confirm that the indicating instruments, recorders along with transducers and energy meters offered by him are suitable for connecting to the instrument transformers having the technical particulars given in reference drawing. Synchronizing Instruments shall also meet the requirements of the relevant clause of this section of the Specification. Digital bus voltage and frequency meters shall be of class 0.5 and shall have digital readouts of five and four digits respectively, with display size, not less than 50 mm (height)

2.1 Metering Instruments

Energy-meters **(NOT REQUIRED)**

Energy meters shall be provided on all line feeders, transformer feeders, buscoupler and bus transfer bays as per the requirements stated in the schedule of requirement of this specification.

On 400/220/132 kV feeders emanating from various substations, where commercial metering is required redundant energy metering in form of MAIN shall be employed.

All 33 kV feeders emanating from various substations shall be treated as feeders with commercial metering requirements. Only single energy meters shall be employed.

Energy meters shall be solid state trivector type. The energy meters are intended to measure, record and display active energy (kWh/MWh), reactive energy (kVARh/MVARh), apparent energy (kVAh/MVAh), Maximum Demand (MVA/kVA/MW/kW/ etc. They should be of

three phase two element type or three element type suitable for measurement of unbalanced loads in three phase, three wire circuits. The meters shall be provided with at least six registers for TOD metering purposes. The meters shall have LCD or cyclometer type registers.

Energy meters shall be of draw out or non-drawout type and suitable for flush mounting with back connected terminals.

Energy meters shall be suitable for operation from the secondary of CTôs and VTôs. Separate test blocks for the testing of the meters (without disturbing the CT and VT secondary connections) shall be provided.

Energy Meters shall have reverse running stops. Meters shall conform to IEC 687 /IS 13779. All watt-hour meters shall have accuracy class of 0.2. All VARh-hour meters shall have accuracy class of 3.0. The energy meters shall also conform the requirements stipulated in Technical Report of Central Board of Irrigation and Power, India.

Energy Meters shall be compensated for temperature errors and factory calibrated to read the secondary quantities. The number of digits provided shall be adequate to cover at least 1500 hours of operation.

Current coils of the meters shall have continuous overload capacity of at least 200% for both accuracy and thermal limits, and shall withstand at least 20 times of rated current for 0.5 seconds without loss of accuracy.

Energy meters should have facilities for data transfers remote metering with proper security via an optically isolated communication port using serial communication. Where required, output ports shall be provided for summation and time synchronisation.

Energy meters shall be provided with features for monitoring tamper and fraud. The possible cases of tamper and fraud shall be proposed by the Project Manager to Contractor for incorporation in to the metering software.

Energy meters should be provided with adequate software and hardware to store the load survey data from the last reset time. Energy meters shall also be provided with self diagnostic features.

Technical requirement for energy meters

Description	**Requirement**
Operating voltage	110V Phase to phase, 65.3V Phase to neutral
Operating current	1ð 5 A
Measurement	Real and reactive energy Maximum demand Bi-directional power flow
Display	Digital type (electronic type). In case of electronic type of display the minimum retention time for non volatile memory shall not be less than 5 years
Communication	Optical Port / Eð Port

Table 9.3.2. Technical requirements for energy meters

2.2 Recording instruments

Recording instruments shall have the following characteristics features :

- Static/Digital type voltage and frequency recorders in individual units for the sub-station with time tagged information shall be acceptable. It shall meet the accuracy of +/-:1.0% span and full span response time of less tha 2 seconds. It shall also meet the high voltage susceptibility test,impulse voltage withstand test,high frequency disturbance test ï class III and fast transient disturbance test leve III as per IEC 602555.

2.3 Transducers

General

The transducers used for recording/indicating instruments and telemetry/data communication applications shall in general conform to IEC 688-1.

Transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase, four wire system. These could be separate or combined type. Serial port on combined type is also acceptable.

The input to the transducers will be from substation current and potential transformers. The output shall be in milli ampere DC proportional to the input. It shall be possible to feed the output current directly to the telemetry terminals, indicating instruments or recording instruments.

The transducer characteristic shall be linear throughout the measuring range.

The transducer output shall be load independent.

The input and output of the transducers shall be galvanically isolated.

The transducer shall derive its auxiliary supply from the quantity to be measured without need for any external supply.

Each transducer shall be housed in a separate compact case and have suitable terminals for inputs and outputs. Input side terminal connectors (from CTôs and PTôs) to be suitable for three phase, four wire connection.

The transducers shall be suitably protected against transient high peaks of voltage and current.

The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 200% of the rated input current as applicable.

Voltage, frequency and current transducers associated with the ISCS shall have an output to 0-10 mA and the active and reactive power transducers shall have an output of 10-0-10 mA.
Voltage, frequency and current transducers associated with conventional systems shall have an output to 4-20 mA and the active and reactive power transducers shall have an output of 10-0-10 mA.

The response time of the transducers associated with ISCS shall be less than 500 milliseconds. Response time for transducers associated with conventional systems shall be less than one second.

The transducers shall have a working temperature range of 0-50C.

The accuracy class of transducers shall be 0.5 or better except for frequency transducer which shall be 0.2.

The transducers shall have an AC ripple on output of less than 1%

The transducers shall be suitable for load resistance of 1000-1500 ohms

The CT and PT ratios and scale ranges for the voltage, current and frequency transducers shall be suitable for the various CT and PT ratios (as applicable) furnished with the specification and compatible with the feeder/transformer voltage levels and ratings.

The transducer shall be provided with terminal connectors for wire of maximum cross section of 4 mm., with dual screws, for rigid connections.

The transducer shall have dual output.

Transducers (recording/indicating instruments and telemetry/data communication application)

The transducers shall in general conform to IEC 688-1 and have the following features:

- Each transducer shall be housed in a separate compact case and have suitable terminals for inputs and outputs.
- The transducers shall have an output of 4-20 mA.
- The response time of the transducers shall be less than one second.
- The accuracy class of transducers shall be 0.5 or better except for frequency transducer which shall be 0.2.
- The PT ratios and scale ranges for the voltage and frequency transducers shall be as follows:

	PT Ratio	**Scale range**
Voltage transducer :	400kV/110V	0-500kV

220kV/110V	0-300kV
132kV/110V	0-200kV
33kV/110	0-50kV

Frequency transducers : as above 45-55 Hertz.

All the transducers shall be suitable for CT and PT parameters specified.

- The transducer shall have dual output.

2.4 Annunciation System:

General

The annunciation shall be of visual and audible type. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels. The audible alarm shall be provided by alarm buzzer or bell. The annunciation facia shall be provided with translucent plastic windows for alarm points with minimum size of 35 mm x 50 mm. The facia plates shall be engraved in black lettering with inscriptions. The list of such inscriptions shall be furnished by the Contractor for the Project Managerôs approval. The inscriptions shall be engraved on each window in not more than three lines with letter sizing not less than 5 mm. Where annunciation systems are already provided, the annunciation scheme shall be engineered as an extension to the existing scheme. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The lamp circuit shall include series resistor of adequate rating. The cover plate of the facia windows shall be flush with the control panel and shall be capable of easy removal to facilitate replacement of lamps. The cover plate transparency and the lamps wattage in the fascia windows shall be designed to ensure clear visibility of the inscriptions in the control rooms (having an illumination level of 350 lux) from the location of the Operatorôs desk.

TRIP and **NONTRIP** facia shall be differentiated. All **TRIP** facia shall have red colour and all **NONTRIP** fascia shall have green colour.

Sequence of operation of the annunciator shall be as given in Table 10.1.

Alarm Condition	**Fault Contact Status**	**Visual Annunciation**	**Audible Annunciation**
Normal	Open	OFF	OFF
Abnormal	Close	Flashing	ON
Accept push button is pressed	(a) Close (b) Open	Steady on Steady on	OFF OFF
Reset push	(a) Close (b) Open	ON ON	OFF OFF
Lamp test push button pressed	Open	Steady on	OFF

Table 10.1. Sequence of annunciator operation

Visual and audible annunciation for the failure of DC supply to the annunciation system shall also be provided and this annunciation shall operate on 240 Volts AC supply with separate fuses. On failure of the power supply to the annunciation system for more than two or three seconds (adjustable setting) a facia shall light up and an audible alarm shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone, however the facia window shall remain steadily lit till the supply to the annunciation system is restored. The sound of the audible alarm (bell) provided for this annunciation shall be different from the audible alarm provided for the annunciation system.

A separate voltage check shall be provided to monitor the failure of supply (240V AC) to the scheme mention above. If the failure of supply exists for more than two to three seconds this relay shall initiate visual and audible annunciation.

The annunciation system shall be capable of catering to at least 20 simultaneous signals at time.

One self resetting push button shall be provided on each panel for testing the facia window lamps. Push buttons for testing flasher and audible alarm circuits of the annunciation system and for testing the annunciation supply failure monitoring circuit shall be provided. These testing circuits shall be so connected that while testing is being done it shall not prevent the registering of any new annunciation that may occur during the test.
One set of the following push buttons shall be provided on each panel as shown in the sample front view drawing attached to this Specification.

- Reset push button for annunciation system.
- Accept push button for annunciation system.

The annunciation shall be repetitive type and shall be capable of registering fleeting signals. Minimum duration of the fleeting signal registered by the system shall be 15 milliseconds.
Auxiliary relays for the annunciation system shall have adequate auxiliary potential free contacts for use in event logger.
The annunciation shall be suitable for operation with normally open contacts which close on a fault or contacts which open on a fault. It shall be possible at site to change annunciators from ñclose to fault ñto ñopen to fault ñand vice-versa.
In case of a static annunciator scheme, special precautions shall be taken by Contractor to ensure that spurious alarm conditions do not appear due to the influence of external electro magnetic or electrostatic interference on the annunciator wiring, and switching disturbances from the neighbouring circuits within the panels.
Annunciation systems to be supplied for existing substations should be matched with the existing scheme in co-ordination with the Project Manager during detail engineering stage.

2.5 PANEL INTERNAL WIRING
1. Panels shall be supplied complete 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 arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally
2. All wiring shall be carried out with 1100V grade, single core, stranded copper conductor wires with PVC insulation. The m minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows.
3. All circuits except current transformer circuits and voltage transfer circuits meant for energy metering one 2. sq. per lead.
4.1 All current transformer circuits one 4.0 sq. mm lead.

4.2 Voltage transformer circuit (for energy meters): Two 2.5 mm sq per lead.
4.3. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.
4.4. 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 panels running throughout the entire length of the panels.
4.5. Wire germination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. 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 wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.
4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.
4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

4.8. All wiring shall be switch board type single conductor tinned annealed copper wire insulated with varnished cambric, faulted asbestos, single braided cotton cover painted overall with flame proof moisture resistant paint and suitable for 660 volt service or equivalent polyncychloride insulation which has proved its utility in tropical regions against hot and moist climate and vermin (Misc. white ants and cockroaches etc) Rubber insulated wiring will not be accepted.

The sizes of wiring in different circuits shall not be less than those specified below :

Table – I

Circuit	Minimum permissible Size of wire.
Metering and relaying circuits connected to Current Transformers.	4.0 mm sq.
Potential circuits for metering and Relaying,	4.0 mm sq.
Other control, visual and audible alarm signaling circuits etc.	2.5 mm sq

The following colour scheme shall be used for the wiring.

Table – II

Circuit where use.	Colour of wire and ferrule.
Red phase of instrument transformer circuit	Red.
Yellow phase of instrument transformer	Yellow.
Blue phase of instrument transformer circuits	Blue.
Neutral connections earthed or not earthed in the instrument transformer circuit	Green.
A.C. Control wiring circuits using D.C. upply	Grey

All wiring inter-connecting the front cubicles with the rear cubicles of the panel board over the access corridor shall be wired in gutters held against the ceiling of the corridor by means of screws. All potential bus wiring, audible alarm bus wiring, AC and DC control supply bus wiring, wiring for cubicles lighting and such other wiring which funs from cubicle to cubicle within the switch board shall be laid out in gutters and shall be carefully screened. As the front and rear cubicles with be detachable, the inter-connection shall be made through suitable terminal connectors securely fixed on the panel.

Wiring connected to the space heaters in the cubicles shall have porcelain braided insulation over a safe length from the heater terminals.

Each wire shall be continuous from end to end without having any joint within itself. Individual wires shall be connected only at the connection terminals or studs of the terminal blocks, meters, relays, instruments and other switchboard devices.

Terminal ends of all wires shall be provided with numbered ferrules suitable coloured (Ref : Table-II) for phase identification. At point of inter/connection where a change of number is necessary, duplicate ferrules shall be provided with the appropriate numbers on the changing end.

At the terminal connection, washers shall be interposed between terminals, wire terminals and the holding nuts. All holding nuts shall be secured by locking nuts. The connection stud shall project at least 6 mm. from the lock nut surface.

Wire ends shall be so connected at the terminal studs that no wire terminal number ferruled gets masked due to succeeding connections. All wires shall be suitable for bending to meet the terminal stud at rectangles with the stud axis, and they shall not be skewed.

All studs, nuts, bolts, scores, etc. shall be threaded according to the British Standard practice unless Employerôs prior approval to any other practice of threading is obtained. Spare quantities of nuts, lock nuts and washers of all varieties used on the panel board shall be supplied to the extent of 10% of the used quantities.

2.6 **TERMINAL BLOCKS**

All the terminal blocks to be used in the panel shall be provided with 1100V grade stud type terminal block of Polyamide material of Elmex) / Connectwell. At least 20% spare terminals shall be provided.

(i) All internal wiring to be connected to external equipment shall terminate on terminal blocks. Disconnecting type Terminal blocks shall be 1100 V grade and have 20 Amps. Continuous rating, molded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts,. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

(ii) Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short-circuiting and earthling facilities.

(iii) At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

(iv) Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side.

(v) There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel sidewall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm

(vi) Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallels and close proximity along each side of the wiring duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the ownerôs external cable connections. All adjacent terminal blocks shall also share this field-wiring corridor. All wiring shall be provided withadequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

(vii) The number and sizes of the Ownerôs multi core incoming external cables will be furnished to the contractor after placement of the order. All necessary cable-terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included the scope of suppl

2.7 PAINTING:-

Powder coating type is preferable.

All sheet steel work shall be phosphated in accordance with the IS:6005 Code of practice for phosphating iron and steel.

(1)All unfinished surface of the steel panels and frame work shall be sand blasted to remove rust, scale, foreign, adhering matter of grease.

(2) A suitable rust resisting primer shall be applied on the interior and exterior surfaces of the steel, which shall be followed by application of an under coat suitable to serve as base and binder for the finishing coat. The finishing coat on the exterior of the panels shall be deep gray powder coated. Polished cellulose appearance while on the interior faces the finishing coat shall be of light gray shaded paint sprayed to give a contrasting effect with the cubicle wiring.

A small quantity of finishing paint shall be supplied with each consignment of the panels to enable the Employer's store at site any finish which may get damaged curing the

transshipment. The panel boards may alternatively be given a plastic durable covering coat for protection of the finish during the transshipment, which shall be capable of being peeled off after installation.

2.8 TERMINAL BLOCK CONNECTION

Terminal Block connectors built from cells of moulded dielectric and brass stud inserts shall be provided for terminating the outgoing ends of the cubicle wiring and the corresponding incoming tail ends of the control cables.All the terminal connectors shall have de-link(disconnecting) facilities.

Provision shall be made on each pillar for holding 20% extra connection (10% incoming + 10% outgoing). All blocks shall be shrouded by easily removable shroud molded of transparent dielectric materials. The terminal blocks shall be suitable for 660 volts service and connection with both aluminum and copper cable.

2.9 SPACE FOR CONTROL CABLES AND CABLE GLANDS

Sufficient space for receiving the control cables inside the board at the bottom of the cubicles and mounting arrangement for the terminal cable glands shall be provided. The specification does not cover supply of control cables and cable glands for which the employer will make separate arrangement.

2.10 SPACE HEATERS

60 W. 240 V. 50 HZ tubular space heaters with thermostat auto suitable for connection to the single phase AC supply complete with on-off switches located at convenient positions shall be provided at the bottom of the switch board cubicle to prevent condensation of moisture. The watt loss per unit surface of heater shall be low enough to keep surface temperature well below sensible heat.

2.11 DISTRIBUTION AND CONTROL OF AUXILIARY POWER CIRCUIT

2.11.1 D.C. CIRCUIT

There shall be separate D.C. incomers for the each control and relay board panel fed from D.C. distribution boards through a suitable fuse switch unit, provided there. M.C.B,s. of required Amps rating shall be provided in the panel as D.C. incomer (source I one number and source II one number). A continuous D.C. bus shall be provided in the control and relay board panel and D.C. supply for control, protection, supervision and indication of circuit breaker and other equipments shall be teed off in each panel from D.C. bus through a set of HRC Fuse (both on +ve and ï ve side) D.C. supply to individual panel thus teed off shall be distributed within the panel as below.

2.11.2 **SWITCHES & FUSES**:

Each panel shall be provided with necessary arrangement for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with fuses. The selection of the main and sub circuit fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC catridge type confirming to IS: 3703 mounted on plug in type fuse bases. The short time fuse rating of fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse rating and voltage.

A D.C. operated no-volt, auxiliary relay provided with hand reset reverse flag and two set of self reset N/C contracts with test push button shall be provided in the operating circuit of each control and relay panel to supervise the breaker control supply. One N/C contact shall be used for visual alarm and the other N/C contact shall be used for audible alarm and shall be connected to the alarm bus of the annunciation scheme.

A.D.C. operated no-voltage auxiliary relay provided with hand reset reserve flag indicator and two sets of self reset N/C contacts with test push button shall be provided in the main alarm bus to supervise the alarm but supply. One N/C contact shall be used for visual alarm and the other for audible alarm. The visual and audible alarm of alarm bus fail and those of incoming

D.C. bus fail shall be common and shall be operated by 240 V single phase A.C. auxiliary supply as described in the Specification.

(** DC sources supervision relays are to be mounted in the panel)

2.12 A.C. CIRCUIT

240 volts, single phase, A.C. auxiliary supply to the control and relay board will be fed from A.C. distribution board through a suitable fuse switch provided thereof. A continuous A.C. bus shall be provided at the control and relay board where from A.C. supply to each panel shall be teed off through a set of links. One 16 Amp rated M.C.B. shall be provided at the control and relay board for the incoming A.C. supply. A set of fuse and link rated for 6 amps for 3 pin plug circuit, 6 amps for 2 pin ply circuit and 6 amps for heater and illuminating lamp circuits shall also be provided. A hand reset type no-volt auxiliary relay rated for 240 volts A.C. and provided for monitoring the auxiliary A.C. supply from D.C. operated facial annunciation scheme.

2.13 MCB's

The incoming DC supply sources (source I and source II)circuits in the control and relay panels shall be controlled by required Two pole DC MCB's. In each control and relay panel there shall be separate DC MCB as incoming to the panels and the sub circuits shall be controlled by HRC fuses of different circuits having both ñ+òve and ñ-ñve control.The incoming MCB's also followed by HRC fuses for better protection. The ratings of the MCB's are to be designed to take care of the continuous rating and also during short ckt or in the event of faults. For AC incoming circuits and other distributed circuits circuits also to be provided with MCB of proper ratings.

2.14 MIMIC DIAGRAMS

10 mm. wide, 2mm thick colour mimic diagrams and symbols showing the exact representation of the system shall be provided in the front of control panel. The mimic strips shall be made with anodized aluminum materials, which shall be screwed on to the panel and can be easily cleaned. The colour code of such aluminium strips are as given in the following table. Upper bus and lower bus of the mimic shall represent the main bus and transfer bus of the station respectively. Central line of the upper bus mimic shall be at a distance of 695 mm from the top of the panel and center to center distance between the bus mimic shall be 610 mm.

When semaphore indicators are used for equipment position they shall be so mounted in the mimic that the equipment close position shall complete the continuity of the mimic.

Indicating lamp , one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

TABLE

COLOUR SCHEME FOR MIMIC DIAGRAMS

Equipment	Colour	I.S. Code No.(IS.5)
400 KV	Orange	
220KV	Signal Red	537
132KV	Lemon Yellow	
33 KV	Brilliant Green	414
415/250V	Black	221
Earth	White	309
110 V	Canary Yellow	-

Automatic semaphore indicators shall be provided for isolators and earth switch position indication and incorporated in the mimic diagram

2.15 DISCREPANCY TYPE CONTROL SWITCHES.

Control switches for circuit breakers shall be incorporated in the mimic diagram to represent the relevant circuit breakers as also the sequence of the mimic diagram. The switches shall

be provided with a built-in two lamp. The switches shall have maintained contact positions for ôONö and ôOFFô positions respectively and two momentary contact positions for ôONö and ôOFFô impulse.

2.15.1 The switches shall be provided with a notching mechanism which should accurately limit the angles of actuation. A strong restoring spring is to be provided to return the switch mechanism automatically from the momentary contact position to the maintained contact position. Such control springs shall be strong enough to prevent any inadvertent operation due to light touch or some other different arrangement should be provided to prevent any inadvertent operation. Such springs shall not be used as current carrying parts in these switches. The rating of the switch contacts shall be suitable for the duty imposed by the circuit breaker closing mechanism and shall conform to the recommendations to be given by the circuit breakers manufacturers. The built-in-pilot lamp of the control switch shall give a steady light when the position of the control switch corresponds to the position of the associated circuit breaker. A flickering light shall be given by the same lamp when due to hand operation or due to automatic tripping of the breaker, the position of the control switch does not coincide with that of the corresponding circuit breaker. The arrangement to provide the flickering voltage for the above purpose shall be made. In order to avoid continuous burning of the aforesaid built-in lamps associated with the control switches under steady state condition, the said lamps shall be connected through a switch. The circuit should be such that irrespective of the position of the aforesaid switch, winking of the lamp shall not be affected by change in respective control switch position. The winking of the control switch pilot lamp shall be followed by an alarm annunciation after a preset time adjustable between 0-10 secs. Switches complete with accessories for the above function shall be supplied.

2.16 INDICATING LAMPS

5/7 Watt Indicating cluster LED type Lamps shall be provided on the control panel mounting with rear terminal connections. Lamps shall be provided with series connected resister preferably built in the lamp assembly. Lamps shall have translucent lamp covers to difuse lights coloured red,green,amber,clear white or blue as specified as per the following:

	Function	Quantity	Colour of lens
1.	Circuit Breaker spring charged/normal pressure indication.	1 No.	Blue
2.	Circuit Breaker trip circuit healthy indication.	2 Nos.	White
3.	Circuit Breaker Low Air Pressure indication	1 No.(where necessary	White
4.	Incoming D.C. fail indication.	2 Nos.	White
5.	A. C. fail indication.	1 No.	White
6.	P. T. supply indication.	3 Nos.(where necessary)	Red/Yellow/ Blue.
7.	Indication lamps for CB closing ,opening Isolator closing and opening		Red and Green
8.	Auto trip	1 No.	Amber
9.	Protection on Transfer Mode	1 No.	White
10.	CB on Local/Remote	2 Nos	White

All the indicating lamps under (1) and (2) shall be provided with push button control. All the lamps shall be connected to the auxiliary D.C. supply of the sub-station except Sl.No 4 and Sl. No.6 which should be connected to the auxiliary A.C. supply and

P.T. secondary supply. The lamps shall be suitable for switch board purpose and shall be of low watt consumption. Lamp and lenses shall be interchangeable and easily replaceable from the front of the panel.Tools if required for replacing the bulbs and lenses shall aalso be included in the scope of supply. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis. In initial supply, 20% of the lamps actually used on the switch boards and 10% of the lamp covers used shall be supplied in excess to serve as spares.

2.17 TEST BLOCKS

Switchboard type, back connected, test blocks with contacts shall be provided with links or other devices for shorting terminals of C.T. leads before interrupting testing instruments in the circuit without causing open circuit of the C.T. The potential testing studs shall preferably be housed in narrow recesses of the, block molding insulation to prevent accidental short-circuit across the studs. All Test Blocks for meters, relays, etc. shall be placed as close to the respective equipment as possible.

2.18 NAME PLATES & MARKING OF IDENTITY

All equipments,instruments, relays and such other similar electrical devices mounted on the front and rear side as well as mounted inside control and relay panels shall be provided with name plates bearing the manufacturerÕs name, serial number and the electrical rating data.

All front mounted equipment shall also be 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.

Each equipment and meter shall be prominently marked with the quantity measured e.g. KV,A,MW,MVAR, etc. All relays and other devices shall be clearly marked with manufacturers name,type,sl No & electrical rating.

Name plates shall be made out of non-rusting metal or 3 ply lamicoid. Name plate shall be black with white engraving lettering.

Each switch shall bear clear inscription identifying its function e.g. ñBREAKERò õ52Aôò SYNCHRONISINGò etc. Similar inscription shall also be provided on each device whose function is not otherwise identified. Switches also have clear inscription for each position indicating e.g. ñTRIP-NEUTRAL-CLOSEòòON-OFFòòR-Y-B-OFFò etc.

All panel shall be provided with name plate mounted inside the panel bearing LOA NO. & Date,Name of the sub-station & Feeder and reference drawing number.

2.19 SAFETY EARTHING FOR THE PANEL

All panels shall be equipped with an earth bus securely fixed.Location of earth bus shall ensure no radiation interference for earth system under various switching conditions of isolators and breakers. The materials and size of the bus shall be atleast 25X6 sq.mm perforated copper threaded holes at gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted aadjoining 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. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

Provision shall be made on each bus bar of the end panels for connecting substation earth grid. Necessary clamps and connectors shall be included in the scope of contract.

All metallic case of the relays,instruments and other panel mounted equipment including gland plate shall be connected to the earth bus by copper wires of size not less than 2.5 sq mm.The colour code of earthing shall be green.

Looping of earth connections which would result in loss of earth connections to other devices when loop is broken shall not be permitted.However looping of earth connections between equipment to provide alternative path to earth bus shall be provided.

VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing the continuity of earthing syatem for other groups.

2.20 PANEL BOARD LIGHTING

The panel interior (both control panel and relay panel) shall be illuminated by 20W, CFL tube light connected to 240 V. single phase A.C. The illumination of the interior shall be free from hand shadows and shall be planned to avoid any strain or fatigue to the fireman likely to be caused due to subnormal or non-uniform illumination. One emergency D.C. light (CFL type) shall also be provided for each relay panel with individual switch, with proper identification mark.

A door operated button switch shall be provided for control of the A.C. lighting for all the control and relay panel interiors.

One 5 amps. two pin socket and one 15 amps. 3 pin power socket outlets together with plugs shall be provided at convenient points in the panel board for A.C. supply.

2.21 ANNUNCIATOR

Each control and relay panel shall be provided with **microprocessor based** anunciator(s) facial on the front of the control panel for projecting mal-operation in the system equipment due to fault. The annunciation board shall be of the switch board type, back connected suitable for semi-flush mounting provided with dust tight cases. The single relays shall be suitable for tropical use. The alarm concealing visual signal resetting and annunciation testing buttons shall be mounted on the front of each control panel at convenient height, preferably under the annunciation board.

a) One part of the annunciation shall comprise of one electrical D.C. operated bell and one D.C. operated hooter for trip and non-trip alarm mounted inside or on top of the switch board cubicle on vibration absorbent mountings. A suitable hand reset relay device shall be employed in the suitable hand reset relay device shall be employed in the suitable alarm circuit to permit manual cancellation of the audible alarm in token of its acceptance by an operator before rectification of the abnormality. The wiring shall be such that a single set of bell and alarm cancellation relay will be sufficient and serve in commons with all the alarm actuating devices.

b) The other part of the anunciator shall discriminate and sort out the cause of alarm and project visual alarm signals by tokens of telephone type flush lamps illumined windows on facial plate. There shall be an independent token for each abnormal condition announced and the wiring of all the tokens shall be so done that each token will operate independently of the other without causing any maloperation on the enunciator. A reset device, manually operated by an operator, shall be provided for each column of the visual alarms to enable the operator to cancel each visual alarm at will after removal of the discrepancy or abnormal condition. Suitable testing device shall be provided on each enunciator to be assembled for routine checking of enunciator alarm and indication.

The enunciator shall be suitable for operation across the D.C. supply voltage of the sub-station.

Momentary closing of fault contacts shall also cause operation of enunciator system as above and shall require canceling and resetting operations by the operator to silence the bell and reset the enunciator window.

c) Minimum of 4 Nos spare windows each for trip and non trip are to be provided in each annunciator

2.22 INCOMING D.C. FAIL ALARM SCHEME

Control and Relay Board shall have a common ñIncoming D.C. Failòalarm scheme operated by 240 V single phase A.C. auxiliary supply for audible as well as visual alarm in case of failure of D.C. incoming supply to the board.

All auxiliary relays, test relays, canceling, resetting and testing push buttons, alarm bells etc. required to render the annunciation system operative as above shall be considered to be within the scope of the tender.

Separate scheme for each source of DC supply shall be considered.

2.23 INCOMING A.C FAIL ALARM SCHEME

Control and Relay Board shall have a common ñIncoming A.C. Failòalarm scheme operated by 240 V D.C. auxiliary supply for audible as well as visual alarm in case of failure of A.C. incoming supply to the board.

3.0 INDICATING INSTRUMENTS AND METERS

3.1 All electrical indicating instruments shall be of digital Type suitable for flush mounting

3.2 Instruments shall have 4- digit display, display height being not less than25 mm.

3.3 Instrument shall confirm to relevant IS and shall have an accuracy class of 1.0 or better. For energy meters it should be of minimum 0.2. watt and VAR meters shall have an indication of (+) and (-) to indicate EXPORT and INPORT respectively

3.4 Digital voltage and frequency meters shall be of class 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25 mm height.

3.5 All instrument shall be switchboard type, back connected suitable for flush mounting and provided with dust tight cases for tropical use with dull black enamel finish.

3.6 All fixing screws, nuts and treated parts shall be designed to Indian Standards.

3.7 All instruments shall have a practicable laboratory means of adjustment of accuracy. The limits of error shall be those permissible for industrial grade instruments of switch board type. The calibration of the instruments shall function satisfactorily when mounted on steel panels or alternatively magnetically shielded instruments shall be used.

3.8 Instruments shall be capable of indicating freely when operated continuously at any temperature from 0 to 50 deg. C.

3.9 All circuits of instruments shall be capable of withstanding the effect of shock vibration and humidity and a dielectric test of 2500 volts r.m.s to ground for one minute as per relevant BSS/ISS

4.0 NON-TARIFF ENERGY METERS (Not Required)

a) Export/Import KWH and KVARH meters for 33KV , 132 KV , 220 KV & 400 KV KV. Line shall be supplied by the Bidder. Necessary cut-out, wiring and 3 element Test Terminal Block are to be supplied by the bidder as specified in the Schedule of requirement of control panel. Export/Import meters for non-tariff use shall be of the commercial grade accuracy i.e 0.2 Class, and shall be of 3 element type and suitable for 3-phase, 3ï wire connection.

b) One 3 element type KWH meter with M.D.I. for each 33 KV. 132 KV,220 KV. Transformer panel shall also be provided and shall be connected preferably on H.V. side.

c) One Trivector metre of solid state type with KWH, KVAH, KVARH with MDI is to be provided both for 33 KV. 132 KV,220 KV control panel.

4.1 MW INDICATOR

In all the 33KV, 132 KV,220,400 KV lines and transformer feeders, indicating MW meters with M.D.I. (three) element type shall be mounted on the front side of the control panels to indicate the instantaneous MW flowing. The MW meters shall be connected to the measuring C.T. core. Scale range for line feeders shall be 200-0-200 MW and for transformer feeders 0-150 MW or as suitable for the proposed system.

4.2 MVAR INDICATOR

In all the 400 KV,220KV. 132 KV line feeders indicating MVAR meters shall be mounted on the front side of the control panel to indicate the instaneous MVAR following through the feeder in either direction. The scale should be center zero. The MVAR meters shall be connected to the measuring C.T. core. The scale shall be 200-0-200 MVAR or as suitable for the proposed system

5.0 Relays

General Requirements

5.1 All electro mechanical relays (auxiliary and tripping relays shall conform to the requirements of IS:3231/ICE-60255 and all Main numerical relays shall confirm to ICE-61850 and other applicable standards for future SCADA purpose. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

5.2 All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractorâs scope of supply.

5.3 All AC operated relays shall be suitable for operation at 50 Hz AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 Amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

5.4 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, lockout relay monitoring 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. Relays case shall have adequate number of terminals for making potential free external connections to the relays coils and contacts, including spare contacts.

5.5 All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-rest type4 contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in-hand-reset operation indicators shall have additional auxiliary relays with operating indicators (Flag relays) for this purpose. Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholtz relays, oil and winding temperature protection, sudden pressure devices,Oil surge relay and fire protection etc.

5.6 Timers shall be of the electromagnetic or solid state type. Pneumatic timers are not acceptable. Short time delays in terms of milliseconds may be obtained by using copper slugs on auxiliary relays. In such case it shall be ensured that the continuous rating of the relay is not affected. Time delays in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided to the extend possible.

5.7 No control relays which shall trip the power circuit breaker when the relays is de-energised shall be employed in the circuits.

5.8 Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

5.9 Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured.

a. The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

b. Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.

c. Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

5.10 All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

5.11 The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

5.12 Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be; offered separately. The acceptance of this alternative/additional equipment shall lie with the OPTCL.

5.13 The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

5.14 All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue.

5.15 Wherever numerical relays are used, the scope shall include the following:-

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is also covered under this clause.

b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC 61850 protocol.

6.0 Protection System

Protective system

6.1 Protection discrimination

On the occurrence of a fault on the power system network the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network. Protection equipment associated with adjacent electrical elements may detect the fault, but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Protection for short connections between post current transformer housings and circuit breakers when the technical advantages of complete overlapping of the protection are outweighed by economic considerations, (i.e. short-zone protection)
- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than a value which can be detected by main protection systems.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection)
- All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

6.2 Protection settings

A list of the settings to be applied to all protection systems together with all associated calculations, shall be provided for review and approval not less than three months prior to the first programmed date for commissioning. The settings for line protection shall be such as to permit correct operation of the protection for earth faults with up to 100 ohms fault resistance. Any limitations imposed on the power system as a result of the settings proposed shall be explicitly stated. In the absence of system data required for calculation purposes, assumptions may be made providing these are clearly identified as such in the relevant calculations.

6.3 Fault clearing time

The protection equipment shall be capable of achieving the following discriminative fault clearing times, inclusive of circuit breaker and signalling times:

- One millisecond for all electrical elements whose boundary connections are defined by circuit breakers located within a given substation.
- For interconnecting tie lines in which the boundary connections of the electrical element being protected are defined by circuit breakers located in adjacent switching stations, an additional 20 ms fault clearance time is allowed at the substation remote from the fault point. This additional fault clearance time is permitted subject to the requirement that the positive sequence impedance of the primary circuit from the switching terminal to the point of fault shall not be less than ten ohms.

The Contractor shall supply the Project Manager with details of the operating times under defined conditions of all protection equipment proposed. Any limitation in operating time performance shall be declared by the Contractor, e.g. end of zone faults where distance protection is applied, high resistance faults, faults at high X/R with significant DC component and time constant, faults coincident with communication channel noise. The Contractor shall specify the increase in operating time which could occur under such conditions.

6.4 Signalling equipment operating times:

For design purposes the operating times of signalling equipment to provide a contact signal for use with associated distance protection shall be assumed to be as follows:

- Intertripping (transfer trip) not greater than: 20 milliseconds
- Permissive transfer trip: 15 to 20 milliseconds
- Blocking signal operate time: 10 milliseconds
- Blocking signal reset time: 10 milliseconds

Protection Schemes

6.5 Line protection

General requirement for line protection relays

The line protection relays shall protect the line and clear faults on line in the shortest possible time with reliability, selectivity and full sensitivity to all types of line fault. The general concept for

1) 400kV and 220kV levels is to have primary and back-up protection systems having equal performance requirement especially in respect of time as would be provided by two Main protections called **Main-I** and **Main-II.** It is desirable that Main-I and Main-II protection should work on two different principles of operation and one back up dir O/C & E/F protn is envisaged.

2) For 132 kV level the concept of one main distance protection and one backup directional O/C and E/F protection is envisaged.

3) For 33 kV level, the requirement is that of modular directional O/C and E/F protection.

The protection requirements are summarised below, and illustrated in the single line diagrams in the schedules.

- **400kV and 220kV lines**
    - Main I Numerical non switched distance protection meeting performance levels.
    - Main II Numerical non switched phase comparison, carrier aided or of numerical distance using a different principle of operation
    - Phase segregated teleprotection facility
    - Power swing detection blocking and tripping
    - Synchronising.
    - Line overvoltage (Only for 400kV and 220kV line □ 200kM long)
    - Autoreclosure
    - Numerical directional overcurrent and earth fault
    - Three phase to ground
    - Numerical local breaker back up
    - Pole discrepancy protection

6.5.1 Distance Protection Relay (Numerical IEC-61850 Protocol compliance)

The relay shall:

1. Be static and modular in construction

2. Have high speed phase segregated non switched distance relays for three phase systems to clear all type of line faults within the set reach of the relay.

3. Cover at least two line sections with 15% in hand margin.

4. Measure all type of faults without the need to switch the measuring elements to the faulty phase or phases. Zone switching to extend the reach of the measuring elements is not allowed. The reach of each zone shall be independently and individually adjustable and shall have settings in steps of 1%. Memory circuits with defined characteristics shall be provided in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions. Independent zero sequence compensation shall be provided for each zone.

5. Have reverse reaching zone operating times as given in Table. The Carrier transmission time has been considered as 20 ms.

6. Have stepped time-distance characteristics and at least two directional and one non-directional independently variable time graded distance protection zones to cover two adjacent line sections.

7. Have a maximum Zone 1 operating time from fault initiation to trip impulse from relay (complete protection time excluding applicable carrier time) under source to line impedance ratios and under all possible combinations of fault with CVT being used on the line (with all filters included) and at 50% of Zone I reach as follows:

- For S.I.R. 0.01 to 4: 30 ms at the nearest end and 50 ms at far end.
- For S.I.R. 4 to 15: 30 ms at the nearest end and 50 ms at far end.

Carrier transmission time is considered as 20 ms. Any reduction in carrier transmission time shall be reflected in the reduction of maximum operating time.

The trip times should not be affected by DC offset and under frequency up to 47Hz.

8. Have a reach for Zones 1,2 and 3 to cover line length as per 3 above. The relay shall have an adjustable characteristic angle setting range of 30 to 75 degree, preferably adjustable dynamically following the load conditions of the power system. It should be ensured that this long coverage is consistent with limitations imposed by heavy loading and sound phase component of fault current. If so characterised by system requirements, it shall be possible to have circular characteristics of offset Mho type & Quadrilateral shaped. If the characteristics of starting relays are such that it cannot pick-up because of very low infeed, under voltage relays may also be used as supplementary relays.

9. Have two independent continuously variable time setting range of 0-3 seconds for Zone 2 and 0-5 seconds for Zone 3.

10. Have a maximum resetting time of less than 35 milliseconds.

11. Have facilities for offset features with adjustment of at least 20% of Zone 3 setting.

12. Have automatic residual compensation capabilities variable from 30-150%.

13. Be such that the setting / reach should not be affected by mutual coupling effect of double circuit line or nearby paralleled circuits. The proof of compensation should be given if provided.

14. Operate instantaneously when circuit breaker is closed to zero volt 3 phase fault.

15. Be suitable for single and three phase tripping.

16. Have a continuous current rating of twice rated current. The voltage circuit shall be capable of continuous operation at 1.2 times rated voltage. The relay shall also be capable of

carrying a high short time current of 70 times rated current without damage for a period of one second.

17. Be selective between internal and external faults.

18. Incorporate three separate high speed trip relays for single phase faults and a fourth high speed trip relay for multi phase faults. Each of these shall have adequate contacts to meet the complete scheme requirements. The relay shall conform to the requirements for tripping relays specified in this specification.

19. Include power swing blocking protection which shall:

- be of triple pole type
- have suitable setting rage to encircle the distance protection described above.
- have a continuously adjustable time delay on pick up of setting range 0-2 seconds.
- block tripping during power swing conditions.

20. Include fuse failure protection which shall:

- monitor all the three fuses of CVT and associated cable against open circuit.
- inhibit trip circuits on operation and initiate annunciation.
- have an operating time less than seven milliseconds.
- remain inoperative for system earth faults.

21. Have integrated two stage over voltage protection facilities.

22. Shall have comprehensive self test feature including diagnostics at power up.

23. Broken conductor detection facility.

24. Distance to fault locator

6.5.2 Distance to fault locator

General

Distance to fault locators shall be the inbuilt features of the distance relay for both Main I and Main II, shall be capable of locating phase to phase and phase to earth faults. They shall also preferably be capable of locating open circuit faults.

1. Have built-in display feature.

2. Display directly in percent of line length or kilometres without the requirement for further calculation.

3. Have an accuracy of 3% or better for all types of faults and fault levels. This level of accuracy should not be impaired under the following conditions:

- presence of remote end infeed
- predominant DC component in fault current
- high fault arc resistance
- severe CVT transients

4. Have facility for remote data transmission

5. Meet IEC 255 Part IV or other equivalent internationally recognised standard.

1. Have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.**Table 16.3.2 Operating Times for Distance Protection**

Operating Time	SIR = Z_S/Z_L)	Fault Position % of Impedance

(ms)		Setting
□ 20	10	5 to 20
□ 30	30	10 to 60
□ 50	60	1 to 95

SIR = System Impedance ratio. Zs = Source impedance. Zl = Relay setting impedance

6.5.3 Line over voltage protection relay

The line over voltage protection (59L) relay shall:

1. Monitor all three phases

2. Have two independent (59L1 and 59L2) stages

3. Have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage. (59L1)

4. Have an adjustable setting range of 100-170% of rated voltage with an adjustable time having setting range 100-200 seconds for the second stage. (59L2)

5. Be tuned to power frequency

6. Be provided with separate operation indicators (flag target) for each stage relays. (59L1 and 59L2)

7. Have a drop-off to pick-up ratio greater than 95%. Integral of overvoltage feature is also acceptable.

6.5.4 Auto reclosing relay

The auto reclosing relay shall:

1. Have single phase and/or three phase reclosing facilities. (Single /three phase reclosure shall be adapted for 400kV/220kV systems and 3pole trip/ reclosure for 132kV system)

2. Have a continuously variable single phase dead time range of 0.1-2 seconds in steps of 0.1 second.

3. Have a continuously variable three phase, one shot dead time range of 0.1-5 seconds in steps of 0.1 seconds.

4. Have a continuously variable reclaim time range of 5- 50 seconds.

5. 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.

6. Have facilities for selecting check synchronising or dead line charging features. It shall be possible at any time to change the required feature by connection of links.

7. Be of single shot type.

8. Include check synchronising relay which shall

- Have a time setting continuously variable between 0.5-5 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%

9. Include dead line charging Relay which shall

- Have two sets of relays and each set shall be able to monitor the three phase voltage.
- Have one set connected to the line CVTôs with a fixed setting of 20% of rated voltage.
- Incorporate necessary auxiliary relays and timers to give comprehensive scheme.

The scheme shall be such as to have Main I and Main II fully segregated such that shutdown and testing on one main protection should not affect the other main protection. The auto reclosure should then be connected to one protection. Integrated auto-reclosure feature as part of both Main I and Main II is also acceptable.
The scheme shall have check synchronous and voltage check interlocks (25, 27). These interlocks are supplementary to all other decision interlocks that may be required or specified in order to ensure correct operation of the scheme.

6.6 Local Breaker Back-up protection relay (50 LBB) for circuit breakers

The local breaker backup protection relay shall:

1. Be of triple pole type

2. Have an operating time of less than 15 milliseconds.

3. Have a resetting time of less than 15 milliseconds.

4. Have three over current elements. Each element shall be arranged to get individual initiation from the corresponding phase of line protection.

5. Be of solid-state type having a setting range of 5-80% of rated current

6. Have a continuous thermal withstand twice the rated current irrespective of the setting.

7. Have three separate timers, one for each phase with continuously adjustable setting range of 0.1-1 seconds.

8. Have necessary auxiliary relays to make a comprehensive scheme.

Protective system

6.7 Unit and backup protection

Power system elements and the network shall be provided with independent high speed discriminative protection systems. Duplicate schemes (Main I and Main II) shall be provided for all 400kV and 220kV systems. For all other systems up to 132kV, the protection equipment shall be divided into "Main" and "Backup" systems.
Protection schemes of different philosophy (Main I and Main II or Main and Back-up) shall preferably be fed from different DC supplies when available in the substation. This shall include energisation of trip coil circuits in case of 400 kV and 220 kV breakers. However in case of 132kV system where a duplicate DC source is available, the two trip coils shall be energised from the different sources.
Protection equipment shall not initiate a trip signal following the normal and correct discharge operation of one or more surge arresters.
Measurement functions relays must be achieved through electronic circuits. Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other electromechanical techniques.
Relays based on numerical design technique shall constitute all primary protections. The Employers intends to avail the improved benefits in the functionality, design, reliability and cost effectiveness of integrated substation control systems in future for which relays with numeric design only shall be required. It is the responsibility of the Contractor to demonstrate that all relay equipment offered has a reasonable level of in-service experience. For numerical relays, the following conditions apply :

1. The Bidder must be able to demonstrate that a minimum of 10 relays of each type offered have been in full service without relay failures for a minimum of three years in two different countries, one of which may be the country of manufacture. Experience involving trial installations is not acceptable.

2. The Bidder must include a statement of the number of years of guaranteed manufacturing and parts support which will be provided for the relays offered.

3. The Bidder is be required to state the full firmware version together with the version of relays for which experience records are offered.
For relays which are provided with communication facilities, the communications facility should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk transfer of settings and fault record information using the appropriate PC based software.

6.8 Protection discrimination

On the occurrence of a fault on the power system network the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network. Protection equipment associated with adjacent electrical elements may detect the fault, but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Protection for short connections between post current transformer housings and circuit breakers when the technical advantages of complete overlapping of the protection are outweighed by economic considerations, (i.e. short-zone protection)
- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than a value which can be detected by main protection systems.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection)
- All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

6.8.1 Codes and Standards

The equipment supplied shall generally comply with the codes and standards indicated in relevant sections of this specification. Additionally the equipment shall also conform the requirements of this specification.

6.8.2 Environmental requirement

The protection, control and metering equipment shall operate satisfactorily under the various atmospheric, mechanical, electrical and environmental conditions as stipulated in the relevant sections of this Specification. The equipment shall conform to EMC Class III.

6.8.3 Future network scada system

At some time in the future the Employer intends to introduce a network SCADA system. All equipment to be installed under this Specification shall be suitable for future remote operation and remote data acquisition.
The limit of responsibility with regard to this contract shall be to provide equipment suitable for future connection to and communication with a SCADA system, either by means of RTU or modem. Neither the RTU nor the modems form part of the scope of this Specification.
The proposed protocol for the SCADA system is IEC 61850 compliance. Equipment necessary to interface the Integrated Substation Control System with the SCADA system are part of the scope of this Specification.

6.8.4 Control and monitoring levels

The substation control and monitoring system shall allow for three levels of man machine interface. The number of levels initially employed will be limited to one i.e. substation levels.

Provision shall be made for the future implementation of the second and third level of network control and monitoring from a system control centre via SCADA.
Selection of substation control shall be from the individual equipment basis i.e., from the control panels.
At the station level, control panels should be located in the main control room.
A mimic diagram representing the substation lay-out in single line diagram form should be provided. The mimic board is intended to give operating personnel an overall view of the switchgear state. It shall be made up from the individual circuit control panels mounted side by side. The arrangement should correspond to the primary equipment layout.
Alarm annunciation equipment should be mounted adjacent to the mimic diagram, or form an integral part of the control panel. Operation of an alarm should cause the appropriate window to flash and sound an audible warning. Operation of an accept button will silence the audible warning, steady the flashing window and prepare the annunciation to respond to subsequent initiation. A reset button should be provided to extinguish alarms which have reset.
A lamp test button shall be provided which will initiate steady state illumination of all alarm windows. Trip or protection initiated alarms should have windows distinct from others (e.g. red display instead of white). Control and selector switches should be of approved types complying with accepted standards such as IEC 337. Control switches shall have two independent motions or two handed operation to effect operation. Indicating instruments should be of approved types complying with accepted standards such as IEC 5 1.

6.9 Enclosures

Protection systems shall preferably be accommodated in rack or hinged rack cubicles and be of modular construction with factory assembled and tested wiring. Conventional analogue relays may be mounted on conventional relay panels which must be mounted to allow access to the front and rear of the panel. Relays mounted on such panels shall be flush mounted. The construction method shall offer the benefits of minimum site construction times and circuit outage requirements.
Interconnections shall be identified in accordance with the requirements for dependent local end marking as specified in IEC Publication 391 Sections 3.4.1.a.1 and 5.1.2. The interconnections shall be recorded on an appropriate schedule or diagram.
For modular protection systems, means shall be provided to lock positively each withdrawable module or unit in the ñserviceòposition. It shall not be possible to remove any module without first short-circuiting all associated current transformer circuits.

6.10 Operator interface

6.10.1General

All numerical protection systems shall be provided with an integral local operator interface facility to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local operator interface. No exceptions to this requirement shall be accepted.

6.10.2 Identification

Each protection system shall have a unique identifier which is clearly visible. If the protection system is software operated the software reference and issue level shall be identified.

6.10.3 Settings

Each protection system shall provide a means by which the user can easily access the protection system to apply the required settings. This facility shall be secure from inadvertent operation. A display of the selected settings shall be provided on the protection system.

6.10.4 Indications

Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate faulted phase, zone, etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover.
For relays based upon numerical techniques, indication shall be provided for failures detected in the protection relay or communications equipment. The indications provided shall be designed to

allow the defective item to be quickly identified. The status of the DC power supplies shall be permanently indicated.
Details of the indication required for specific types of relay are provided in the individual parts of this section of the specification covering particular types of relay.

6.11 Protection system output contacts

All protection systems shall be provided with an adequate number of contacts of suitable rating to carry out the required tripping functions, alarm indications, fault recorder functions and such supplementary signalling functions as may be necessary for initiation of automatic switching control, inter tripping etc. In all cases contacts intended for tripping duty shall be designed such that they cannot inadvertently interrupt trip coil current.

6.12 Testing and isolating facilities

Each functional protection system shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.
Adequate test facilities shall be provided within the protection system to enable the protection and auto-reclosing equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled.
Relays based on digital and numerical design techniques shall include supervision facilities which provide a periodic self check of the key elements within the relay and also provide continuous self monitoring of all internal power supplies and microprocessor operation. A defect in any of the self supervision facilities shall not cause maloperation of the protection relay internal self-test facilities and shall give an alarm should an internal fault occur.
Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labelled. The labels on the isolation points shall either describe the function or be uniquely numbered.
The Contractor shall provide a list of all of the protection and auto-reclose equipment being offered under the contract.
The Contractor shall also provide a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and auto-reclose equipment.

6.13 Service life and support

The protection systems shall be designed for a service life of at least 15 years, and preferably 20 years, given that normal maintenance in accordance with manufacturers recommendations is carried out during the lifetime of the protection system.
The Contractor shall state the service life of the protection system equipment in relation to that of the main HV plant and apparatus so that Employer can assess the cost of any replacement during the life of the substation.
The Contractor shall state the period for which lifetime support will be provided for the protection system equipment and shall make recommendations for the provision of spare parts.
The Contractor shall supply circuit diagrams for each protection system and the associated tripping system(s). The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.
When the Contractor has been notified of incorrect operation, or failure to operate when required, of any protection system supplied under the contract, the Contractor shall investigate the incident and inform Employer of any such incidents if they result in the necessity to modify the equipment. The Contractor shall also inform Employer of the details of the modifications required to prevent such incidents re-occurring.
The Contractor shall offer a service to enable any faulty item of protection equipment to be rectified or replaced within a stated period of the fault being reported. The Contractor shall state the repair/replacement period.

The Contractor shall, when requested, offer the Employer a maintenance contract for the protection equipment supplied under the contract. The Contractor shall supply details of the cost of the maintenance contract and information on test procedures and test frequencies that would be supplied under the maintenance contract.
The Contractor shall offer training for Employerûs personnel in the operation and maintenance of the protection equipment.

6.14 Thermal rating of equipment

Relay equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or twice the setting value, whichever is the more onerous.
Relay equipment intended for use in a normally quiescent mode and having a short time rating - for example, high impedance differential protection - shall be rated in accordance with the intended function and taking account of such inherent protective devices as may be incorporated in the design.
The short time rating for all protection relaying schemes shall be 100 times the nominal relay rating for a duration of one second.
Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30 s.

6.15 Insulation

The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 2500V.
All open contacts of the protection system shall withstand a voltage of 1000V. The protection system shall comply with the dielectric test requirements of IEC 255-5. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested form SeriesC of Table1 of IEC 255-5. The protection system shall comply with the impulse test requirements of IEC 255-5 with test voltage of 5kV.

6.16 Test requirements

6.16.1 General requirements

The Contractor shall supply test results and/or in service operating evidence to confirm compliance with the general and performance requirements as detailed in this Specification.

6.16.2 Pre-commissioning and energisation tests

The Contractor shall submit details of all pre-commissioning and energisation tests to the Project Manager for approval prior to the tests, and shall provide the Project Manager with the opportunity to witness the commissioning tests.

6.16.3 Testing, inspection and test certificates

The Bidder shall enclose with his bid the reports of type and routine tests conducted on similar equipment earlier as a proof of designing and developing similar equipment. Bid documents, furnished without these test reports shall be considered as incomplete and shall be liable for rejection.
All equipment furnished shall conform to the type tests and shall be subject to routine tests in accordance with the requirements stipulated for control and relay panel equipment. The Project Manager reserves the option to call for any or all the type tests to be repeated on the equipment. The Project Manager further reserves the option to intimate the type tests to be carried out on the equipment up to six months after the award of contract. Payments would be made for the type tests actually carried out in accordance with the rates given in the Bid Price Schedule.
The Project Manager will have the right to call for any other tests of reasonable nature to be carried out at the Contractor's premises or at site or in any other place, in addition to the aforesaid type and routine tests, to satisfy that the materials comply with the Specification.
The Contractor shall advise the Project Manager three months in advance of the type tests to be conducted on the finished equipment giving a programme for conducting the tests and shall

proceed to test the equipment only after approval of the Project Manager. All type tests shall be performed in presence of Project Manager should he so desire.
The Contractor shall give one months notice of routine tests and inspection to be carried out on the finished equipment. A programme for conducting the tests shall be furnished and the Contractor shall proceed to test the equipment after approval of the Project Manager. The tests shall be witnessed by the Project Manager should he so desire.
All inspections, type tests and routine tests shall be carried out after approval of all the relevant drawings required under the contract.
None of the equipment to be furnished or used in connection with this contract shall be despatched until factory tests are satisfactorily completed. Such factory tests on the equipment shall not however relieve the Contractor from full responsibility for furnishing equipment conforming to the requirements of this contract, nor prejudice any claim right or privilege which the Employer may have because of the use of defective or unsatisfactory equipment. Should the Project Manager waive the rights to inspect and test any equipment, such a waiver shall not relieve the Contractor, in any way, of his obligations under this contract.
Six (6) copies of test reports of successful tests shall be submitted by the Contractor to the Project Manager for approval before shipment of equipment.
For equipment tests for which IEC recommendations or Indian Standards are available, test reports confirming that the equipment has passed the specified type and routine tests shall be furnished for the approval of the Project Manager by the Contractor before shipment of the equipment.
For equipment/tests for which IEC/IS specifications do not exist, the Contractor shall propose a test procedure for the approval of the Project Manager before conducting tests. Test certificates for tests carried out shall be submitted for approval of the Project Manager before shipment of the equipment.
Failure of any equipment to meet the requirements of tests carried out at works or at site shall be sufficient cause for rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in the completion of the works in accordance with the agreed programme.
The Employer reserves the right to call for field tests on the completely assembled equipment at site.
The price for conducting all the type tests in accordance with relevant standards and specifications shall be indicated in Bid Price Schedule and these would be considered for bid evaluation. The break-up price of type tests shall be given in the relevant price schedule for payment purpose only. In case Bidder does not indicate charges for any of the type tests or does not specifically identify any test in the price schedules, it will be assumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to rejection.
Six (6) copies of all test reports shall be supplied for approval before shipment of equipment. The reports shall indicate clearly the standard values specified for each test, to facilitate checking of the test reports. Fourteen (14) bound copies of test reports shall be submitted along with the equipment after approval of test results.

6.16.4 Soak test

All solid state equipment/system panels shall be subject to the Hot Soak Test as a routine test in accordance with the procedure detailed in the following paragraph.
All solid state equipment shall be burn-in tested for minimum of 120 hours continuously under operational conditions. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50C. Each panel shall be complete with all associated sub-systems and the same shall be in operation during the above test. During the last 48 hours of the above test, the temperature inside the panel shall be monitored with all the doors closed. The temperature of the panel interior shall not exceed 65C.

6.16.5 Type tests

Impulse voltage withstand test as per Clause 6.1 of IS 8686 (for a test voltage appropriate to Class III as per Clause 3.2 of IS-8686)

High Frequency Disturbance test as per Clause 5.2 of IS 8686 (for a test voltage appropriate to Class III as per Clause 3.2 of IS 8686)
Type tests listed under IEC-Technical Committees recommendation `TEC-57' and functional type tests listed under **CIGRE Study Committee 34** (Protection) Report on simulator, Network analyser or PTL as applicable.

6.16.6 Routine tests
Contact insulation resistance test as per Clause 10.5 of IS-3231.
Insulation withstand capability as per Clause 10.5 of IS-3231 on all AC/DC relays.

7.0 Protection Schemes

7.1 General
The following sections of this specification identify the protection requirements for specific schemes. Drawings showing single line diagrams for each type of circuit are included in this Specification. The arrangements shown on these drawings represent the minimum requirements. Other protection arrangements may be provided but the Bidder must clearly state the reasons for offering supplementary protection schemes.

7.2 Technical requirements
Technical requirements of the protection and auxiliary relays, recorders and meters to be provided as part of the scope are detailed I the following sub clauses.
The setting ranges of the equipment offered, if different from that specified shall be acceptable if they meet the functional requirements. The Bidder shall quote for protection equipment meeting the requirements given in these sub clauses.
The Bidder may also quote alternative or additional protections or relays considered necessary by him for providing an effective and reliable protection scheme. These equipments shall be quoted separately as an alternative or addition to the main offer. The Employer reserves the right to accept or otherwise such equipment.

7.3 400kV Reactor protection

Protection requirement
The 400 kV reactors provided with the lines shall have the following protections**.**

- Differential protection.
- Restricted earth fault protection.
- Backup impedance protection.

7.3.1 Differential protection relay (87R)
This relay shall :

1. Be triple pole type
2. Have operation time less than 25 milliseconds at five times setting.
3. Be tuned to system frequency.
4. Have three instantaneous high set units to ensure rapid clearance of heavy faults with saturated CTôs.
5. Have current setting range of 10 to 40% of 1 Amp.
6. Be Low impedance type.
7. Be stable for all external faults.
8. Be provided with suitable non-linear resistors to limit the peak voltage to 1000 volts.

7.3.2 Restricted earth fault protection relay (64 R)

This relay shall:

1. Be single pole type
2. Be of current/voltage operated high impedance type
3. Have a current setting of 10-40% of 1A and a suitable voltage setting range.
4. Be tuned to system frequency.
5. Be fitted with suitable non-linear resistors to limit the peak voltage to 1000 volts.

7.3.3 Back up impedance protection relay (21 R)

This relay shall:

1. Be triple pole type
2. Be single step polarised `mho' distance relay or impedance relay suitable for measuring phase to ground and phase to phase faults.
3. Have an ohmic setting range of 20-320 ohms and shall be continuously variable.
4. Have an adjustable characteristic angle of 30 to 80 degree.
5. Have a definite time delay with a continuously adjustable setting range of 0.2 - 2.0 seconds. Shall initiate three phase tripping

7.4 Transformer protection

The following protection shall be provided for all 315MVA 400/220kV and 220/132/33 KV,160 or 100MVA autotransformers(33 kv side is delta winding and is a loaded winding), and 220/33kV and 132/33kV double wound transformers: **All the relay shall be latest numerical version having IEC 61850 protocol compliance**

1. Transformer differential protection (87AT)
2. Over fluxing protection (99AT)
3. Restricted earth fault protection (64AT)
4. Back-up directional over current protection (67/51/50) on HV side
5. Back-up directional earth fault protection (67N/51N/50N) on HV side
6. Back-up directional over current protection (67/51/50) on LV side
7. Back-up directional earth fault protection (67N/51N/50N) on LV side
8. Restricted earth fault protection (64R)
9. Transformer over load protection (51OL)
10. LBB for 400kV, 220kV and 132kV sides.

7.4.1 Transformer differential protection relay (87AT)

This relay shall :

1. Be triple pole type, with faulty phase identification/indication
2. Have an operating time not greater than 30 milliseconds at five times setting.
3. Have three instantaneous high set units to ensure rapid clearance of heavy faults with saturated CTôs.
4. Have an adjustable dual slope bias setting range of 10%-50%.
5. Be suitable for rated current of 1A.
6. Have second harmonic and fifth harmonic restraint feature and also be stable under normal over fluxing conditions and inrush of current during charging.

7. Have at least three bias winding per phase.

8. Have an operating current setting adjustable between 10% and 50%

9. Should not require interposing transformers and the relay should correct the vector group difference and CT primary/load current difference.

7.4.2 Over fluxing protection relay (99AT)
This relay shall :

1. Operate on the principle of voltage to frequency ratio and have two settings - for alarm and trip.

2. Have inverse time characteristics, matching with transformer over fluxing withstand capability curve.

3. Provide an independent `alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of ñ***v/f***ò between 100% to 130% of rated values.

4. Have a set of characteristics of various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at ñ***v/f***ò values of 1.4 and 1. 5 times, the rated values, respectively.

5. Have a tripping time governed by ñ***v/f***ò Vs. time characteristics of the relay.

6. Have an accuracy of operating time better than ± 10%.

7. Have a resetting ratio of 98% or better.

7.4.3 Restricted earth fault protection relay (64AT)
This relay shall:

1. Be single pole type.

2. Be of current/voltage operated high/low impedance type.

3. Have a current setting range of 10-40% of 1A and a suitable voltage setting range.

4. Be tuned to the system frequency

5. Have suitable non-linear resistor in case required to limit the peak voltage to 1000 Volts.

7.4.4 Transformer overload protection feature
The transformer overload protection shall:

1. Be a single pole type

2. Be a definite time overcurrent type

3. Have two separate sets of overcurrent relay elements, each with continuously adjustable setting range of 50-200% of rated current independently.

4. Have two separately adjustable time delay relays, one for alarm having setting range of 1 to 10.0 seconds, continuously. The second time delay relay should have continuously adjustable setting range of 1.0 to 10.0 minutes for tripping.

5. Have a drop-off/pick-up ratio greater than 95%.

7.4.5 HV /LV side back-up directional over current protection
This relay shall:

1. Be single pole type.

2. Have IDMT characteristics with a definite minimum of three seconds at ten times the setting.

3. Have a variable setting range of 50% to 200% of rated current.

4. Have a characteristic angle of 45 degrees, a directional controlled, low transient over reach, high set instantaneous unit of continuously variable setting range of 500- 2000% of rated current.

5. Provision of highest setting in two stages.

7.4.6 HV/LV side back-up directional earth fault protection

This shall also have identical specification as at clause above excepting that the adjustable setting range shall be 20-80%.

7.5 TEE protection differential relays (87 TT1,87TT2) (applicable for 5 CT scheme)

Where a Tee Protection for a five CT system is provided the following shall be applicable.

7.5.1 First set of differential relays

One set of differential protection relays (87 TT1) shall

1. Be triple pole type.
2. Have an operating time less than 30 milliseconds at five times setting
3. Have three instantaneous high set over current units.
4. Have an adjustable bias setting range of 20% to 50%
5. Be suitable for rated current of 1A.
6. Have three bias windings.
7. Have an operating current setting of 15% or less.

7.5.2 Second set of differential relays.

The second set of Differential relay (87 TT2) shall:

1. Be triple pole type.
2. Have operating time less than 25 milliseconds at five times setting.
3. Be tuned to system frequency
4. Have current setting range of 20 to 80% of 1A.
5. Be voltage operated, high impedance type
6. Be stable for all external faults.
7. Be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts.

7.6 BUS BAR PROTECTION:

Bus bar protection schemes shall be provided for each main and transfer bus of 400 KV and 200 KV provided in the switch yard. This shall constitute main and check features. The overall scheme shall be engineered such that operation of both main and check features connected to the faulty bus shall result in tripping of the same. The scheme shall be provided with necessary expansion capacity and interfaces for adding features when the switch yard is extended in future to its ultimate capacity. The bus bar relay shall be of latest numerical relay having IEC protocol 61850 compliance.

7.6.1 Busbar protection (Latest version numerical having IEC-61850 protocol compliance)

Bus bar protection schemes shall be provided for each main bus of 400kV and 220kV switchyard. The overall 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. However in case of transfer bus, where provided, only one busbar protection scheme shall be required.

Each busbar protection scheme shall

1. Be of modular construction and have features of self monitoring facility to ensure maximum availability of scheme. The scheme shall be static/ microprocessor/ Numerical based.

2. Have maximum operating time up to trip impulse to trip relay for all types of faults of 15 milli seconds at 5 times setting value.

3. Operate selectively for each busbar.

4. Give hundred percent security up to 40kA fault level.

5. Incorporate a check feature.

6. Incorporate continuous supervision for CT secondaries against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate alarm.

7. Not give false operation during normal load flow in busbars.

8. Incorporate clear zone indication.

9. Be of phase segregated and triple pole type and provide independent zones of protection for each bus (including transfer bus if any). If a bus section is provided then each side of the bus section shall have separate busbar protection scheme.

10. Include individual high speed hand reset tripping relays for each feeder, including future ones.

11. Be of low/medium impedance biased differential type and have operate and restraint characteristics.

12. Be transient free in operation

13. Include continuous DC supplies supervision.

14. Shall include multitap auxiliary CT's for each bay including future bays as per SLD and also include necessary CT switching relays wherever CT switching is involved.

15. Include protection 'in/out' switch for each zone with at least six contacts for each switch.

16. Shall have CT selection incomplete alarm wherever CT switching is involved.

17. Have necessary auxiliary relays to make a comprehensive scheme.

At existing substations busbar scheme with independent zones for each bus will be available. All necessary co-ordination for 'CT' and 'DC' interconnections between existing schemes (panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relays, trip relays, flag relays required to facilitate the operation of bays covered under this contract shall be fully covered in the scope of the bidder.

The Contractor shall offer all equipment to meet the requirements as above to make the scheme full and comprehensive.

7.6.2 Weatherproof relay panels

Where required these panels shall be provided for busbar differential protection. The panels shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contact multiplication and for changing the CT and DC circuits to relevant zone of protection.

The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 3.0 mm thick and properly braced to prevent movement. The enclosures of the panel shall provide a degree of protection of not less than IP55 (as per IS 2147). The constructional requirements shall comply with the relevant section of this Specification.

Two test terminal blocks required for bus coupler bay CT connection shall be supplied and mounted inside the panel of adjacent bay.

The test terminal blocks shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. Such blocks shall have

washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

7.7 Tripping relay (86)

High speed tripping relay shall:

1. Be instantaneous (operating time not to exceed 10 milliseconds).
2. Reset within 20 milliseconds. Not self resetting.
3. Be DC operated
4. Have adequate contacts to meet the requirement of scheme, other functions such as auto-reclose relay, LBB relay as well as cater to associated equipment such as event logger, disturbance recorder, fault locator, etc.
5. Be provided with operation indicators for each element/coil.

7.8 Flag relays

These shall have:

1. Hand reset flag indication
2. Two elements
3. Four contacts (NO or NC or combination as required), for each element/coil.

7.9 Trip circuit supervision relay

The relay shall be capable of monitoring the healthiness of each `phase' trip coil and associated trip circuit of circuit breaker during `ON' and `OFF' conditions. The relay shall have adequate contacts for providing connections to alarm and event logger. The relay shall have time delay on drop-off of not less than 200 milliseconds and be provided with operation indications for each phase.

7.10 Supply supervision relay

The relay shall be capable of monitoring the DC supply to which it is connected and indicating failure. 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 milliseconds and be provided with operation indicator/flag.

7.11 Bus coupler / transfer bus coupler protection

The protection scheme for the above are to be provided with directional numerical over current and earth fault protection scheme . The relay shall be latest version numerical and IEC 61850 compliant for future SCADA purpose.The details as indicated under unit back up protection relay.

All 220 kV substations shall be of Double Main (DM) or Double Main and Transfer (DMT) busbar configuration and shall be provided with a single bus coupler circuit breaker. In addition 220 kV DMT busbar configurations shall be provided with a transfer bus coupler circuit breaker. The required protection equipment for these breakers comprises overcurrent and earth fault relays. These relays shall comply with the requirements for backup over current and earth fault protection as described elsewhere in this section, except that the relays shall not be directional. The earth fault element shall have a current setting range of at least 20 - 80 per cent in six equal steps.

All 132 and 33 kV substations shall be of Single Main and Transfer (SMT) busbar configuration and a bus section isolator. Overcurrent and earth fault protection, complying with the requirements as given elsewhere in this section but without directional feature, shall be provided.

In DMT/SMT configurations, whenever the main breaker of a feeder or transformer is substituted by the bus coupler or transfer bus coupler breaker, a facility for switching over of the trip function of the feeder or transformer relays from the main breaker to the bus coupler or transfer bus

coupler breaker, shall be provided through provision of a lockable protection transfer switch. The provision of a key interlock on the above switch is to be so arranged that at one time only one feeder or transformer can be taken to transfer mode.

7.12 Circuit breaker monitoring auxiliary relays

All circuit breakers shall be provided with several relay contacts for annunciation of circuit breaker conditions such as :

- Low air/hydraulic oil/gas pressure.
- Lockout conditions due to abnormally low air/hydraulic oil/gas pressure.
- Pole discrepancy trip.
- Compressor/hydraulic pump trouble.

The exact requirements for this shall be available in the circuit breaker drawings to be provided by the manufacturer. The programmable Inputs/Outputs of the numeric relays shall be used as much as possible for providing annunciation in the control room for such cases. In case this is found inadequate, suitable auxiliary flag relays may be provided in the relay panels to provide annunciation.

7.13 Disturbance recorder (Required for 400 and 220 KV sub-station)

7.13.1 General

Where required disturbance recorders shall be provided separately. Integrated out put from the relays memory is also acceptable.

Disturbance recorders shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage and neutral current, open or closed position of relay contracts and breakers during system disturbances. Necessary auxiliary VTôs, to generate open delta voltage, shall be supplied by the Bidder. The Bidder shall furnish along with the offer a typical printout for simulated conditions, on original paper.

The disturbance recorder shall be an individual acquisition unit, one for each feeder, and shall have at least 8 analogue and 16 event channels for acquisition of fault data and events. The restitution unit, printer, EGA/VGA screen and key board shall be common for the entire substation. The acquisition unit shall acquire fault data and store either on portable magnetic cassettes or floppy discs, or instantaneously transfer data to the restitution unit for storage in solid state non-volatile memory. The restitution unit shall be capable of reading fault data from the magnetic cassettes or floppy discs or from its own memory, as the case may be, and controlling the printer to give the graphic form whenever desired by the operator. The acquisition units shall be located in the protection panels of the respective feeders and the restitution unit along with the printer shall be located suitably within the substation control room. Only one printer for the entire substation is required for disturbance recording purposes.

The disturbance recorder system shall have non-volatile memory of the last ten faults of at least 1.6 second duration each.

7.13.2 Features of the disturbance recorder.

The disturbance recorder shall incorporate the features as described below:

7.13.3 Software stability

The operation of the equipment shall be based on programme stored in non-volatile solid state memory. The programme shall be stable and no inadvertent change of programme shall occur.

7.13.4 Reliability

Large scale integrated circuits shall be used as far as possible to reduce the number of components and interconnections and the amount of wiring. The components used shall be

subjected to strict quality control which shall include screening of components by heat soaking and testing their functioning prior to assembly.

7.13.5 Simplicity of maintenance and repair

The number and type of modules employed shall be minimised. The modules shall be of plug-in type and shall be easily accessible for maintenance and repair wherever required.

7.13.6 Immunity from the effects of hostile environment

The equipment shall be designed to operate satisfactorily even when subject to the effects of severely hostile electrical environment such as interference signals arising from switching transients. The equipment shall be mounted in self contained, free standing cubicles and shall be of dust, vermin and rodent proof construction. Ventilation arrangements shall be provided if warranted by power dissipation level of the equipment.

7.13.7 Interface with PC

The disturbance recorder should have an interface arrangement for the transfer and storage of data to PC through its serial port. Necessary PC, software, special cables etc. shall be part of the disturbance recorder and should be included in the Bid.
PC based user friendly, disturbance recorder evaluation software shall be provided for the analysis and evaluation of the record data made available in the PC under WINDOWS environment. The software features shall include:

- Repositioning of analogue and digital signals
- Selection and amplification of time and amplitude scales of each analogue and digital channel
- Calculation of MAX/MIN frequency and phase difference values
- Recording of MAX/MIN values etc. of analogue channels
- Grouping of signals 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.

7.13.8 Power supply

Disturbance recorder equipment shall be suitable for operation from 220V DC or 110V DC supplies as available at substation. Voltage variation of +10% and -20% can be expected. Any other power supply that may be required for proper functioning of the equipment including the printer shall be derived by the Bidder from his own equipment and shall form an integral part of the disturbance recorder system.

7.13.9 Alarms and indications

All external and internal faults in the disturbance recorder equipment such as power supply fail, printer faulty, paper exhausted, processor/memory fail etc. are required to be indicated by means of light emitting diodes on the front of panels of the equipment if type 2 disturbance recorders are offered, or on the front of panel of the restitution unit if type 1 disturbance recorders are offered.

7.13.10 Scan rate

The frequency response shall be DC on lower side and 250 Hz or better on upper side. The acquisition unit shall have a scan rate of 1000 Hz/channel or better.
The equipment shall have as an inherent part of it, starting sensors based on over voltage, rate of change of current, and rate of change of frequency. These starting sensors, when picked up, shall start the disturbance recorders to give out the graphic form of analogue and event signals, in the

case of type 2 disturbance recorders. If type 1 disturbance recorders are offered the starting sensors, on pick up, shall preserve the fault data acquired during the period of system disturbance, including pre-fault and post fault time, on magnetic cassettes, floppy disks,CD or solid state memory of restitution unit, as the case may be. Preserved fault data shall not be erased other than by the operator. Erasing arrangement shall be provided in the restitution unit.

7.13.11 Starting sensors

The equipment shall have inherent to it starting sensors based on over voltage, rate of change of current and rate of change of frequency. The starting sensors on pick-up shall preserve the fault data acquired during the period of system disturbance including pre-fault and post fault time on magnetic cassettes,CD or floppy diskettes or solid state restitution unit as the case may be.

7.13.12 Pre-fault and post-fault time

Pre-fault time shall not be less than 160 ms and the post fault time adjustable at a minimum of two seconds and a maximum of not less than five seconds. If another system disturbance occurs during one post-fault time, the recorder shall also be able to record the same.

7.13.13 Amplitude and event resolution

Amplitude resolution shall not be less than eight bit. Event resolution shall be 2 ms or better.

7.13.14 Print out

The print out shall contain the following:

1. Feeder identity.
2. Date and time (in hour, minute and second up to 100th of a second).
3. Identity of trigger source.
4. Graphic form of analogue and event signals of all the channels.

The print out shall be clear and legible without the help of looking glass or any such device. Minimum acceptable paper width shall be 8-1/2 inches. (216 mm approx.)

7.13.15 Type and quantity of paper

Printer shall use plain paper. The Bidder shall provide as part of his scope of supply sufficient consumable for 6 months operation. The arrangement of feeding and removing paper rolls shall be quick and simple.

7.13.16 Time generator

Each disturbance recorder shall have its own time generator. The facility shall exist to synchronise the time generator from station time synchronisation equipment having output of following types at 30 min interval

1. Voltage signal - 3 to 50V continuously settable, with 50 ms minimum pulse duration.
2. Potential free contact (Minimum pulse duration of 50 ms.)
3. IRIG-B
4. RS232C

At substations where station time synchronisation equipment is not available, time generator of any one of the disturbance recorders can be taken as master. The facility shall exist to synchronise the time generators of other disturbance recorders and event loggers in that station with respect to it. The recorder shall give annunciation in case of absence of `Sync'. pulse within a specified time. The clock of the time generator shall be such that, the drift is limited to ± 0.5 seconds per day, if allowed to run without synchronisation. Facility shall exist to display the time in hours, minutes and seconds on the front of panel.

7.13.17 Inputs

The equipment 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 them compatible to the equipment shall form an integral part of the equipment. However, such processing of input signals shall in no way distort its wave form. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. The input circuits shall withstand the following tests.

- 5kV impulse test in accordance with IEC 225 Part-IV.
- High frequency disturbance test in accordance with IEC 255 Part-IV).

8.0 Event logger (**)

**As per the customers requirement
All 400 and 220 KV sub-station shall have separate Event Logger panel provision.

8.1 General

The event logger shall be used to record the open and close states of switch yard equipment, relays and changes of alarms.
The function of the equipment should be based on programmes stored in it. The stored programmes should permit some degree of flexibility of operation. Facility should be provided to erase the existing programme and reprogram allowing changes to be made very easily.
The number of modules and different types of modules should be minimised. The modules should be of plug-in type and should be easily accessible to simplify maintenance and repair.
The equipment should be designed to operate satisfactorily in severely hostile electrical environment such as in 400kV/220kV switchyard which are prone to various interference signals, typically from large switching transients.
The equipment should be carefully screened, shielded, earthed and protected.
Input/ Output circuits should withstand the following tests:

- Impulse test in accordance with IEC 255, Part-IV.
- High frequency disturbance test in accordance with IEC 255, Part-IV.

Since the equipment will be used in dedicated non-attended situations, programme stability is vitally important. Programme must not be capable of being changed unintentionally during normal operation.

8.2 Construction

The equipment should be constructed in clearly defined plug-in modules. A monitor module should be provided for indicating internal faults such as processor failure, memory failure, other internal hardware failures, and also external plant failures. These failures should be displayed on the LED's mounted on the monitor module. The equipment is used to record changes in digital points, i.e. operations and resetting of alarms and switching of primary equipment within a substation. Approximately 500 points should be accommodated in a single equipment. When such changes occur, a print out on a local teletype writer, which forms a part of this contract, should result.
The date and time should be printed to the nearest 10 ms followed by a message describing the point which has operated. Such messages may be abbreviated or in full English forms. Events occurring whilst a previous event is in process of being printed are to be stored to await printing. Over 100 such events must be stored. Facility shall exist to synchronise the internal clock system which will give a pulse output every half an hour with a pulse duration of at least 50 milliseconds through potential free contracts. However, if master clock system is not available, time generator of any one of the disturbance recorder shall be taken as master and event logger(s) in that station will be synchronised with it. The event logger shall give annunciation in case of absence of synchronising pulse within a specified time window. The internal clock of the event logger shall be such that the drift is limited to □0.5 seconds per day, if allowed to run without time synchronisation. The print out of current alarm and plant stages must be available on request by the operator. the operator should also be able to enter the date and time from the key board.

8.3 Technical requirements

The event recorder shall record all changes of alarms and plant states of switchyard equipment, along with the date and time of all alarms and plant state changes to the nearest 10 ms.
Facility shall be provided to commit 50 points of sequential memory or 25% of alarm whichever is the greater. In addition the unit shall be capable of handling up to 40 changes in any one 10 ms interval and 500 alarms and changes of state of switchyard equipment.
On receipt of an alarm the equipment must:

- Print out a message on Printer
- Set off an audible alarm.
- Set off a beacon.

Allow normal inputs of

- Accept
- Alarm demand log
- Plant state demand log
- Date and time

The Bidder shall furnish along with the offer a two copies on original paper typical print out for simulated conditions.
Only plain paper readily available in India shall be used for the printer. The arrangement of feeding and removing paper rolls or stacks shall be quick and simple. The width of paper shall be 216 mm approximately. The Bidder shall provide as part of his scope of supply, consumables for up to six months operation.
Event printout of the shall contain as a minimum the following:

- Station identification.
- Date and time (in hour, minutes, seconds and milliseconds).
- Event number.
- Event description (at least 40 characters).

The auxiliary power supply required for the event logger, VDU and printer shall be either 220V DC or 110V DC (as available in the station) with voltage variation of + 10% to -20%. Any other power supply that may be required for proper functioning of the equipment has to be derived by the Bidder from his own equipment which shall form an integral part of the event logger station.
Bidder shall supply VDU, printer and keyboard arrangement.
At existing substations where an event logger is provided, Bidder shall provide necessary potential free contracts of various relays/equipment for plant and alarm states and shall co-ordinate with existing event logger for proper logging of events.
A combined solution of disturbance recorder and event logger function with a VDU, key board and a printer is also acceptable.

9.0 Synchronising equipment

Where required synchronising equipment shall be provided along with this Contract.
The synchronising instruments shall be mounted on a synchronising trolley. The trolley shall be equipped with double voltmeter, double frequency meter, synchroscope and lamps fully wired. The trolley shall be of mobile type with four rubber padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement.
The trolley shall have two metre long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

Synchronising check relay with necessary ancillary equipment shall be provided. This shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have a continuously adjustable time setting range of 0.5-3 seconds. A guard relay shall be provided to prevent a closing attempt by means of synchronising check relay when control switch is kept in closed position before the two systems are in synchronism.
Suitable auxiliary voltage transformers, wherever necessary, shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.
Each circuit for which a synchronous closure is required shall be provided with a lockable synchronising selector switch which shall be used to select the voltage signals (incoming and running voltage) appropriate for that circuit. The provision of a key interlock shall ensure that at any one time only one feeder / transformer can be synchronised.

10.0 Time synchronisation equipment for substation

The Bidder shall offer necessary time synchronisation equipment complete in all respects including antenna, all cables, processing equipment etc. required to receive co-ordinated universal time (UTC), transmitted through GEO Positioning Satellite System (GPS).
The time synchronising system should be compatible for synchronisation with event loggers, disturbance recorders, relays, computer systems and all other equipment provided in the protection, control and metering system of the substation wherever required.
Equipment should operate up to an ambient temperature of 50C and 100% humidity. The synchronisation equipment shall have two microsecond accuracy. Equipment should give real time corresponding to IST (taking into consideration all factors such as voltage and temperature variations, propagation and processing delays etc.
Equipment should meet the requirement of IEC 255 for storage and operation. The system should 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 output ports. Various combinations of output ports shall be selected by the Project Manager, during detailed engineering, from the following:

1. Voltage signal : 0-5V continuously settable, with 50 ms. minimum pulse duration.
2. Potential free contact : minimum pulse duration of 50 ms
3. IRIG-B & SNTP
4. RS232C

The equipment should have a periodic time correction facility of one second periodicity.
Time synchronisation equipment shall be suitable for operation from 220V DC as available at substation with a voltage variation of +10% and -20%. Any other power supply that may be required for proper functioning of the equipment shall be derived by the Bidder from his own equipment which shall form an integral part of the system.
Equipment shall have real time digital display in hour, minute, second (24 hour mode) and have a separate time display unit to be mounted on the top of control panels having display size of approximately 100 mm height.
Bidder shall quote unit rates for each type of output port for the purpose of addition/deletion.
Schedule of Quantities

11.0 General

Protection, control, metering panels and associated equipment to be located in switchyard control rooms at various substations shall be offered as panels/systems/modules of following description. The quantities are given at the end of this section.

Sl. No.	Description of Panels	Control Panel type and designtation	Relay Panels type and designtation
1	Line protection panel:		
1.1	400kV line-4CT,5CT (1 $^{1}/_{2}$ breaker scheme)	CPF4H	RPF4H
1.2	220kV line-DMT	CPF2D	RPF2D
1.3	132kV lineð MT	CPF1M	RPF1M
1.4	33kV lineð MT	CPF0M	RPF0M
2	Transformer protection panel:		
2.1	400/220kV Auto-	CPH4H	RPH4H
	Transformer	CPL2D	RPL2D
2.2	220/132kV Auto-	CPH2D	RPH2D
	Transformer	CPL1M	RPL1M
2.3	220/33kV power	CPH2D	RPH2D
	Transformer	CPL0M	RPL0M
2.4	132/33kV power	CPH1M	RPH1M
	Transformer	CPL0M	RPL0M
3	Reactor protection panel:		
3.1	Bus reactor	CPR4H	RPR4H
3.2	Line reactor	CPS4H	RPS4H
4.1	Transfer bus coupler		
	220kV line-DMT	CPT2D	RPT2D
	220kV line-T	CPT2T	RPT2T
4.2	Bus coupler		
	220kV line-DMT	CPB2D	RPB2D
	132kV lineð MT	CPB1M	RPB1M
	33kV lineð MT	CPB0M	RPB0M
4.5	Bus sectionaliser	CPZ2D	RPZ2D

11.1 Type designations for the various panels

The panels are designated by a alpha-numeric code consisting of five characters (AAANA) through out this schedule in this specification to represent their use for various applications. Their representation shall be as here under:

Character position	1 2	3	4	5
Character representation	AA	A	N	A

H				$1^1/_2$ breaker scheme
D				Double main and transfer switching scheme
M				Main and transfer switching scheme
S				Single bus
T				Two mains bus switching scheme
R				Ring main bus switching scheme
0			33kV	
1			132kV	
2			220kV	
4			400kV	
F		Feeder		
H		Transformer High Voltage Side		
L		Transformer Low Voltage Side		
R		Bus reactor		
S		Shunt(line) reactor		
T		Transfer bus coupler		
B		Bus coupler and Bus bar		
Z		Bus sectionaliser		
C		Capacitor bank protection		
V		Bus bar		
M		Diameter with Transformer and Feeder		
N		Diameter with Feeder and Feeder		
O		Diameter with Feeder and Feeder		
P		1/2 Diameter with Single Feeder		

Q	1/2 Diameter with Single Feeder with Reactor
CP	Control panel
RP	Relay panel
KP	Common panel

11.2 Bill of quantities for individual panels

Each panel described above shall constitute the equipment as detailed here under . The quantities of each type of equipment are minimum. The bidder may include additional devices in the panels depending upon the design and requirements as per stipulations of the specification.

Control panel (CPANA)

Sl. no	List of equipment	CPA4H / CPA2H	CPA2D /CPA1M /CPA2T	CPA1M /CPA0S / CPA0T
		Quantities required for each panel		
		For 400kV / 220kV and 1 $^1/_2$ breaker scheme	For 220kV and 132kV	For 33kV
1.	Ammeter (Digital)	3 Nos. for each bay (1 for each bay in case of 220 kV) + 1No. for reactor (as per requirement)	1No. (2 Nos. for Bus section coupler)	1No.
2.	Wattmeter (Digital)	1 No. for each bay	1 No. (2 Nos. for Bus section coupler)	1 No.
3.	VARmeter (Digital)	1 No. for each bay + 1 No. for line reactor (as per requirement)	1 No. (2 Nos. for Bus section coupler)	1 No.
4.	Voltmeter (Digital)	1 No. for each bay	1 No. for each bay	1 No. (only in bus coupler panel)
5.	Digital voltmeter with selector switch	1 set for new substation in any one specific control panel	1 set for new substation in bus coupler panel	Not required
6.	Digital frequency meter	1 set in any one specific control panel	1 set in bus coupler panel	1 set in bus coupler panel
7.	Solid state trivector type energy meter for recording export, import of MWH, MVA and MVARH with	NOT REQD	NOT REQD	NOT REQD

	MDI.			
8.	Winding temperature indicator	Not required	Not required	Not required
9.	Discrepancy control switch for breaker	1No. for each circuit breaker	1No. for each circuit breaker	1 No. for each circuit breaker
10.	Discrepancy control for isolator	1No. for each isolator	1No. for each isolator	1No. for each isolator
11.	Discrepancy control for earth switch	one for each earth switch	one for each earth switch	one for each earth switch
12.	Mimic to represent SLD	one for each panel	one for each panel	one for each panel
13.	Ammeter selector switch	one for line reacter (as per requirement)	one for each panel	one for each panel
14.	Voltage selector switch	one for each bay	one for each bay	one for each volt meter (only in buscoupler Bay)
15.	DC source selector switch	one for each panel	one for each panel	one for each panel
16.	Indicating lamps			
16.1.	Red indicating lamps for ON	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker
16.2.	Green indicating lamps for OFF	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker
16.3.	White indicating lamp for circuit breaker healthy	one for each circuit breaker	one for each circuit breaker	one for each circuit breaker
16.4.	Indicating bulb for circuit breaker control position (Local/Remote) (If required)	two for each circuit breaker	two for each circuit breaker	two for each circuit breaker
16.5.	Blue indicating lamp (for spring charge)	one for each circuit breaker	one for each circuit breaker	one for each circuit breaker
16.6.	for annutiation D.C. fail	one in any one specific control panel	one in bus coupler pannel	one in buscoupler pannel
16.7.	for Annunciation A.C. fail	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
16.8.	for flasher healthy	one in any one specific control pannel	one in buscoupler pannel	one in buscoupler pannel

16.9.	for Busbar VT secondary healthy	three for each bus in any one specific control panel	three for each bus in buscoupler pannel	three for each bus in buscoupler pannel
17.	Push buttons			
17.1.	for alarm accept	one for each panel	one for each panel	one for each panel
17.2.	for alarm reset	one for each panel	one for each panel	one for each panel
17.3.	for lamp test	one for each panel	one for each panel	one for each panel
17.4.	for audio alarm reset	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.5.	for annunciation D.C. fail accept	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.6.	for annunciation D.C. fail test	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.7.	for annunciation A.C. fail accept	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.8.	for annunciation A.C. fail test	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
18.	Annunciation windows with necessary annunciation relays	24 for each feeders bay 24 for each treansformer bay 24 for each Tie	24 for each feeders panel 24 for each transformer panel 24 for each Tie and each bus coupler panel	18 for each feeders panel 18 for each transformer panel 18 for each bus coupler panel
19.	Synchronising socket	one for each circuit breaker	one for each circuit breaker	Not required
20.	Bus CVT selector switch (as per requirment)	one for each panel	one for each panel	one for each panel
21.	Protection trip transfer switch (TTS)	not required	one for each panel	one for each panel
22.	Reactor de-interlocking push button	one for each circuit breaker bay (where applicale)	not required	not required
23.	Hooter	one for each new sub-station	one for each new sub-station	one for each new sub-station
24.	Buzzer	one for each new sub-station	one for each new sub-station	one for each new sub-

				station

11.3 Line protection panel (RPLNA)

The line protection panel or panels may be a single panel or more panels to accommodate all the equipments listed below. However, for bay extension, new panels must match the existing panels in all respect.

Sl. No	Equipment	Quantities required			
		400kV RPL3H	220kV RPL2A	132kV RPL1A	33kV RPL0A
1	Main-I protection scheme (composite numerical distance protection relay with auto reclosing and check syncronising facility)	1 set	1 set	1 set	Not required
2	Main-II protection scheme(composite numerical distance protection or phase comparision relay with auto reclosing and check syncronising facility)	1 set	1 set	Not required	Not required
3	Composite numerical directional & or non-directional over current and earth fault relay.(selectable Features Dir & Non Dir)	1 set	1 set	1 set	1 set
4	Over voltage/ Under voltage protection scheme (if not available in the main-I& II protection module)	1 set	1 set	1 set	Not required
5	Selector switch for carrier in/out for main-I and main-II protection scheme	2 Nos.	2 Nos.	1No.	Not required
7	Disturbance recorder (if not available in the distance protection or main protection module)	1 set	1 set	1 set	Not required
8	Distant-to-fault locator for phase and earth faults(if not available in the distance protection or main protection module)	1 set	1 set	1 set	Not required
9	CVT selecting relays or switches (depending on switching scheme)	1 set	1set	1set	Not required
10	Test terminal blocks for Main-I/ Main II/other protection relay	1 set for each module	1 set for each module	1 set for each module	1 set for each module
11	Auxiliary relays for carrier supervision of Main-I and Main II protection relays (depending on its application)	1 set	1 set	1 set	Not required
12	Carrier receive lockout relay (depending on its application)	1 set	1 set	1 set	Not required
13	Breaker failure protection scheme	1 set	1 set	1 set	1 set
14	Trip circuit pre and post supervision relays for trip coil I and II	1 set	1 set	1 set	1 set
15	DC supply supervision relay	1 set	1 set	1 set	1 set
16	Flag relays for circuit breaker trouble shooting	1 set	1 set	1 set	1 set
17	Trip relays single/three phase for group-A	1 set	1 set	1 set	1 set

18	Trip relays single/three phase for group-B	1 set	1 set	1 set	1 set
19	Trip relays single/three phase for LBB	1 set	1 set	1 set	1 set
20	Under Frequency Relay(in built feature of O/C & E/F relay)	1 set	1 set	1 set	1 set

11.4 Transformer protection panel(RPHNA and RPLNA)

The transformer protection panel or panels may be a single panel or more panels to accommodate all the equipments listed below. However, for bay extension, new panels must match the existing panels in all respect.

Sl. No	Equipment	Quantities required		
		For each High Voltage panel of 400/220kV and 220/132kV transformers	For each High Voltage panel of 220/33kV and 132/33kV transformers	For each Low Voltage Panel of transformers
1	Main-I Transformer composite numerical protection comprising of the following: • Differential protection • Restricted earth fault protection • Over fluxing protection	1 set	1 set	Not required
2	Main-II Duplicated numerical protection as Main-I	1 set	Not required	Not required
3	Composite numerical directional over current and earth fault protection relay(selectable Features Dir & Non Dir)	1 set	1 set	1 set
	Restricted earth fault protection (Electromechanical of high impedance with Stabilising resistor & metrosil)	1 set	1 set	1 set
4	Over load protection (if not included in sl.no. 1 and 2 above)	1 set	1 set	1 set
5	Over voltage/ Under voltage protection scheme (if not available in the main protection module)	1 set	1 set	Not required
6	Flag relays for thermal imaging, MOG, WTI, OTI, Bucholz, PRV,OSR and status indication etc.. (1.MOG-Al,2.WTI,BUCH,OTI ï Al & Trip,3. PRV,OSR ï Trip)	1 set	1 set	Not required
7	Solid state trivector type energy meters for measurement of export/ import of MWH, MVA and MVARH with MDI.	1 set	1 set	1 set
8	CVT/PT selection relays (depending upon the the switching scheme of the	1 set	1 set	1 set

	system)			
9	Breaker failure protection scheme	1 set	1 set	1 set
10	Trip circuit pre and post supervision relays for trip coil I and II.	1 set	1 set	1 set
11	DC supply supervision relay	1 No for each panel	1 set	1 set
12	Flag relays for circuit breaker trouble shooting	1 set	1 set	1 set
13	Trip relays three phase for group-A	1 set	1 set	1 set
14	Trip relays three phase for group-B	1 set	1 set	1 set
15	Test terminal blocks for all protection relays	1 set for each module	1 set for each module	1 set for each module

11.5 Transfer bus coupler (RPT2D) / Bus coupler and Busbar (RPBNA) protection panel

Bus bar protection panel shall be equipped to accommodate all present and future bays.

Sl. No	**Equipment**	**Quantities required**			
		RPB4H	RPB2A	RPB1A/ RPB0A	RPT2D
1.	Composite numerical Directional Over current and earth fault protection (selectable Features Dir & Non Dir)	1 set	1 set	1 set	1 set
2.	Test terminal block for all protection relays	1 set for each module	1 set for each module	1 set for each module	1 set for each module
3.	Trip circuit pre and post supervision relays for trip coil I and II	Not required	1 set	1 set	1 set
4.	DC supply supervision relay	Not required	1 set	1 set	1 set
5.	Flag relays for circuit breaker trouble and status indication etc.	Not required	1 set	1 set	1 set
6.	Breaker failure protection scheme	Not required	1 set	1 set	1 set
7.	Trip relays single/three phase for group-A	Not required	1 set	1 set	1 set
8.	Trip relays single/three phase for group-B	Not required	1 set	1 set	1 set
9.	Bus bar differential relay for Bus-I	1 set	1 set	Not required	Not required
10.	Bus bar differential relay for Bus-II	1 set	1 set	Not required	Not required
11.	CT switching/selection relays(if required)	1 set	1 set	Not required	Not required
12.	Bus bar differential relay for Check Zone	1set	1set	Not required	Not required

At existing substations, necessary trip relays and auxiliary relays required shall be included in the offer to accommodate the new bays for existing bus bar protection schemes.

11.6 Common equipment (RPKNA)

Sl. No	Equipment	Quantities required
1.	Bus-I voltage recorder	1 No.
2.	Bus-II voltage recorder	1 No.
3.	Bus-I frequency recorder	1 No.
4.	Bus-II frequency recorder	1 No.
5.	Bus-I & Bus-II Digital Volt meter	1 Set
6.	Bus-I & Bus-II Digital Frequency meter	1 Set
7.	Event logger(Separate panel)	1 No.

11.7 Bus sectionalizer protection panel

Sl. No	Equipment	Quantities required
1.	Composite numerical directional Over current and earth fault protection relay(selectable Features Dir & Non Dir)	2 sets
2.	Test terminal block for all protection relays	1 set
3.	Trip circuit pre and post supervision relay for trip coil I and II	2 No
4.	DC supply supervision relay	1 No
5.	Flag relays for circuit breaker trouble and status indication etc.	2 No
6.	Breaker failure protection scheme	2 set
7.	Trip relays three phase for group-A	2 set
8.	Trip relays three phase for group-B	2 set
9.	Bus bar differential relay for Bus-I (numerical type- IEC -61850)	1 set
10.	Bus bar differential relay for Bus-II (numerical type- IEC -61850)	1 set
11.	CT switching/selection relays	1 set
12.	Bus bar differential relay for Check Zone (numerical type- IEC -61850)	1set

11.8 Synchronising panel

Synchronisation panels are required for new substations and addition of new voltage (132kV and above) to existing substation.

Sl. No	Equipment	Quantities required
1	Double Voltmeter (0-150v range)	1 no for each panel
2	Double Frequency meter (45-55Hz)	1 no for each panel
3	Synchroscope	1 no for each panel
4	Synchronising relay	1 set for each panel

**** ALL THE RELAYS SHALL BE OF NUMERICAL VERSION HAVING IEC 61850 PROTOCOL COMPLIANCE.ALL CARE SHALL BE TAKEN IN DESIGNING THE PROTECTION SYSTEM FOR FUTURE SCADA PROVISION. THERE SHALL BE ADEQUATE NO OF INPUT AND OUT PUT CONTACTS FOR USE. SHALL HAVE SELF SUPERVISING AND INTERNAL FAULT DETECTING/DIAGNOSING FACILTY. SUFFICIENT FAULT /DISTURBANCE RECORDING FACILITIES.**

12.0 ERECTION AND MAINTENANCE TOOL EQUIPMENT:

All special testing equipment required for the installation and maintenance of the apparatus,instruments devices shall be furnished . The testing plug shall be supplied along with the panels for conducting testing of relays. These testing plug should be suitable for test terminal box provided in the panel.

12.1 TROPICALISATION:

Control room will be normally air-conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot,humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring,equipment and accessories shall be protected against fungus growth,condensation,vermin and other harmful effects due to tropical environment.

12.2 RELAY TEST KIT

One relay test kit shall comprise of the following equipment as detailed hereunder.

1. Relay tools kits: 3 Sets
2. Test plugs: 2 Nos
3. Special type test plugs for using with modular type cases(if applicable): 1 No

13.0 ADDITIONAL INFORMATION ON PROTECTION RELAYS, SWITCHES ETC.

13.1 RELAYS:

1. All relays shall confirm to the requirements of IS: 3231/IEC-60255 and IEC-61850 protocol compliance. Relay shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

2. Shall be draw out or plug in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied, which is in the scope of this contract.

3.The protective relay shall be suitable for efficient and reliable operation of the protection scheme as indicated in the specification. Necessary auxiliary relays etc for interlocking scheme, for multiplying contacts suiting for the scheme and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme, contacts shall be silver faced with spring action. It shall have adequate numbers of terminals for making potential free external connection to the relay coils and contacts, including spare contacts. All the contacts of the auxiliary relays and timers except lock out type relays shall have self reset type contacts

4. No control relay which shall trip the power circuit breaker when the relay is deenrgised shall be employed in the circuit.

5. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

6. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

7. The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

8. The numerical relays shall include the followings:

i) Necessary software and hardware to up/down load the datas to/from the relay from/to the personal computer (supply is in the scope of this contract.).

ii) The relay shall have suitable communication facilities for future connectivity to SCADA. The relay shall be capable of supporting IEC 870-5-103 protocol. Neither the interface hardware nor the software for connectivity to SCADA will form part of the scope of this specification.

iii) In the numerical relays the features like disturbance recorder and event logging function as available in these relays shall be supplied.

13.2 A) Transmission Line protection:

The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines.

1. The maximum fault current could be as high as 40 KA and minimum fault current could be as low as20% of rated current of the CT secondary. The starting and measuring relay characteristics should be satisfactory under these extremely varying conditions.
2. The protective relays shall be suitable for use with capacitor voltage transformer having non-electronic damping and transient response as per IEC.
3. Disturbance recorder, Distance to fault locator, over voltage, auto reclose functions are integral functional part of the relay.
4. The following protection for line protection shall be provided.

13.3 For 400 KV & 220 KV

Main ï I Numerical distance protection scheme.
Main ï II Numerical distance protection scheme of a make different from that of Main ï I.
Back up: Directional Over current and Earth fault protection.
For 132 KV.
Main- Numerical distance protection scheme.
Back up: Directional over current and Earth fault protection.

13.4 MAIN-I & MAIN-II:

1. Shall be numerical type and shall be continuous self monitoring and diagnostic feature.
2. Shall be non-switched type with separate measurements for all phase to Phase & phase to ground faults.
3. Shall have stepped time distance characteristics and a minimum of three independent zones & a zone for reverse reach..
4. Shall have mho & quadrilateral (with site selection facilities) characteristics or other suitable characteristics for the above mentioned zones.
5. Shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

13.4.1 For 400,220 KV

	400KV	220KV
Source to Impedance ratio:	4	15
Relay setting (ohms)	10/20	22
Fault locations (as % of Relay settings)	50	50
Fault resistance (ohms)	0	0
Maximum operating time	40ms	45ms for Phase faults
For all faults	60ms for all other faults	

13.4.2 For 132 KV line:

Datas as indicated for 200 KV line
Shall remain same except maximum
Operating time: 5ms relaxation in the above timings

6. Relay shall have independent setting of ñRò and ñXò and also an adjustable relay characteristic angle having setting range from 30 -75 degree.
7. Shall have independent continuously variable time settings from 0 to 5 seconds.

8. Shall have resetting time of less than 55 miliseconds (including the reset time of the trip relays)
9. Shall have offset features with adjustable 10 ï 20% of zone setting.
10. Shall have variable residual compensation.
11. 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 volts three phase fault.
12. Shall have week end in-feed features.
13. Shall be suitable for single and three phase tripping.
14. Shall have a continuous current rating of two times of rated current. The voltage circuits shall be capable of operation at 1.2 times rated voltage. The relay shall have the capability to carry a short circuit current of 70 times the rated current without damage for 1second.
15. Shall be provided with necessary self reset type trip duty contacts for completion of the scheme.(a minimum number of such contacts shall be 4 per phase). The making capacity of the contacts shall be 30 amps for 0.2 seconds with an inductive load of L/R>10ms.
16. Shall have permissive under reach/over reach/blocking communication mode.
17. Shall have sufficient number of potential free contacts for carrier aided tripping, Auto reclosing, Event logger, Disturbance recorder & Data acquisition system.
18. Shall have power swing blocking protection (i) suitable setting range to encircle the distance protection (ii) block tripping during power swing conditions.
19. Include fuse failure protection (i) monitor all three fuses of CVT and associated cable against open circuit(ii) inhibit trip circuits on operation and initiate annunciation(iii)have an operating time less than 7ms(iv)remain inoperative for system earth faults.
20. Shall have directional back up Inverse Definite minimum Time earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature.
21. Shall have broken wire features having option for tripping/ annunciation.

13.5 BACK UP DIRECTIONAL O/C & E/F PROTECTION SCHEME.

1. Shall have three over current and one earth fault elements.
2. Shall be numerical type.
3. Shall have suitable VT fuse failure for relay alarm purpose.

O/C features:

4. Shall have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting.
5. Shall have variable setting range up to 200% of rated current.
6. Shall have relay characteristic angle of 30/45 deg lead.
7. LED indications for different type faults.

E/F features:

8. Shall have IDMT characteristics with a definite minimum time of 3.0 seconds at 10 times setting.
9. Shall have variable setting range up to 80% 0f rated current.
10. Shall have characteristic angle of 45/60 deg lag.
11. LED indications for all type of faults
12. Include necessary separate interposing voltage transformers or have internal features in the relay for open delta voltage to the relay.
13. Shall have continuous self monitoring and diagnostic feature.

13.6 AUTO RECLOSING RELAY:

1. Shall have single phase and three phase reclosing facilities.
2. Shall have continuously variable single phase dead time range of 0.1 ï 2 sec
3. Shall have continuously variable reclaim time range 5 ï 25 sec.
4. Shall have provision of selection with single phase//three phase//single and three phase auto reclosure and non auto reclosure mode (can be selected through programming).
5. Shall have provision of selecting check synchronizing or dead line charging.
6. Shall be single shot type.

7. Shall have priority circuit to closing of both circuit breakers incase one and half breaker arrangements to allow sequential closing of breakers.
8. Include check synchronizing relay which shall
I) Have a time setting variable from 0.5 ï 5 sec with a facility of additional 10 sec.
II) Have a response time within 200 ms with the timer disconnected.
III) Have a phase angle setting not exceeding 35 deg.
IV) Have voltage difference setting not exceeding 10%
V) Include dead line charging relay.

13.7 TRANSFORMER PROTECTION:

Transformer differential protection scheme shall be of numerical relay.
1. Shall be triple pole type with faulty phase identification/indication.
2. Shall have an operating time not greater than 30ms at 5 times the rated current.
3. Shall have three instantaneous high set over current units.
4. Shall have an adjustable bias setting range of 10 ï 50%.
5. Suitable for rated 1 amp current.
6. Shall have 2nd harmonics or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof features shall not be achieved any intentional time delay.
7. Shall have an operating current setting of 15% or less.
8. Shall have an internal feature of the relays to take care of the angle and ratio correction.
9. Shall have provision of self monitoring and diagnostic feature.
10. Shall have provision of recording features to record graphic from of instantaneous values during faults and disturbances for the pre and post fault period and during running conditions.
11. Current in all the windings in separate analog channels and voltage in one channel.

The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay.
a) REF protection operated.
b) HV breaker status (suitable for 1&1/2 breaker system also)
c) IV & LV breaker status.
d) Bucholtz /OLTC Bucholtz /PRV alarm/trip.
e) WTI/OTI alarm/trip
f) MOG alarm

Necessary hardware and software for automatic up-loading the data captured by disturbance recorder to the personal computer.
12. Shall have built in features of definite time over load protection (alarm) relay.
a) Shall be single pole type.
b) Shall have definite time O/C.
c) Shall have one set of O/C relay element, with continuously adjustable setting up to 200%(50% -200%) of rated current.
d) Shall have adjustable time delay alarm having setting range of 1 to 10.0 sec continuously.
e) Shall have a drop-off/pick-up ratio greater than 95%
13. Shall have feature of REF protection for three winding transformers.
a) Shall have current setting (continuously variable) range from 10%- 40% of 1 Amp.
b) Shall be tuned to the system frequency.
c) Shall have provision of for limiting the peak voltage (>1000Volts) during fault condition.
14. Shall be numerical type and shall have continuous self monitoring and diagnostic feature.

13.8 OVER FLUXING PROTECTION:

1. Shall be latest version numerical relay.
2. Shall have the principle of voltage to frequency ratio and shall be phase to phase connected.
3. Shall have inverse time characteristics, matching with transformer over fluxing withstand capability curve.

4. Provide an independent alarm with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of v/f, from 100% to 130% of rated values.
5. Shall have tripping time to be governed by v/f Vs time characteristics of the relay.
6. Shall have a set of characteristics for various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at v/f values of 1.4 and 1.5 times, the rated values, respectively.
7. Shall have resetting ratio of 95% or better.
8. Shall be numerical type and shall have continuous self monitoring and diagnostic feature.
9. Shall have fault recording feature.

13.9 LOCAL BREAKER BACKUP PROTECTION SCHEME:

1. Shall have triple pole type.
2. Shall be of numerical type and shall have continuous self monitoring and diagnostic feature.
3. Shall have an operating time of less than 15ms
4. Shall have resetting time of less than 15ms.
5. Shall have three over current elements.
6. Shall be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element.
7. Shall have setting range of 20-80% of rated current.
8. Shall have continuous thermal withstand two times rated current irrespective of the setting.
9. Shall have a timer with continuously adjustable setting range of 0.1 ï 1 sec.
10. Shall have necessary auxiliary relays to make a comprehensive scheme.

13.10 TRIPPING RELAY:

1. High speed tripping relay.
2. Instantaneous operation(time not to exceed 10ms)
3. Reset within 20ms
4. Shall be DC operated.
5. 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.
6. Shall have provision of operation indicators for each element/coil.

13.11 TRIP CIRCUIT SUPERVISION RELAY:

1. The relay shall be capable of monitoring the healthiness of each ñphaseò trip coil and associated circuit of circuit breaker during ON and OFF conditions.
2. Shall have adequate contacts for providing connection to alarm and event logger.
3. Shall have time delay on-drop-off of not less than 200ms and be provided with operation for each phase.

13.12 DC SUPERVISION RELAY:

1. Shall be capable of monitoring the failure of DC supply to which it is connected.
2. Shall have adequate potential free contacts to meet the scheme requirement.
3. Shall have a time delay drop-off of not less than 100ms and be provided with operational indicator/flag.

13.13 SWITCHES:

1. Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.
2. The selection of operating handles for the different types of switches shall be as follows.

Purpose	Type
Breaker, Isolator control switches	Discrepancy type

Synchronising switches Oval, Black, keyed handle (having common key for a group of switches)

Synchronising selector switch Oval or knob, block

Instrument switches Round, knurled, black

Protection transfer switch Pistol grip, lockable & black

** In case the rotary switches are provided for breaker and isolator control Semaphores are also to be provided along with the switches.

3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip position to ñafter closeò and ñafter tripò position respectively.

4. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make before break type contacts so as to prevent open circuiting of CT secondary when charging the position of the switch. Voltmeter transfer switch for AC shall be suitable for reading all line to line and line to neutral voltage for non effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

5. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the off position and it shall be coordinated to fit into all the synchronizing switches. These shall be arranged to connect the synchronizing equipment when turned to the ñonò position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the ON position.

6. Lockable type switches which can be locked in particular position shall be provided when specified. The key locks shall be fitted on the operating handles.

7. The contacts of all the switches shall preferably open and close with snap action to minimizing the arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy Springs shall not be used as current carrying parts.

8. The contact combination and their operation shall be such as to give completeness to the interlock
and function of the scheme.

9. The contact rating of the switches shall be as follows.

Description	Contact Rating In Amperes		
	220 V DC	50 V DC	230 V AC
Make & carry continuously	10	10	10
Make & carry for 0.5 sec	30	30	30
Break for			
i) Resistive load	3	20	7
ii) Inductive load (L/R=40ms)	0.2	-	-

13.14 INDICATING INSTRUMENTS, RECORDERS & TRANSDUCERS:

All instruments, meters, recorders and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt, megavar, bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with the transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronizing equipment.

13.14.1 Indicating Instruments:

1. All electrical indicating instruments shall be of digital type suitable for flush mounting.
2. Shall have 4 digit display, display height being not less than 25mm.

3. Shall confirm to relevant IS and shall have an accuracy class 1.5and or better watt and Var meters shall have an indication of (+) and (-) to indicate Export and Import respectively.
4. Digital voltage and frequency meters shall be of 0.5 class and shall have digital display of 5 and 4 digits respectively, with display size not less than 25mm height.

13.14.2 Bus voltage & Frequency recording instruments:

1. Shall be static/digital type frequency and voltage recorder either as individual units or composite unit for total sub-station with time tagged information shall also be applicable if it meets the accuracy of ± 1.0% span and full span response time of less than 2 seconds. The static/digital shall also meet the high voltage susceptibility test, impulse voltage with stand test ,high frequency disturbance test-class III and fast transient disturbance test level III as per IEC -60255.

13.14.3 Transducers:

1. Transducers shall in general confirm to IEC-688-1
2. Shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.
3. Transducers shall have input from sub-station current and voltage from the instrument transformers. The output shall be in miliampere D.C proportional to the input and shall feed the output current to the indicating instruments /telemetry terminals.
4. Characteristic shall be linier throughout the measuring range.
5. Output shall be load independent.
6. Input and output shall be galvanically isolated.
7. Transducers should work satisfactorily at 120% of rated value continuously.
8. Shall have 4-20mAmp.
9. Response time shall be less than 1 sec.
10. Accuracy class shall be 1 or better voltage/current, 0.5 or better for watt/var and 0.2 or better for frequency transducers.
11. Shall have a low AC ripple on output less than 1%.
12. Shall be suitable for load resistance of 1000 ï 1500.
13. Shall have dual output.

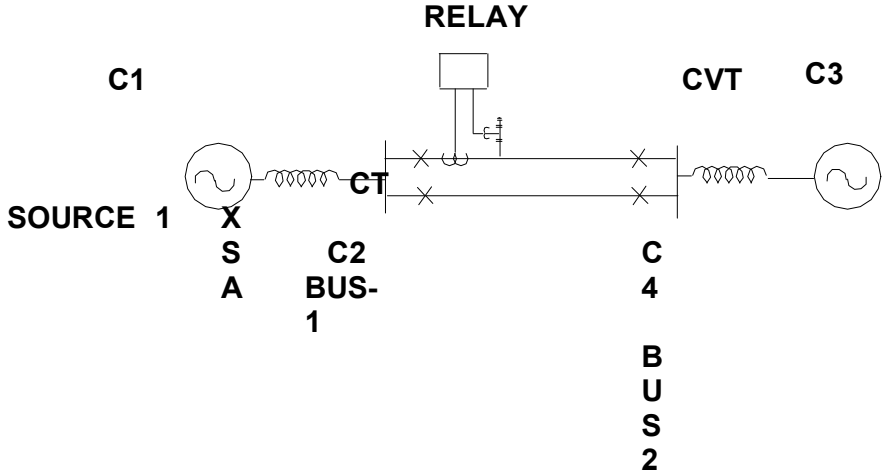
Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure ï 1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System Parameters System voltage =400KV ; CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure ï 2)



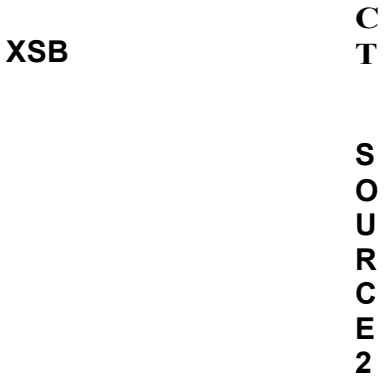


Figure-1

Line parameters/km

Positive Sequence Resistance, (r1)	= 0. 02897 Ý
Positive Sequence Reactance (x1)	= 0.3072 Ý Zero Sequence
Resistance (r0)	= 0.2597 Ý Zero Sequence
Reactance (x1)	= 1.0223 Ý Zero Sequence
Mutual Resistance (rm)	= 0.2281 Ý Zero Sequence
Mutual Reactance (xm)	= 0.6221 Ý Zero Sequence
succeptance (bo)	= 2.347 µ mho Positive
Sequence succeptance (b1)	=3.630 µmho

Types of Line	Short		Long
Secondary Line Impedance	2 Ý		20 Ý*
Length of Line in Km	23.57		235.7
SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ý (5500 MVA)	109.09 Ý (1467 MVA)	290.9 Ý (550 MVA)

* Alternatively , the tests can be done with 10 Ý secondary impedance and source impedance may accordingly be modified.

CVT Model:

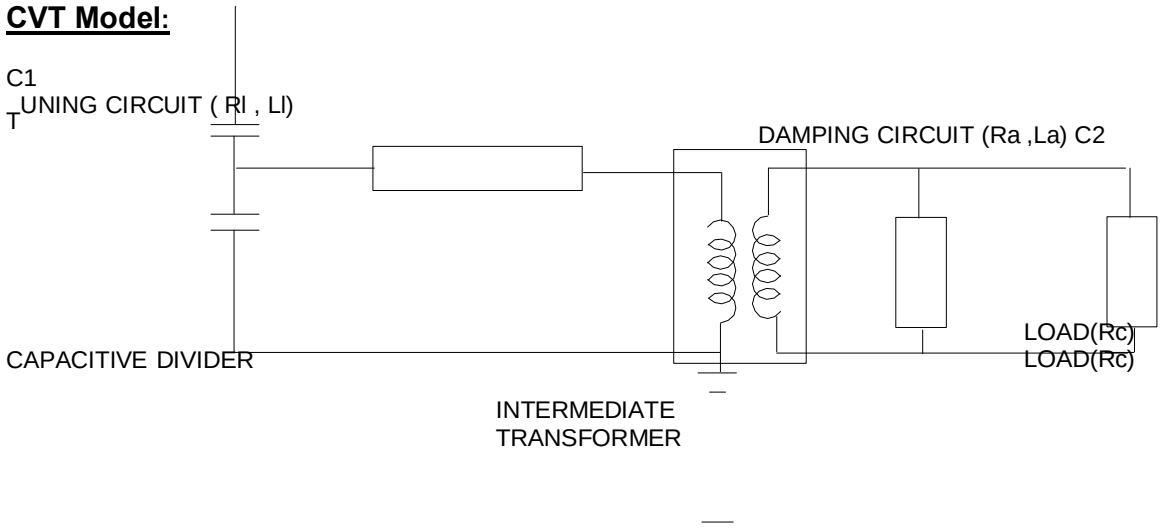


Figure-2

XC1 : 1.455 µ mho,XC2 : 27.646 µ mho
Rl : 320 Ý , Xll : 34243 Ý, Ra : 4.200 Ý, Xla : 197.92 Ý,Rc : 14.00 Ý, Transformation ratio of : 181.8 Intermediate transformer.

TECHNICAL SPECIFICATION

FOR

SUBSTATION AUTOMATION SYSTEM

SECTION: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1.The substation automation system shall be offered from a manufacturer who must have designed,manufactured, tested,installed and commissioned substation automation system which must be in satisfactory operation on 220kV system or higher for at least 2 (Two) years as on the date of bid opening.

1.2.The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.
The SAS shall contain the following main functional parts:

(A) Bay control Intelligence Electronic Devices (IED s) for control and monitoring.

(B) Station Human Machine Interface (HMI)

(C) Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.

(D) Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101 protocol.

Gateway for remote supervisory control (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-101 protocol. The specific protocol to be implemented is enclosed as Appendix-I. Interoperability profile shall be as per IEC 61850 PROTOCOL . It shall be the bidderôs responsibility to integrate his offered system with existing RSCC system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with SLDCs.

(E) Remote HMI.

Peripheral equipment like printers, display units, key boards, Mouse etc.

1.3. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.

1.4. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.5. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

2. **System design**

2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as required. The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff. The offered SAS shall support remote control and monitoring from

Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) housed in air-conditioned *Switchyard Panel Room* suitably located in switchyard and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence. Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers. Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G . I conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure. The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers. At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times. Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level. The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or

event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

Remote control centres

Station HMI.

Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time. The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, etc. (see description in "Bay level control functions").

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place. In addition to software interlocking hardwired interlocking are to be provided for:

(a)Bus Earth switch Interlocking

(b)Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi- activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

Bay control functions including data collection functionality in bay control/protection unit.

Bay protection functions Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

Control mode selection
Select-before-execute principle
Command supervision: Interlocking and blocking
Double command Synchrocheck,
voltage selection Run Time Command cancellation
Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
Operation counters for circuit breakers and pumps Hydraulic pump/ Air compressor runtime supervision Operating pressure supervision through digital contacts only
Breaker position indication per phase
Alarm annunciation
Measurement display
Local HMI (local guided, emergency mode) Interface to the station HMI.
Data storage for at least 200 events
Extension possibilities with additional I/O's inside the unit or via fibre- optic communication and process bus

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED**.**

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

Settable voltage, phase angle, and frequency difference. Energizing for dead line -

live bus, live line - dead bus or dead line
ï dead bus with no synchro-check function.

Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions0

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least
200 time-tagged events. The disturbance recorder function shall be as per detailed in section C&R

3.1.2.2. **Bay Monitoring Function:**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz),

and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems can be ascertained during detailed Engineering.

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give

commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

Single-line diagram showing the switchgear status and measured values

Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked**.**

Measurement dialogues

Alarm list, station / bay-oriented

Event list, station / bay-oriented

System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for: Selected object under command

Selected on the screen

Not updated, obsolete values, not in use or not sampled

Alarm or faulty state

Warning or blocked

Update blocked or manually updated

Control blocked

Normal state

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the ñexecutionò of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.
The chronological event list shall contain:

Position changes of circuit breakers, isolators and earthing devices

Indication of protective relay operations

Fault signals from the switchgear

Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.

Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

Date and time

Bay

Device

Function e.g. trips, protection operations etc.

Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

The date and time of the alarm

The name of the alarming object

A descriptive text

The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

Type of blocking

Authority

Local / remote

control RSCC / SAS control

Errors

etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

Breaker and disconnector

Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

Display only

Normal operation (e.g. open/close of switchgear)

Restricted operation (e.g. by-passed interlocking)

System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

No engineering allowed

Engineering/configuration allowed

Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

Historical reports of selected analogue Values:

- Day (at 15 minutes interval)
- Week
- Month
- Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

Iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current vale it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

Vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

Viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,
The Substation Automation System shall have communication ports as follows:

(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCC & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centreûs data scan and control commands may be different for different data points within the substation automation system's database.

3.3.2 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line , the details of which shall be provided during detailed Engineering .

3.3.3 **Interface equipment:**

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in section project.
In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and Remote Control Centre.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101/104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc..

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**
It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components.

Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.

The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 20GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 **HMI (Human Machine Interface**)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.
The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing. All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW** The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS One switch shall be provided to connect all IEDs in one diameter of each 400kV yard and for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They 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. They 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, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.
One no. Bay level unit shall be provided for supervision and control of each 765, 400 and 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). 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 bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. Further in case of one and half breaker schemes, the BCU for Tie CB shall be provided in Tie CB relay panel. The tie CB relay panel shall also house the Ethernet switch(es) to be provided for the diameter. The bay control unit for future bay (if required as per section project) shall be installed in a separate panel.

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.

4.2.1 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 voltage and current shall be from the secondaries of instrument transformers. 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

4.3 Switchyard Panel Room:

The **switchyard panel room shall be constructed to house** Bay level units, bay mimic, relay and protection panels, PLCC panels etc. one each for a diameter in 400kVsub-station and for two bays in 220kV Level. In case of incomplete diameter the switchyard panel room shall have necessary space for accommodating the future bay IEDs. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessray illuminations, fire alarm system with at least two detectors **with necessary power supply if required** and it shall be wired to SAS. The detailed **constructional** requirement of switchyard panel room **is detailed in section civil of technical specification andair conditioning requirement of switchyard panel room shall be as detailed in section Air conditioning system of technical specification**. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

4.4 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer.

During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5.0 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 Station level software

5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of

restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.1.1.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.
The application software within the control/protection devices shall be programmed in a functional block language.

5.1.1.3 Network Management System:

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work- station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a)Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

5.1.1.4 The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

6.0TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1		**Type Tests:**
6.1.1		**Control IEDs and Communication Equipment:**
	a.	**Power Input:**

i. Auxiliary Voltage
ii. Current Circuits iii. Voltage Circuits iv. Indications

b. Accuracy Tests:

i. Operational Measurd Values ii. Currents
iii. Voltages

iv. Time resolution

c. Insulation Tests:

i. Dielectric Tests

ii. Impulse Voltage withstand Test

d. Influencing Quantities

4. Limits of operation

5. Permissible ripples

iii. Interruption of input voltage

e. Electromagnetic Compatibility Test:

i. 1 MHZ. burst disturbance test ii. Electrostatic Discharge Test

iii. Radiated Electromagnetic Field Disturbance Test iv. Electrical Fast transient Disturbance Test

v. Conducted Disturbances Tests induced by Radio Frequency Field vi. Magnetic Field Test

vii. Emission (Radio interference level) Test. viii. Conducted Interference Test

f. Function Tests:

i. Indication

ii. Commands

iii. Measured value Acquisition iv. Display Indications

g. Environmental tests:

22. Cold Temperature

23. Dry Heat

iii. Wet heat

iv. Humidity (Damp heat Cycle)

v. Vibration vi. Bump

vii. Shock

6.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IEDs applicable type test certificates shall be submitted.

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields :

I) Message field with display of present time and date ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node. shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.
Inverter of suitable capacity shall be provided for station HMI **disturbance recorder evaluation unit** and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown.

9.0 DOCUMENTATION

The following documents shall be submitted for employerõs approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in ñdxfòformat.

List of Drawings
Substation automation system architecture
Block Diagram
Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
Calculation for power supply dimensioning
I/O Signal lists Schematic diagrams List of Apparatus
List of Labels
Logic Diagram (hardware & software) **Switchyard Panel Room** layout drawing
Control Room Lay-out
Test Specification for Factory Acceptance Test (FAT) Product Manuals

Assembly Drawing
Operatorûs Manual
Complete documentation of implemented protocols between various elements
Listing of software and loadable in CD ROM
Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

For all training courses, the travel (e.g., airfare) and per-diem expenses will be borne by the participants.
The Contractor shall quote training prices as indicated in BPS.
The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.
(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
(c) System Expansion:Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
(e) Subsystem Maintenance: Theory of design and operation, maintenance

techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment
shall be taught in detail.

(f) Operational Training:Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.

(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) System Initialization and Failover: Including design, theory of operation, and practice

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

(f) Hands-on Training:One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.

(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.

(e)Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

(f)Hands-on Training: One week, with allocated computer time for trainee

performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

The contractor shall provide training for OPTCL personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

Mechanical and electrical design
Security against electrical interference (EMI) High quality components and boards
Modular, well-tested hardware
Thoroughly developed and tested modular software
Easy-to-understand programming language for application programming
Detailed graphical documentation and application software
Built-in supervision and diagnostic functions
Security
Experience of security requirements
Process know-how
Select before execute at operation
Process status representation as double indications
Distributed solution
Independent units connected to the local area network
Back-up functions
Panel design appropriate to the harsh electrical environment and ambient conditions
Panel grounding immune against transient ground potential rise

Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)

The sum of actual outage duration within the reporting period

AOH =AOD

5) Availability:

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

12.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner. .

13.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

I) Station HMI

ii) Redundant Station HMI (in Hot-stand by mode)

iii) Bay level units along with bay mimic **as detailed in section Project.**

iv) **Bay Level Unit for Auxiliary system (as per requirement)**

v) Disturbance Recorder Work Station(Maintenance HMI)

vi) Colour Laser Printer ï 1 No. (For Reports & Disturbance records)

vii) Dot matrix printers - (one each for Alarms and log sheets)

viii) All interface equipment for gateway to RCC and RSCC

ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required

x) Remote workstation including HMI and along with one printer xi) **Modems as per requirement.**

Xii) Any other equipment as necessary.

List of Analogue and Digital Inputs ;

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 415V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free

contacts from PLCC or independently by counting the receive/send commands.

- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

I) For line
Current : R phase Y phase B phase
Voltage : R-Y phase Y-B phase B-R phase
ii) For transformer/reactor
Current: R phase Y phase B phase
WTI (for transformer and reactor) Tap position (for transformer only)

iii) For TBC and bus coupler

Current: R phase,Y phase,B phase
iv) Common
a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage: R-Y phase Y-B phase B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)
d) Switchyard Panel Room Temperature. e) LT system
I) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
4. Voltage R-Y, Y-B, B-R of Main Switch Board section-
5. Voltage R-Y, Y-B, B-R of Diesel Generator
6. Current from LT transformer-I
7. Current from LT transformer-II
vi) Current from Diesel Generator vii)Voltage of 220V DCDB-I
viii) Voltage of 220V DCDB-II
ix) Current from 220V Battery set-I
x) Current from 220V Battery set-II
6. Current from 220V Battery charger-I
7. Current from 220V Battery charger-I
8. Voltage of 48V DCDB-I
xiv) Voltage of 48V DCDB-II
xv) Current from 48V Battery set-I
xvi) Current from 48V Battery set-II
xvii) Current from 48V Battery charger-I
xviii) Current from 48V Battery charger-I

Digital Inputs

The list of input for various bays/SYSTEM is as follows:
1. Line bays
i)Status of each pole of CB.

ii)Status of Isolator, Earth switch
iii)CB trouble
iv)CB operation/closing lockout v) Pole discrepancy optd
vi)Trip coil faulty
vii)LBB optd
viii)Bus bar protn trip relay optd
ix)Main bkr auto recloser operated
x)Tie/transfer auto recloser operated xi) A/r lockout
xii)Tie/transfer bkr a/r lockout xiii) Direct trip-I/II sent
xiv)Direct trip-I/II received
xv)Main I/II blocking
xvi)Main I/II-Inter trip send
xvii)Main I/II-Inter trip received
xviii)O/V STAGE ï I operated
xix)O/V STAGE ï II operated
xx)FAULT LOCATOR FAULTY
xxi)MAIN-I/II CVT FUSE FAIL
xxii)MAIN-I PROTN TRIP
xxiii)MAIN-II PROTN TRIP
xxiv)MAIN-I PSB ALARM
xxv)MAIN-I SOTF TRIP
xxvi)MAIN-I R-PH TRIP
xxvii)MAIN-I Y-PH TRIP
xxviii)MAIN-I B-PH TRIP
xxix)MAIN-I START
xxx)MAIN-I/II Carrier aided trip
xxxi)MAIN-I/II fault in reverse direction
xxxii)MAIN-I/II ZONE-2 TRIP
xxxiii)MAIN-I/II ZONE-3 TRIP
xxxiv)MAIN-I/II weak end infeed optd
xxxv)MAIN-II PSB alarm
xxxvi)MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii)MAIN-II Y-PH TRIP
xxxix)MAIN-II B-PH TRIP
xl)MAIN-II start
xli)MAIN-II aided trip
xlii)MAIN-I/II fault in reverse direction
xliii)Back-up o/c optd
xliv)Back-up e/f optd
xlv)220V DC-I/II source fail
xlvi)SPEECH CHANNEL FAIL
xlvii)PLCC Protection Channel-I FAIL
xlviii)PLCC Protection Channel-II FAIL

2. Transformer bays

i)Status of each pole of CB, Isolator, Earth switch
ii)CB trouble
iii)CB operation/closing lockout
iv)Pole discrepancy optd
v)Trip coil faulty
vi)LBB optd
vii)Bus bar protn trip relay optd
viii)REF OPTD
ix)DIF OPTD
x)OVERFLUX ALARM (MV)

xi)OVERFLUX TRIP (MV)
xii)OVERFLUX ALARM (HV)
xiii)OVERFLUX TRIP (HV)
xiv)HV BUS CVT ½ FUSE FAIL
6. BUS CVT ½ FUSE FAIL
xvi)OTI ALARM/TRIP
6. PRD OPTD
xviii)OVERLOAD ALARM
xix)BUCHOLZ TRIP
xx)BUCHOLZ ALARM
xxi)OLTC BUCHOLZ ALARM
xxii)OLTC BUCHOLZ TRIP
xxiii)OIL LOW ALARM
xxiv)back-up o/c (HV) optd
xxv)back-up e/f (HV)optd
xxvi)220v DC-I/II source fail
xxvii)TAP MISMATCH
xxviii)GR-A PROTN OPTD
xxix)GR-B PROTN OPTD
xxx)back-up o/c (MV) optd
xxxi) back-up e/f (MV)optd

3. **Transformer bays**

i)Status of each pole of CB, Isolator, Earth switch
ii)CB trouble
iii)CB operation/closing lockout
iv)Pole discrepancy optd
v)Trip coil faulty
vi)LBB optd
vii)
Bus bar protn trip relay optd
viii)REF OPTD
ix)DIF OPTD
x)HV BUS CVT ½ FUSE FAIL
xi)OTI ALARM/TRIP
xii)PRD OPTD
xiii)BUCHOLZ TRIP
xiv)BUCHOLZ ALARM
xv)OIL LOW ALARM
xvi)Back-up impedance relay
xvii)220v DC-I/II source fail
xviii)GR-A PROTN OPTD
xix)GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i)Status of each pole of CB, Isolator, Earth switch
ii)CB trouble
iii)CB operation/closing lockout
iv)Pole discrepancy optd
v)Trip coil faulty
vi)LBB optd
vii)Bus bar protn trip relay optd
viii)REF OPTD
ix)DIF OPTD
x)Line/ BUS CVT ½ FUSE FAIL
xi)OTI ALARM/TRIP

xii)PRD OPTD

xiii)BUCHOLZ TRIP
xiv)BUCHOLZ ALARM
xv)OIL LOW ALARM
xvi)Back-up impedance relay
xvii)220V DC-I/II source fail
xviii)GR-A PROTN OPTD
xix)GR-B PROTN OPTD

5 Bus bar Protection

i)Bus bar main-I trip
ii)Bus bar main-II trip
iii)Bus bar zone-I CT open
iv)Bus bar zone-II CT open
v)Bus transfer CT sup. Optd
vi)Bus transfer bus bar protn optd
vii)Bus protection relay fail

6. Auxiliary system

i)Incomer-I On/Off
ii)Incomer-II On/Off
iii)415V Bus-I/II U/V
iv)415v bus coupler breaker on/off
v)DG set bkr on/off
vi)Alarm/trip signals as listed in Section: DG set
vii)LT transformer-I Bunchholz Alarm & trip
viii)LT transformer-II Buchloz Alarm & trip
ix)LT transformer-I WTI Alarm & trip
x)LT transformer-II WTI Alarm & trip
xi)LT transformer-I OTI Alarm & trip
xii)LT transformer-II OTI Alarm & trip
xiii)PLCC exchange fail
xiv) Time sync. Signal absent
xv)Alarm/trip signals as listed in Section: Battery and Battery charger
xvi) 220v DC-I earth fault
xvii) 220v DC-II earth fault
xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

i)AC Compressor 1 ON/OFF
ii)AC Compressor 2 ON/OFF
iii)Fire Detection 1 ON/OFF
iv)Fire Detection 2 On/OFF
v)Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for OPTCL use in future.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM

DR WORKSTATION REDUNDANT HMI

Printers GPS

Redundant Station LAN

RSCC RCC
RCC

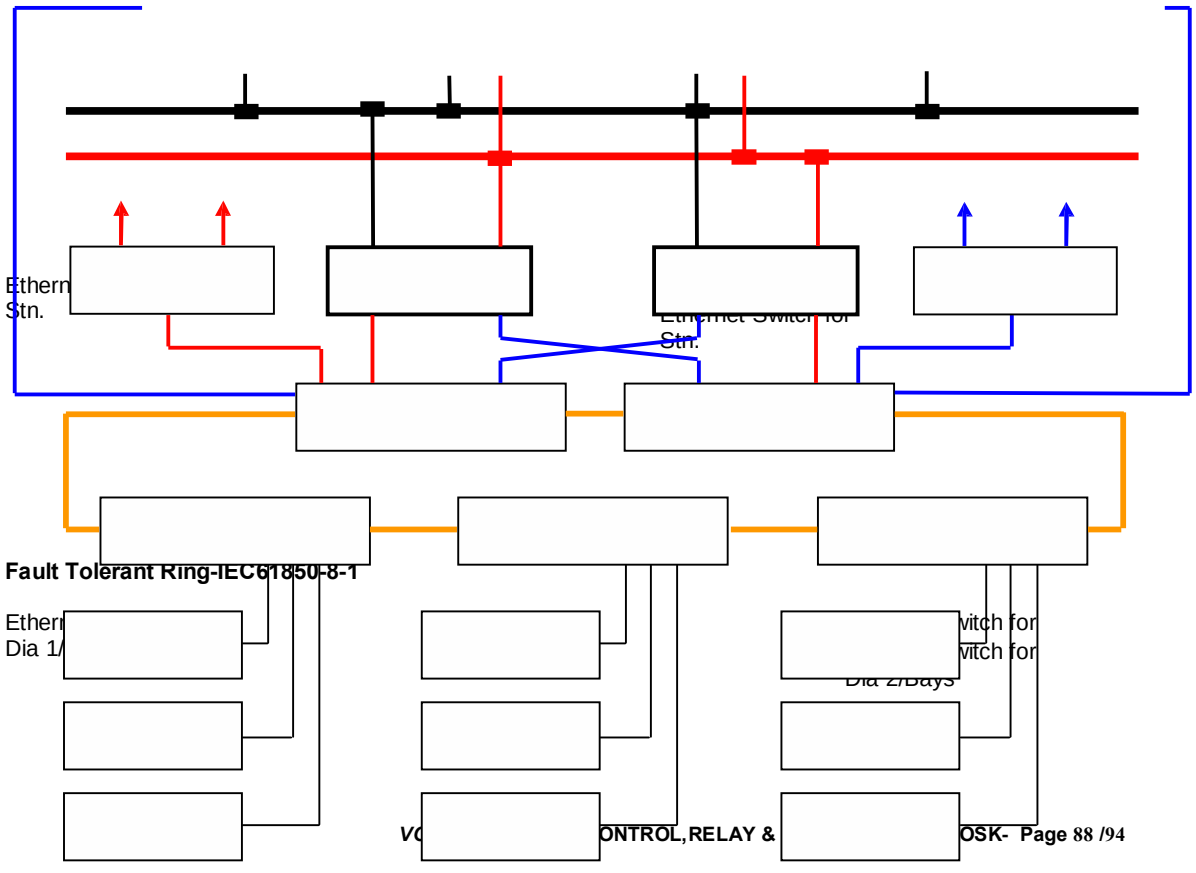
RSCC RCC
RSCC RCC

Gateway 1

Server 1
(HOT)
S
(HOT)

Server 2
(STAND BY)
Server 2
(STAND BY)

Gateway 2
Gateway 2



Ethernet Switch for
Ethernet Switch for
Dia n/Bays

IEDs for
Control

IEDs for
IEDs for
Control

IEDs for
IEDs for
Control

Fiber Optic
Connections

IEDs for
Protection

EDs for
EDs for
Protection

EDs for
EDs for
Protection

Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. The IEDs and switches for each of the dia. of 765kV and 400kV shall have separate switchyard panel room. For 220kV yards, IEDs for two bays can be housed in one switchyard panel room along with its switch.
3. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
4. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on
IEC 60870-5-101 protocol.
5. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.

5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

TECHNICAL SPECIFICATION

FOR

SPECIFICATION OF AIR-CONDITIONED KIOSK

SPECIFICATION OF AIR-CONDITIONED KIOSK

1 CONSTRUCTION:

The Kiosk shall be made of "sandwich insulated panels" 80 mm thick with Poly Urethane Foam (PUF) as filler material between polyester pre-coated cold rolled steel. The insulation characteristics of PUF material shall conform to following requirement:

Sl. No.	Particular	Parameters
1.	Thickness	78.6 mm
2.	Density	40 kg/m3
3.	Compressive Strength	1.2 kg.cm3
4.	Tensile Strength	3.6 kg/m2
5.	Bending Strength	4.0 Kg/m2
6	Adhesion Strength	2.9 Kg/m2
7.	Dimension Stability	At 25°C: 0.1% at 38°C: 0.1% and at 38°C: 0.4%
8.	Temperature Range	-15°C to 95°C
9.	Thermal Conductivity	0.02 kcal/hr/m/°C
10.	Fire Resistance	As per BS-4735 Horizontal Burn <125 mm
11.	Water absorption	0.2% @ 100% RH
12.	Vapour Permeability	0.08/0.12 a/hr/m2
13.	Self Extinguishing	Yes
14.	Biodegradable	Yes

The thickness of the inner-side and outer steel sheet except floor panel sheet shall be minimum 0.8 mm and 0.6 mm respectively. The outer bottom sheet shall be hot dip galvanised steel sheets of minimum 1.0 mm thickness to avoid rusting at bottom. The sandwich panels shall be manufactured by high-pressure injection techniques. The floor of the kiosk shall be suitably designed for accommodating the control and relay IEDs in the panels. The adequate lighting shall be provided in the kiosk. The Kiosk shall have adequate space for working and maintain clearances as per requirement of Indian Electricity Rules. The kiosk shall be provided with locking arrangement.

2 AIR CONDITIONING

The Air Conditionings system shall be provided in the Kiosks to be used for housing panels having control IEDs and protection Panels for performing sub-station automation and protection functions generally confirm to relevant IS codes as detailed ins section GTR. These kiosks shall be placed in the Switchyard area generally unmanned; therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

i. Operation

The Air Conditioning is required for critical application i.e. for maintaining the temperature for critical sub-station control and protection equipment. To provide redundancy for such critical applications, each kiosk shall be installed with

environment control system comprising of two units of air conditioners working in conjunction through a micro processor based controller for desired operation. The system shall be designed for 24 Hours, 365 Days of the year to maintain the inside kiosk temperature for proper operation of the critical equipment. One of the air-conditioner shall be running at a time and on failure of the same or as described hereunder, the other unit shall start automatically. To ensure longer life of the system, the redundant units shall also be running in cyclic operation through the controller. However, during running of one air-conditioner unit, if inside temperature of the shelter reaches to a predefined (i.e. 35°C), the other unit shall start running to maintain the temperature to specified value (i.e. 18±2°C) and gives alarm for such situation. After achieving this temperature, the other unit shall again shut off.

ii. **Sequence of Operation of the Unit**

Suitable arrangement shall be made to operate the unit in the following order. However, the actual operation arrangement shall be finalized during detailed engineering.

1. Evaporator Fan
2. Condenser Fan
3. Compressor

iii. **Construction**

The Air Conditioning unit shall be completely self-contained. All components of the units shall be enclosed in a powder-coated cabinet and colour of same shall be matched with kiosk colour. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested as a system to ensure trouble free installation and start up. Suitable isolation or other by passing arrangement shall be provided such that any unit/component could be maintained/ repaired without affecting the running standby unit. The maintenance of unit shall be possible from outside the kiosk. The point never ends at this. When fliers are with flies

iv. **Required Features of Various Components**

The Compressor shall be very reliable, trouble free and long life i.e. hermitically sealed Scroll type of reputed make suitable for operation. Compressor should be installed on vibration-isolated mountings or manufacturers recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower filter, cabinet, indoor supply and return grill, etc.

v. The kiosk shall be erected at least 300 mm above the finished ground level with suitable pedestal to avoid any entry of water.

2. **Proto Testing**

One kiosk meeting the specified requirement as described above, shall be fabricated at the factory and offered for proto inspection at the factory. This proto shall be equipped with all required accessories like air-conditioning system, fire and smoke detector, lighting, various cut outs etc. The offered kiosk shall be inspected for finish, all fittings and accessories, opening including doors and locks. The kiosk shall be tested for dust and rain protection to check out any leakage and air tightness. The following main tests shall be carried out:

a) Illumination inside the kiosk shall be switched off and it shall be checked that no

light enters through panel joints, holes and other joints in the kiosk.

b) Water Leakage Test (with a water pipe with suitable pressure from all sides for one hour.)

c) Working and functional tests of all accessories like air-conditioning system, fire and smoke detector, lighting arrangements as per technical specification

d) Start up test for air conditioner

e) Satisfactory operation of air conditioner installed on Kiosk.

f) The total heat load for panels and devices to be placed inside the kiosk including PLCC, all lEDs etc. shall be calculated and equivalent calculated heating load (maximum value from among the calculated values for various kiosk) shall be placed inside the kiosk and the kiosk shall be made operational for four hours with all accessories and inside & outside temperature of kiosk shall be recorded.

On successful completion of proto testing, all other system shall be manufactured after incorporation of all alteration/modifications observed/suggested during/after proto testing.

The detail test procedure shall be submitted by the contractor and get it approved from the owner before commencement of proto testing

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OFFICE OF THE SR. GENERAL MANAGER,
CENTRAL PROCUREMENT CELL,
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TECHNICAL SPECIFICATION

FOR

SPLIT TYPE INDIVIDUAL UNIT AIR CONDITIONER

TECHNICAL SPECIFICATION FOR AIR CONDITIONING SYSTEM

1.0 GENERAL

The specification covers supply, installation, testing and commissioning and handing over of Air conditioning system for the control room building

The AC units for control room building shall be set to maintain the following inside conditions.

DBT 24.4 Deg C ± 2 Deg C

1.1 The following room shall be air conditioned

a) Control Room
b) Conference room
c) Testing lab

1.2 Air conditioning requirement of rooms indicated shall be met by using split AC units. High wall type split AC units of required capacity as per design (to be submitted for approval) with high wall type indoor evaporator unit shall be used. In case the area is more than ductable split AC units may also be designed for better effect.

1.3 The exact quantity of the split AC units shall be designed taking the room area and the same may be proposed for necessary approval. However 2 TR capacity split AC units of **5 star** rating to be considered. The quantity shall be approximately as mentioned below.

PROPOSED NO OF A.C UNITS SHALL BE OF 5 STAR RATING:

1) FOR ALL 220/132/33 KV S/S CONTROL ROOM AREA
   A) 20 NOS 2 TR CAPACITY.
   B) 220/33 KV S/S:15 NOS 2 TR CAPACITY.
2) FOR ALL 132/33 KV SUB-STATION: 15 NOS 2 TR CAPACITY.
3) FOR 400/220 KV S/S CONTROL ROOM: 30 NOS 2 TR CAPACITY

1.4 Copper refrigerant piping complete with insulation between the indoor and remote outdoor condensers as required.

1.5 SCOPE: The scope of the equipment to be furnished and services to be provided under the contract are outlined herein and the same is to be read in conjunction with the provision contained. The scope shall be deemed to include all such items which although not specifically mentioned in the bid documents and/or in bidders proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation. Unit should be hermetically sealed

1.7 PVC drains piping from the indoor units up to the nearest drain point to be done.

1.8 Power and control cables between the indoor unit and outdoor unit and earthing

1.9 GI brackets for for outdoor condensing unit and proper earthing.

1.10 Specification for Split AC units.

The split AC units will be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

Out door units shall comprise of hermetically sealed reciprocating/rotary compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils assembled in a sheet metal. The casing and the total unit shall be properly treated and shall be weather proof type. They shall be compact in size and shall have horizontal discharge of air.

The indoor unit shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by special motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multifunction cordless remote control unit with special features like programmable timer, sleep mode and softy dry mode etc.

The split AC units shall be of Carrier/Blue Star/Hitachi/Voltas/Samsung/LG make.

The air conditioner unit should be provided with a required voltage stabilizer (from 90 V to 275 V AC).

ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

1-COAXIALCABLES

2-CONTROL & POWER CABLES

TECHNICAL SPECIFICATION

ITEM- H.F. CO-AXIAL CABLE, CONTROL CABLE & TELEPHONE CABLE

SCOPE

The specification covers the design, manufacture, testing before dispatch and setting to service of the following cables for their utility in power line carrier communication system in OPTCL.

1. H.F. Co-axial cable
2. Control cable
3. Telephone cable
4. H.F. Co-axial cable

General:

(a) The H.F.C0-axial cable shall be offered to connect the coupling unit (Line Matching under Symmetrical LMU) with PLC terminals. This serves maximum transfer of power between the carrier equipment to HT lines with minimum losses. The cable is also used for interconnection between two line matching units.

(b) The high frequency cable to be offered shall be suitable for being laid in the ground or in trenches or in ducts. It shall be duly armoured and confirm IS:5802 of 1978.

(c) The center core of the cable shall consists of tinned or enameled higfh purity copper conductor which has to be insulated by polythene sheath and shall be screened by tinned copper braidings. This braiding shall be sheathed by a PVC cover and GI wire enamoured and overall PVC sheathed and shall be suitable for tropical use. The six, type and quality of insulation shall be stated in the tender.

(d) The capacitance of the co-axial cable shall be low as to minimize attenuation at the carrier frequency range.

Tentative Particulars:

1.	Cable impedance	125 ohm or 75 ohm unbalanced. (both shall be quoted
2.	Centre conductor	0.8 mm dia
3.	Dia over insulation	7.6 mm
4.	Thickness of insulation	1.75 mm
5.	Outer conductor	Braiding of tended copper (Electrolytic grade) wire of 0.2 mm dia with 90% coverage
6.	Barrier	Malinex tape
7.	Inner Sheath	Special cable grade PVC (Black/Gray) Radial Thickness ï 1.2mm.
8.	Braiding & Armouring	Single braid of 0.3mm GI wire with 79% coverage.
9.	Overall sheath	Special cable grade PvC(Black/Gray) Radial thickness-1.4 mm
10.	Diameter over	16.0 mm (maximum)
11.	Maximum Conductor resistance	35.33 ohms/Km.
12.	Dielectric strength (Core to shield)	5 KV rms ro 1 minute.
13.	Characteristic capacitance at 1 KHz	36.10 pf/meter
14.	Maximum attenuation at various frequencies	
	Frequency (KHz)	ds/KM
	10	0.8
	60	1.4

	300	3.30
	500	4.70
15.	Minimum bending radios for installation	20 CM
16.	Insulation resistance	Meg. Ohm/Km(Min.)

2. Telephone Cable:

1) The telephone cables are of armoured or unarmoured type depending on the requirements. The telephone cable shall have 0.5 or 0.6 mm annealed tinned copper conductor, PVC insulated, cores colour coded, twisted into pairs, laid up, taped and overall PVC sheathed confirming to ITD specification. In case of armoured cable, it must be GI wiser/strip armoured with inner and outer sheathed confirming to IS: 1554 (Part-I)/1976.

2) The following cables may be quoted in the tender.

(1) 25 pair Armoured telephone cable
(2) 10 pair Armoured telephone cable
(3) 10 pair unarmoured telephone cable
(4) 5 pair unarmoured telephone cable.

3) The following cables may be quoted in the tender.

(1) 2.5 sq.mm twin core (solid)
(2) 10 sq.mm multistrand twin core.

4) tests ï Type Test reports shall be furnished.

TECHNICAL SPECIFICATION FOR

CONTROL AND POWER CABLES

PART 1 : SCOPE AND CONDITIONS

1. SCOPE

This specification covers the testing and performance requirements of power and control cables for installation on the Distribution System to be established at the loaction as indicated against this tender.

The equipment offered shall have been successfully type tested and the design shall have been in satisfactory operation for a period not less than two years on the date of bid opening. Compliance shall be demonstrated by submitting with the bid, (i) authenticated copies of the type test reports and (ii) performance certificates from the users..

The power and control cables shall conform in all respects to highest standards of engineering, design, workmanship, this specification and the latest revisions of relevant standards at the time of offer and the Project Manager shall have the power to reject any work or material, which, in his judgement, is not in full accordance therewith.

2. STANDARDS

Except where modified by this specification, the power and control cables shall be designed, manufactured and tested in accordance with the latest editions of the following standards.

IEC / ISO	Indian Standard	Title
IEC 811	IS-18-10810:1982	Testing cables
IEC 502	IS-7098:1985 (part 2)	LT and 3.3 - 33kVXLPE cables
IEC 502	IS - 1554:1988 (part 1)	PVC Cables .65/1.IkV
IEC 227	IS - 5819 :1970	Short circuit ratings for PVC cables
IEC 228	15-8130:1984	Conductors for insulated cables
IEC 502	IS - 6474: 1984	XLPE Cables
IEC 502		Extruded solid dielectric insulated power cables for rated voltages from IkV to 30kV
IEC 540 IS - 5831: 1984		Test Methods for insulation and sheaths of electric cables and cords
IEC 287		Calculation of the continuous current rating of cables.
IS - 3975 : 1979		Mild steel wires, strips and tapes for armouring of cables

The Bidder may propose alternative standards, provided it is demonstrated that they give a degree of quality and performance equivalent to or better than the referenced standards. Acceptability of any alternative standard is at the discretion of the Project Manager. The Bidder shall furnish a copy of the alternative standard proposed along with his bid. If the alternative standard is in a language other than English, an English translation shall be submitted with the standard. In the case of conflict the order of precedence shall be 1) IEC or ISO Standards, 2) Indian Standards, 3) other alternative standards.

This list is not to be considered exhaustive and reference to a particular standard or recommendation in this Specification does not relieve the Contractor of the necessity of providing the goods complying with other relevant standards or recommendations.

3. SERVICE CONDITIONS

The service conditions shall be as follows:

Åmaximum altitude above sea level l1,000m

Åmaximum ambient air temperature 50°C

Åmaximum daily average ambient air temperature 35°C

- minimum ambient air temperature o°C
- maximum temperature attainable by an object exposed to the sun 60°C
- maximum yearly weighted average ambient temperature 32°C
- maximum relative humidity 100%
- average number of thunderstorm days per annum (isokeraunic level) 70
- average number of rainy days per annum 120
- average annual rainfall 150cm
- wind pressures as per IS 802 (Part I/ Sect.l) : 1995

Wind Zones (Orissa)	**2**	**3**	**5**
Terrain Category 1	**57.4 kg/m^2**	**73.1 kg/m^2**	**94.3kg/m^2**
Terrain Category 2	**49.3**	**62.6**	**80.9**
Terrain Category 3	**35.6**	**45.3**	**58.4**
	Light	**Medium**	**Heavy**

Environmentally, the region where the work will take place includes coastal areas, subject to high relative humidity, which can give rise to condensation. Onshore winds will frequently be salt laden. On occasions, the combination of salt and condensation may create pollution conditions for outdoor insulators.

Therefore, outdoor material and equipment shall be designed and protected for use in exposed, heavily polluted, salty, corrosive and humid coastal atmosphere.

4. SYSTEM CONDITIONS

The equipment shall be suitable for installation in supply systems of the following characteristics:

Å Frequency 50Hz

Å Nominal system voltages 33kV

		llkV
		400/230V
Å Maximum system voltages:	33kV System	36.3kV
	llkV System	12.1kV
	LV System	476V
Å Minimum LV voltage		340V
Å Nominal short circuit levels:	33kV System	25kA
	llkV System	12.5kA
Å Insulation Levels:		
1 .2/50 (j.s impulse withstand voltage		
(positive and negative polarity):	33kV System	170kV
	llkV System	75kV
Å Power frequency one minute withstand		
voltage (wet and dry) rms	33kV System	70kV
	1 IkV System	28kV
	LV System	3kV
Å Neutral earthing arrangements:	33kV System	solidly earthed
	llkV System	solidly earthed
	LV System	solidly earthed

PART 2 : TECHNICAL

All power and control cables to be used in the OPTCL distribution system shall be of the cross-linked polyethelene (XLPE) or polyvinyl chloride (PVC) insulated with PVC sheathing types.

8. 1.1KV POLYVINYL CHLORIDE (PVC) INSULATED CABLES

8.1. RATED VOLTAGE AND TEMPERATURE

The rated voltage of the cable shall be l.l kV and the maximum operating voltage shall not exceed 110% of the rated voltage.

These cables are suitable for use where the combination of ambient temperature and temperature rise due to load results in a conductor temperature shall not exceeding 70°C* under normal operation and 160°C under short circuit conditions.

*See 13.2.4 for heat resisting and general purpose applications.

8.2. CABLE DESIGN

ALL LV Power cable shall be of XLPE insulation armoured type.

The cable offered shall be single-core, four core or multi-core armoured or unarmoured XLPE insulated / PVC insulated, PVC sheathed to meet the following requirements:

8.2.1. Conductor

Å L.V System Cables (Power Cable XLPE insulated)

The conductor shall be of compacted round shape in single core cables and sector shaped in 3.5 or 4 core cables, made up from stranded aluminum wires complying with IS -8130:1984 / IEC 228. The Cable shall be of XLPE insulated with armoured.

Cables with reduced neutral conductors shall comply with the cross-sections shown in the table below.

Å Control and Panel Wiring Cables (PVC insulated)

The conductor shall be of round stranded plain copper wires complying with IS - 8130:1984/IEC 228.

The conductors shall be of Flexibility Class 2 as per IS - 8130 : 1984.

8.2.2. Cross-Sectional area of reduced Neutral Conductors:

Nominal cross-sectional area of main conductor (mm2)	25	35	50	70	95	120	150	185	240	300	400	500	630
Cross-sctional area of reduced neutral conductor (mm^2)	16	16	25	35	50	70	70	95	120	150	185	240	300

8.2.3. Conductor Screening Not required

8.2.4. Insulation

The insulation shall be of Polyvinyl Chloride (PVC) compound. The 'General Purpose' Type A shall be used for the LV cables and 'Heat Resisting' Type C for the Control and Panel Wiring cables. Both shall conform to the requirements of IS - 5831: 1984.

Type of Insulation	Normal Continuous Operation	Short Circuit Operation
General Purpose	70°C	160°C
Heat Resisting	85°C	160°C

The PVC insulation shall be applied by extrusion and the average thickness of insulation shall not be less than the specified nominal value and the maximum value not more than O.lmm plus 0.1 of nominal and as specified in IS - 1554(part 1): 1988. The insulation shall be applied so that it fits closely on to the conductor and it shall be possible to remove it without damage to the conductor.

8.2.5. Insulation Screening Not required

8.2.6. Core Identification and Laying Up of Cores

3.5 and 4 core cables shall be identified by colouring of the PVC insulation and multi core by numbers as per IS- 1 554 (part 1): 1988

Panel wiring shall have a single colour except for power supplies which shall be as per the above IS standard.

In multi-core cables, the cores shall be laid up together with a suitable lay as recommended in IS - 1554 (Part 1): 1988. The layers shall have successive right and left hand lays with the outermost layer having a right hand lay.

8.2.7. Inner Sheath

The laid up cores of the 3.5, 4 and multi core cables shall be covered with an inner sheath made of thermoplastic material (PVC) applied by extrusion.

The thickness of the sheath shall conform to IEC 502/IS - 1554: 1988. Single core cables shall have no inner sheath.

8.2.8. Armouring Only the 3.5 and 4 core LV cables will be armoured. The armour shall be applied helically in a layer of steel wires over the inner sheath of the cable. The armour shall consist of round or flat steel wires and comply with the requirements of IEC 502/IS - 1554: 1988. The steel wires shall comply with IS - 3975:

8.2.9. Outer Sheath

An outer sheath of polyvinyl chloride (PVC) shall be applied over the armour wires (where fitted). The sheath shall be embossed at regular intervals as per the Cable Identification clause of this specification

and the minimum thickness and properties shall comply with the requirements of IEC 502/IS - 1554: 1988. The outer sheath for cables with general purpose insulation shall be of the type ST1 PVC compound and for cables with heat resisting insulation type ST2 PVC compound conforming to the requirements of IEC 502/IS - 5831: 1984.
The outer serving shall incorporate an effective anti-termite barrier and shall be capable of withstanding a l0kV DC test voltage for five minutes after installation and annually thereafter.
Cables shall be installed as a single four core cable or three single phase cables plus neutral in a close trefoil formation.
Current ratings shall be calculated in accordance with IEC 287 "Calculation of the continuous current rating of cables with 100% load factor".
8.2.10. Conductor Sizes
Å The following conductor sizes will be used on the Employer's LV distribution system: 300, 120 and 50 mm^2 single core, 300 mm^2 three and a half core and 120 mm^2 four core.
Å The following shall be used for Control and Panel Wiring:
2.5 mm^2 single core, 2. 5 and 4.0 mm^2 four core and 1.5 and 2.5 mm^2 multicore
8.2.11. Cable Drum Length
The cable shall be supplied in 500metre lengths.

CABLE IDENTIFICATION
The manufacturer's and Employer's name or trade mark, the voltage grade, cable designation and year of manufacture shall be indented or embossed along the whole length of the cable. The indentation or embossing shall only done on the outer sheath. The alphanumerical character size shall be not less than 20% of the circumference of the cable and be legible.
The following code shall be used to designate cables:

Constituent	Code Letter
Aluminium conductor	A
XLPE insulation	2X
PVC insulation	Y
Steel round wire armour	W
Non-magnetic round wire armour	Wa
Steel strip armour	F
Non-magnetic strip armour	Fa
Double steel round wire armour	WW
Double steel strip armour	FF
PVC outer sheath	Y

Note: No code letter is required for copper conductor

10. SAMPLING OF CABLES

10.1. Lot
In any consignment the cables of the same size manufactured under essentially similar conditions of production shall be grouped together to constitute a lot.

10.2. Scale of Sampling
Samples shall be taken and tested from each lot to ascertain the conformity of the lot to specification.

10.3. Sampling Rates
The number of samples to be selected shall be as follows:

Number of drums in the Lot	Number of Drums to be taken as samples	Permissable number of defective drums
Up to 25	3	0
26 to 50	5	0
51 to 100	8	0
101 to 300	13	1
301 and above	20	1

The samples shall be taken at random. In order to achieve random selection the procedure for selection detailed in IS - 4905: 1968 shall be followed.

1 1 . NUMBER OF TESTS AND CRITERION FOR CONFORMITY

Suitable lengths of test samples shall be taken from each of the selected drums. These samples shall be subjected to each of the acceptance tests. A test sample shall be classed as defective if it fails any of the acceptance tests. If the number of defective samples is less than or equal to the corresponding number given in 8.3 the lot shall be declared as conforming to the requirements of acceptance test.

1 2. TESTS ON 1 . 1 KV PVC INSULATED CABLES

12.1. Type Tests

Certification of type tests already completed by independent test laboratories shall be presented wiyh the bid for each cable type. These tests shall be carried out in accordance with the requirements of IS -8130: 1984/IEC 502, IS - 5831:1984/IEC 540 and IEC 811 unless otherwise specified.

Type testing of 33kV,l IkV and 1.1 kV cables shall include the following:

Test	Requirement Reference	Test Method as a Part of IS-10810/IEC 811
(a) Tests on conductor		
Annealing test (copper)	IS-8130: 1984/IEC 502	1
Tensile test (aluminium)	IS-8130: 1984/IEC 502	2
Wrapping test (aluminium)	IS-8130: 1984/IEC 502	3
Resistance test	IS-8130: 1984/IEC 502	5
(b) Tests for Armour wires/strips	IS - 3975: 1979/IEC 502	36 - 42
(c) Tests for thickness of insulation and sheath	IS-5831:1984/IEC 540	6
(d) Physical tests for Insulation		
Tensile strength and elongation at break	IS-5831:1984/IEC 540	7
Ageing in air oven	IS-5831:1984/IEC 540	11
Hot test	IS-5831:1984/IEC 540	30
Shrinkage test	IS-5831:1984/IEC 540	12
Water absorption (gravimatic)	IS-5831:1984/IEC 540	33
(e) Physical tests for outer sheath		
Tensile strength and elongation at break	IS-5831: 1984/IEC 540	7

Ageing in air oven	IS-5 831: 1984/IEC 540	11
Shrinkage test	IS-5831: 1984/IEC 540	12
Hot deformation	IS-5831: 1984/IEC 540	15

Test	**Requirement Reference**	**Test Method as a Part of IS-10810/IEC811**
Loss of mass in air oven	IS-5831: 1984/IEC540	10
Heat shock	IS-5831: 1984/IEC540	14
Thermal stability	IS-5831: 1984/IEC540	IS-5831: 1984 Appendix B
(f) Partial discharge test (11 and 33kV only)	Section 13.2 of this specification	46
(g) Bending test (11 and 33kV only)	Section 13.2 of this specification	50
(h) Dielectric power factor test (11 and 33kV only)	Section 13. 4 of this specification	48
As a function of voltage		
As a function of temperature		
(j) Insulation resistance (volume resistivity) test	IS-8130: 1984/IEC502	43
(k) Heating cycle test (11 and 33kV only)	Section 13.5 of this specification	49
(1) Impulse withstand test (11 and 33kV only)	Section 13.6 of this specification	47
(m) High voltage test	Section 13.7 of this specification	45
(n) Flammability test	Section 13.8 of this specification	53

Tests (g), (h), (j), (1) and (m) are only applicable to screened cables.

Not withstanding the conditions of the above paragraph the following tests on screened 11 and 33kV cables shall be performed successively on the same test sample of completed cable.

1. Partial discharge test

2. Bending test followed by partial discharge test

3. Dielectric power factor as a function of voltage

4. Dielectric power factor as a function of temperature

5. Heating cycle test followed by dielectric power factor as a function of voltage and partial discharge tests

6. Impulse withstand test

7. High voltage test

If a sample fails in test number 7, one more sample shall be taken for this test, preceded by tests 2 and 5.

12.2. Acceptance Tests

The following shall constitute acceptance tests:

Å Tensile test (aluminium)

Å Annealing test (copper)

Å Wrapping test

Å Conductor resistance test

Å Test for thickness of insulation and sheath

Å Hot set test for insulation*

Å Tensile strength and elongation at break test for insulation and outer sheath

Å Partial discharge test (for screened cables only)**

Å High voltage test

Å Insulation resistance (volume resistivity) test.

ÅXLPE insulation only

** test to be completed on full drum of cable

12.3. Routine Tests

Routine tests shall be carried out on all of the cable on a particular order. These tests shall be carried out in accordance with the requirements of IS - 8130: 1984/IEC 502 and IS - 5831:1984/IEC 540 unless otherwise specified.

The following shall constitute routine tests.
Å Conductor resistance test
Å Partial discharge test (for 1 IkV and 33kV screened cables only)*
Å High voltage test
* test to be completed on full drum of cable

12.4. Optional Test

Cold impact test for outer sheath (IS - 5831 - 1984), which shall be completed at the discretion of the Project Manager and at the same time as test at low temperature for PVC as stipulated in the section on special tests.

12.5. Special tests

Special tests shall be carried out at the Project Manager's discretion on a number of cable samples selected by the Project Manager from the contract consignment. The test shall be carried out on 10% of the production lengths of a production batch of the same cable type, but at least one production length. Special tests shall be carried out in accordance with the requirements of IEC 502 and IEC 540 unless otherwise specified.

The following special tests shall be included:
Å Conductor Examination (IEC-228)
Å Check of Dimensions
Å 4-Hour High Voltage Test for 11 kV and 33kV Cables only
Å Hot set test for XLPE Insulation

Å Test at low temperature for PVC

13. DETAILS OF TESTS

13.1. General

Unless otherwise stated, the tests shall be carried out in accordance with the appropriate part of IS - 10810/IEC 502: 1994 and the additional requirements as detailed in this specification.

13.2. Partial Discharge Test

Partial discharge tests shall only be made on cables insulated with XLPE of rated voltages above 1.9/3.3kV.

For multicore cables, the test shall be carried out on all insulated cores, the voltage being applied between each conductor and the metallic screen.

The magnitude of the partial discharge at a test voltage equal to 1.5Uo shall not exceed 20pC for XLPE and 40pC for PVC, where Uo is the power frequency voltage between the conductor and earth or J metallic screen.

13.3. Bending Test

The diameter of the test cylinder shall be 20 (d +D) ± 5% for single core cables and 15 (d+D) ± 5% for multicores, where D is the overall diameter of the completed cable in millimetres and d is the diameter of the conductor. After completing the bending operations, the test samples shall be subjected to partial discharge measurements in accordance with the requirements of this specification.

13.4. Dielectric Power Factor Test

13.4.1. Tan ŭ as a Function of Voltage

For cables of rated voltage 1.1 kV and above

The measured value of tan ŭ at Uo shall not exceed 0.004 and the increment of tan ŭ between 0.5 Uo and 2 Uo shall not be more than 0.002.

13.4.2. Tan ŭ as a Function of Temperature For cables of rated voltage 1.1 kV and above

The measured value of tan 8 shall not exceed 0.004 at ambient temperature and 0.008 at 90°C for XLPE cables.

13.5. Heating Cycle Test

The sample which has been subjected to previous tests shall be laid out on the floor of the test room and subjected to heating cycles by passing alternating current through the conductor until the conductor reaches a steady temperature 10°C above the maximum rated temperature of the insulation in normal operation. After the third cycle the sample shall subjected to a dielectric power factor as a function of voltage and partial discharge test.

13.7. High Voltage Test

13.7.1. Type/Acceptance Test

The cable shall withstand, without breakdown, at ambient temperature, an ac voltage equal to 3Uo, when applied to the sample between the conductor and screen/armour (and between conductors in the case of unscreened cable). The voltage shall be gradually increased to the specified value and maintained for a period of 4 hours.

If while testing, interruption occurs during the 4 hour period the test shall be prolonged by the same extent. If the interruption period exceeds 30 minutes the test shall be repeated.

13.7.2. Routine Test

Single core screened cables, shall withstand, without any failure, the test voltages given in this specification for a period of five minutes between the conductor and metallic screen.

Single core unscreened cables shall be immersed in water at room temperature for one hour and the test voltage then applied for 5 minutes between the conductor and water.

Multicore cables with individually screened cores, the test voltage shall be applied for 5 minutes between each conductor and the metallic screen or covering.

Multicore cables without individually screened cores, the test voltage shall be applied for 5 minutes in succession between each insulated conductor and all the other conductors and metallic coverings, if any.

13.7.3. Test Voltages

The power frequency test voltage shall be 2.5 Uo + 2kV for cables at rated voltages, up to and including 3.8/6.6kV, and 2.5 Uo for cables at higher rated voltages.

Values of single phase test voltage for the standard rated voltages are as given in the following table:

Voltage Grade kV	Test Voltage	
	Between conductors and screen/armour kV(rms)	Between conductors kV(rms)
0.65/1.1	3	3

If, for three core cables, the voltage test is carried out with a three phase transformer, the test voltage between the phases shall be 1.732 times the values given in the above table.

When a DC voltage is used, the applied voltage shall be 2.4 times the power frequency test voltage. In all instances no breakdown of the insulation shall occur.

13.8. Flammability Test

The period for which the cable shall burn after the removal of the flame shall not exceed 60 seconds and the unaffected portion (uncharred) from the lower edge of the top clamp shall be at least 50mm.

14. CABLE ACCESSORIES

The accessories are for the following types of cable:

33kV XLPE, single core round stranded plain aluminium conductor to IEC 228/IS - 8130: 1984, semi-conducting conductor screen, XLPE insulation, non - metallic semi-conducting insulation screen with non - magnetic tape or metallic cover,inner PVC sheath, non-magnetic wire or strip armour and PVC outer sheath.

11kV XLPE, single or three core round stranded plain aluminium conductor to IEC 228/IS - 8130: 1984, semiconducting conductor screen, XLPE insulation, non - metallic semiconducting insulation screen with non - magnetic tape or metallic cover, inner PVC sheath , non-magnetic wire or strip armour for single core cables, and steel wire armour on three core cables and PVC outer sheath.

LV (1100V) PVC, single, three and a half and four core round or sector shaped stranded plain aluminium grade H4 conductor, PVC insulation, inner PVC sheath, steel wire armour for three phase cables and P.V.C. outer sheath.

14.1. JOINTS AND TERMINATIONS

Joints and terminations shall be supplied in complete kit form with all materials and components required to complete the installation. A complete set of instructions for the joint or termination shall also be included in each kit.
Heat shrink pre-moulded joints and terminations shall be required for all XLPE and PVC cables and for transition joints.
All components shall be capable of being stored without damage or deterioration at temperatures up to 50°C. The material expiry date shall be marked on all packages, where appropriate.
Details of all equipment, tools and protective clothing required to complete the joint or termination shall be included with each joint or termination kit.
Components shall not be adversely affected in any manner by contact with other materials normally used in the construction of cable joints or terminations and shall not increase the rate of corrosion of any metals with which they may come into contact.
Components supplied with adhesive coatings shall have means to prevent the coated surfaces from adhering to each other.
Joints and terminations for armoured or screened cables shall include all items needed for wire or tape clamping. Rings shall be provided for such application.
The recovered thickness of insulation over the connector shall be uniform and equal to or greater than the cable insulation thickness as given in IEC 502/IS - 1554/IS - 7098.
The protection provided by the galvanised steel wire armouring shall be reinstated over the joint (s).
Electric field stress control shall be provided on all of the High Voltage joints and terminations.
Joints shall provide waterproofing, mechanical and electrical protection, and be completely sealed from cable jacket to cable jacket. Joints shall accommodate crossing of the cores.
Where required 33kV, 1 IkV and 1.1 kV cable joints shall be straight through joints only.
Terminations shall be designed to provide a complete moisture seal, including the crotch area of multi-core cables and complete rejacketing of the individual cores, conforming to Class 1 terminations as per IEEE 48. They shall be generally suitable for indoor and outdoor installation, be resistant to ultra violet radiation and chemical attack.

Minimum creepage distance for outdoor terminations shall not be less than:

Adhesives used shall have a softening temperature of not less than 90° C, be compatible with other components and after curing shall not flow at temperatures of normal service.
1.1 kV, 1 IkV and 33kV joints and terminations shall be designed so that no insulating or semi-conducting tapes shall be required.Reinstallation of the insulation and semi - conducting cover shall be achieved with the use of multiple layers of heat shrinkable tubes possessing high dielectric strength and thermal stability.
Phase identification colours shall be marked on the cable box, cable tail ends and single core cables at all connecting points and/or any positions the Project Manager may determine. Cable boxes shall be provided with suitable labels indicating the purpose of the supply where such supply is not obvious or where the Project Manager may determine.
All cables shall be identified and shall have phase colours marked at their termination.

14.2. CONNECTORS/TERMINALS

Connectors and terminals shall perform without distress under normal loading, cyclic loading and fault conditions, and shall not limit the rating of the cables which they joint.
33kV connections shall be compressed by hydraulically operated tools and 1 IkV/LV connectors by hand operated tools. The range of connectors/terminals should be kept to a minimum so as limit the the range of dies which may required and the use of die-less compression tools of the tension or non-tension type shall be permitted. Only approved and proven compression tools supplied by a reputable manufacturer shall be used.
The ends of connectors/terminals shall be suitably chamfered or coned to facilitate insertion of the conductors. Connectors shall have a solid central barrier to facilitate the insertion of the conductor to the correct depth.
The following items of information shall be clearly stamped on each connector/terminal:

- Manufacturer's name or trade mark.
- The conductor size (metric) for which the connector/terminal is suitable.
- The die number or size suitable for compressing the connector/terminal.
- The part of the connector/terminal surface to be compressed.
- The sequence of die action from the starting point and finishing point.

Compounds or greases for improving contact between the connector/terminal and the conductor are permitted. They must, however, be chemically neutral to the connector/terminal and conductor materials and must be present in position in the delivered connectors/terminals.
Cable connectors/terminals shall be able to accommodate typical variations in dimensions of cables supplied by different manufacturers.
Connector/terminal material shall not react chemically with the cable conductors to which they are connected.

Size and type of connectors required:

Straight through connectors for the following conductors:

Å 300 - 300 mm^2 stranded round plain aluminium

Å 185-185 mm^2 stranded round plain aluminium

Å 120-120 stranded sector shaped plain aluminium Termination lugs for the following conductors:

Å 300 mm^2 stranded round and sector shaped plain aluminium

Å 185 mm^2 stranded round plain aluminium

Å 150 mm^2 stranded sector shaped plain aluminium for the neutral of the 3.5 core 300 mm^2 cable.

Å 120 mm^2 stranded round and sector shaped plain aluminium

Å 70 mm^2 stranded round plain aluminium

Å 50 mm^2 stranded round plain aluminium

Termination lugs shall be suitable for bi-metallic connections.

Terminals for pole top terminations of 33kV and 1 IkV cables shall be of the post type capable of accepting a tap off connector. Appropriate tap off connectors shall be provided for making connections from the cable to the line conductors.

14.3. CONTROL/LV WIRING ACCESSORIES 14.3.1. Terminations

Control wire terminations shall be made with solderless crimping type and tinned copper lugs which firmly grip the conductor. Insulated sleeves shall be provided at all the wire termination. 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 wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule. Numbers 6 and 9 shall not be included for ferrules purposes except where underlined and identified as 6 and 9.

LVAC cable terminals shall be provided with adequate size crimp type lugs.The lugs shall be applied with the correct tool, which shall be regularly checked for correct calibration. Bi-metallic joints between the terminals and lugs shall be provided where necessary.

Terminals shall be marked with the phase colour in a clear and permanent manner.

A removable gland plate shall be provided by the contractor at every cable entry to mechanism boxes, cabinets and kiosks. The Contractor shall be responsible for drilling the cable gland plate to the required size.

Armoured cables shall be provided with suitable glands for terminating the cable armour and shall be provided with an earthing ring and lug in order to connect the gland to the earth bar.

PART 3 : GENERAL PARTICULARS AND GUARANTEES

15. COMPLIANCE WITH SPECIFICATION

The power and control cables shall comply in all respects with the requirements of this specification. However, any minor departure from the provisions of the specification shall be disclosed at the time of bidding in the Non Compliance Schedule in this document.
The mass and dimensions of any item of equipment shall not exceed the figures stated in the schedules.

16. COMPLIANCE WITH REGULATIONS

All the equipment shall comply in all respects with the Indian Regulations and Acts in force.
The equipment and connections shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.

17. QUALITY ASSURANCE, INSPECTION AND TESTING

17.1. General

To ensure that the supply and services under the scope of this Contract, whether manufactured or performed within the Contractor's works or at his sub-contractor's premises or at any other place of work are in accordance with the Specification, with the regulations and with relevant authorised international or Indian Standards, the Contractor shall adopt suitable Quality Assurance Programmes and Procedures to ensure that all activities are being controlled as necessary.
The quality assurance arrangements shall conform to the relevant requirements of ISO 9001 or ISO 9002 as appropriate.
The systems and procedures which the Contractor will use to ensure that the Plant complies with the Contract requirements shall be defined in the Contractor's Quality Plan for the Works.The Contractor shall operate systems which implement the following:
Hold Point "A stage in the material procurement or workmanship process beyond which work shall not proceed without the documented approval of designated individuals or organisations."
The Project Manager's written approval is required to authorise work to progress beyond the Hold Points indicated in approved Quality Plans.
Notification Point "A stage in material procurement or workmanship process for which advance notice of the activity is required to facilitate witness."
If the Project Manager does not attend after receiving documented notification in accordance with the agreed procedures and with the correct period of notice then work may proceed.

17.2. Quality Assurance Programme

Unless the Contractor's Quality Assurance System has been audited and approved by the Project Manager, a Quality Assurance Programme for the Works shall be submitted to the Project Manager for approval a minimum of one month from contract award, or such other period as shall be agreed with the Project Manager. The Quality Assurance Programme shall give a description of the Quality System for the Works and shall, unless advised otherwise, include details of the following:
ÅThe structure of the organisation;
ÅThe duties and responsibilities assigned to staff ensuring quality of work;
ÅThe system for purchasing, taking delivery and verification of materials;

ÅThe system for ensuring quality of workmanship;
ÅThe system for control of documentation;
ÅThe system for the retention of records;
ÅThe arrangements for the Contractor's internal auditing;
Å A list of the administration and work procedures required to achieve and verify Contract's quality requirements. These procedures shall be made readily available to the Project Manager for inspection on request.

17.3. Quality Plans

The Contractor shall draw up for each section of the work Quality Plans which shall be submitted to the Project Manager for approval at least two weeks prior to the commencement of work on the particular section. Each Quality Plan shall set out the activities in a logical sequence and, unless advised otherwise, shall include the following:
ÅAn outline of the proposed work and programme sequence;
ÅThe structure of the Contractor's organisation for the Contract;
ÅThe duties and responsibilities assigned to staff ensuring quality of work for the Contract;
ÅHold and Notification Points;
ÅSubmission of engineering documents required by the specification;
ÅThe inspection of materials and components on receipt;
ÅReference to the Contractor's Work Procedures appropriate to each activity;
ÅInspection during fabrication/construction;
ÅFinal inspection and test.

17.4. Non-conforming product

The Project Manager shall retain responsibility for decisions regarding acceptance, modification or rejection of non-conforming items.

17.5. Sub-contractors

The Contractor shall ensure that the Quality Assurance requirements of this specification are followed by any sub-contractors appointed by him under the Contract.

The Contractor shall assess the sub-contractor's Quality Assurance arrangements prior to his appointment to ensure compliance with the appropriate ISO 9000 standard and the specification.

Auditing of the sub-contractor's Quality Assurance arrangements shall be carried out by the Contractor and recorded in such a manner that demonstrates to the Project Manager the extent of the audits and their effectiveness.

17.6. Inspection and testing

The Project Manager shall have free entry at all times, while work on the contract is being performed, to all parts of the manufacturer's works which concern the processing of the equipment ordered. The manufacturer shall afford the Project Manager without charge, all reasonable facilities to assure that the equipment being furnished is in accordance with this specification.

The equipment shall successfully pass all the type tests, acceptance tests and routine tests referred to in the section on Tests and those listed in the most recent edition of the standards given in this specification.

The Project Manager reserves the right to reject an item of equipment if the test results do not comply with the values specified or with the data given in the technical data schedule.

Type tests shall be carried out at an independent testing laboratory or be witnessed by a representative of such laboratory or some other representative acceptable to the Project Manager. Routine and acceptance tests shall be carried out by the Contractor at no extra charge at the manufacturer's works.

Type Test certificates shall be submitted with the bid for evaluation. The requirement for additional type tests will be at the discretion of the Project Manager.

The Project Manager may witness routine, acceptance and type tests. In order to facilitate this, the Contractor shall give the Project Manager a minimum of four weeks notice that the material is ready for testing. If the Project Manager does not indicate his intention to participate in the testing, the manufacturer may proceed with the tests and shall furnish the results thereof to the Project Manager.

Full details of the proposed methods of testing, including connection diagrams, shall be submitted to the Project Manager by the Contractor for approval, at least one month before testing.

All costs in connection with the testing, including any necessary re-testing, shall be borne by the Contractor, who shall provide the Project Manager with all the test facilities which the latter may require, free of charge. The Project Manager shall have the right to select the samples for test and shall also have the right to assure that the testing apparatus is correct. Measuring apparatus for routine tests shall be calibrated at the expense of the Contractor at an approved laboratory and shall be approved by the Project Manager.

The Contractor shall be responsible for the proper testing of the materials supplied by sub-contractors to the same extent as if the materials were completed or supplied by the Contractor.

Any cost incurred by the Project Manager in connection with inspection and re-testing as a result of failure of the equipment under test or damage during transport or off-loading shall be to the account of the Contractor.

The Contractor shall submit to the Project Manager five signed copies of the test certificates, giving the results of the tests as required. No materials shall be dispatched until the test certificates have been received by the Project Manager and the Contractor has been informed that they are acceptable.

The test certificates must show the actual values obtained from the tests, in the units used in this specification, and not merely confirm that the requirements have been met.

In the case of components for which specific type tests or routine tests are not given in this specification, the Contractor shall include a list of the tests normally required for these components. All materials used in the Contract shall withstand and shall be certified to have satisfactorily passed such tests.

No inspection or lack of inspection or passing by the Project Manager's Representative of equipment or materials whether supplied by the Contractor or sub-contractor, shall relieve the Contractor from his

liability to complete the contract works in accordance with the contract or exonerate him from any of his guarantees.

17.7. **Guarantee**

The Contractor shall guarantee the following :

Å Quality and strength of materials used;

Å Satisfactory operation during the guarantee period of one year from the date of commissioning, or 18 months from the date of acceptance of the equipment by the Project Manager following delivery, whichever is the earlier;

Å Performance figures as supplied by the Bidder in the schedule of guaranteed particulars.

18. PROGRESS REPORTING

The Contractor shall submit for approval within four weeks of the starting date of the contract, an outline of production, inspection, delivery (and installation) in a chart form. Within a further period of four weeks, the Contractor shall provide a detailed programme of the same information in a form to be agreed by the Project Manager. The Contractor shall submit two copies of monthly progress reports not later than the 7th day of the following month. The reports shall show clearly and accurately the position of all activities associated with the material procurement, manufacture, works tests and transport, with regard to the agreed contract programme.

(The preferred format for presentation of programmes is MS Project Version 4.0. Programmes and monthly updates should be submitted on 3.5" diskettes.)

The design aspect of the progress report shall include a comprehensive statement on drawings, calculations and type test reports submitted for approval.

The position on material procurement shall give the dates and details of orders placed and indicate the delivery dates quoted by the manufacturer. If any delivery date has an adverse effect on the contract programme, the Contractor shall state the remedial action taken to ensure that delays do not occur.

The position on manufacture shall indicate the arrival of raw material and the progress of manufacture. Any events that may adversely affect completion in the manufacturer's works shall also be reported.

All works tests done shall be listed and test results shall be remarked upon. Any test failure shall be highlighted.

The dispatch of each order shall be monitored on the progress report giving the date by which the equipment will be available for transport, the estimated time of arrival on site and the dates actually achieved.

Delays or test failures in any part of the programme which may affect any milestone or final completion dates shall be detailed by the Contractor who shall state the action taken to effect contract completion in accordance with the contract programme.

19. SPARE PARTS AND SPECIAL TOOLS

The Contractor shall provide prices for spare conductor, joints and termination equipment.

The Project Manager may order all or any of the spare parts listed at the time of contract award and the spare parts so ordered shall be supplied as part of the definite works. The Project Manager may order additional spares at any time during the contract period at the rates stated in the Contract Document.

A spare parts catalogue with price list shall be provided for the various cables, joints and termination equipment and this shall form part of the drawings and literature to be supplied.

Any spare apparatus, parts or tools shall be subject to the same specification, tests and conditions as similar material supplied under the Contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the equipment and must be suitably marked and numbered for identification.

Spare parts shall be delivered suitably packed and treated for long periods in storage. Each pack shall be clearly and indelibly marked with its contents, including a designation number corresponding to the spare parts list in the installation and maintenance instructions.

20. PACKING AND SHIPPING

20.1. Packing

The cable shall be wound on strong drums or reels capable of withstanding all normal transportation and handling.

Each length of cable shall be durably sealed before shipment to prevent ingress of moisture. The drums, reels or coils shall be lagged or covered with suitable material to provide physical protection for the cable during transit and during storage and handling operations.
In the case of steel drums adequate precautions shall be taken to prevent damage being caused by direct contact between the cable sheath and the steel. These precautions shall be subject to the approval of the Project Manager.
If wooden drums are used then the wood shall be treated to prevent deterioration from attack by termites and fungi.
Each drum or reel shall carry or be marked with the following information:
ÅIndividual serial number
ÅEmployer's name
ÅDestination
ÅContract Number
ÅManufacturer's Name
ÅYear of Manufacture
ÅCable Size and Type
ÅLength of Conductor (metres)
ÅNet and Gross Mass of Conductor (kg)
ÅAll necessary slinging and stacking instructions.
ÅDestination;
ÅContractor's name;
ÅName and address of Contractor's agent in Orissa;
ÅCountry of origin;
The direction of rolling as indicated by an arrow shall be marked on a flange.

20.2. Storage

The site selected for the storage of cable drums shall be well drained and preferably have a concrete/firm surface which will prevent the drums sinking into the ground or being subjected to excess water thus causing flange rot.
All drums shall be stood on battens, in the upright position, and in such a manner to allow sufficient space between them for adequate air circulation. During storage the drums shall be rotated 90° every three months. In no instances shall the drums be stored "flat" on their flanges or one on top of each other.

20.3. Shipping

The Contractor shall be responsible for the shipping of all cables, drums and reels supplied from abroad to the ports of entry and for the transport of all goods to the various specified destinations including customs clearance, offloading, warehousing and insurance.

The Contractor shall inform himself fully as to all relevant transport facilities and requirements and loading gauges and ensure that the equipment as packed for transport shall conform to these limitations. The Contractor shall also be responsible for verifying the access facilities specified.

The Contractor shall be responsible for the transportation of all loads associated with the contract works and shall take all reasonable steps to prevent any highways or bridges from being damaged by his traffic and shall select routes, choose and use vehicles and restrict and distribute loads so that the risk of damage shall be avoided. The Contractor shall immediately report to the Project Manager any claims made against the Contractor arising out of alleged damage to a highway or bridge.

All items of equipment shall be securely clamped against movement to ensure safe transit from the manufacturer's facilities to the specified destinations (work sites.)

The Contractor shall advise the storage requirements for any plant and equipment that may be delivered to the Project Manager's stores. The Contractor shall be required to accept responsibility for the advice given in so far as these arrangements may have a bearing on the behaviour of the equipment in subsequent service.

20.4. Hazardous substances

The Contractor shall submit safety data sheets in a form to be agreed for all hazardous substances used with the equipment. The Contractor shall give an assurance that there are no other substances classified as hazardous in the equipment supplied. The Contractor shall accept responsibility for the disposal of such hazardous substances, should any be found.

The Contractor shall be responsible for any injuries resulting from hazardous substances due to non compliance with these requirements.

21. SUBMITTALS

21.1. Submittals required with the bid

The following shall be required in duplicate :

Å completed technical data schedule;

Å descriptive literature giving full technical details of equipment offered;

Å type test certificates, where available, and sample routine test reports;

Å detailed reference list of customers already using equipment offered during the last 5 years with particular emphasis on units of similar design and rating;

Å details of manufacturer's quality assurance standards and programme and ISO 9000 series or equivalent national certification;

Å deviations from this specification. Only deviations approved in writing before award of contract shall be accepted;

21.2. Submittals required after contract award

21.2.1. Programme Five copies of the programme for production and testing.

21.2.2. Technical particulars

Within 30 days of contract award five bound folders with records of the technical particulars relating to the equipment. Each folder shall contain the following informatio

Ågeneral description of the equipment and all components, including brochures;

Åtechnical data schedule, with approved revisions;

Åcalculations to substantiate choice of electrical and mechanical component size/ratings;

Å statement drawing attention to all exposed points in the equipment at which copper, aluminium or aluminium alloy parts are in contact with or in close proximity to other metals and stating clearly what protection is employed to prevent corrosion at each point;

Å detailed installation and commissioning instructions;

At the final hold point for Project Manager approval prior to delivery of the equipment the following shall be submitted:

Å inspection and test reports carried out in the manufacturer's works;

Å Installation and maintenance instructions. 21.2.3. Operation and maintenance instructions

A copy of the detailed installation and commissioning instructions shall be supplied with each type cable joint and termination equipment.

21.3. Drawings

Within 30 days of contract commencement the Contractor shall submit, for approval by the Project Manager, a schedule of the drawings to be produced detailing which are to be submitted for "Approval" and which are to be submitted "For Information Only". The schedule shall also provide a programme of drawing submission, for approval by the Project Manager, that ensures that all drawings and calculations are submitted within the period specified above.

All detail drawings submitted for approval shall be to scale not less than 1:20. All important dimensions shall be given and the material of which each part is to be constructed shall be indicated on the drawings. All documents and drawings shall be submitted in accordance with the provisions of this specification and shall become the property of the Employer.

All drawings and calculations submitted to the Project Manager shall be on international standard size paper, AO, Al, A2, A3, or A4. All such drawings and calculations shall be provided with a contract title block, which shall include the name of the Employer and Consultants and shall be assigned a unique project drawing number. The contract title block and project numbering system shall be agreed with the Project Manager.

Lettering sizes and thickness of lettering and lines shall be selected so that if reduced by two stages to one quarter of their size, the alphanumeric characters and lines are still perfectly legible so as to enable them to be microfilmed.

For presentation of design drawings and circuit documents IEC Publication 617 or equivalent standards for graphical symbols are to be followed.

22. APPROVAL PROCEDURE

The Contractor shall submit all drawings, documents and type test reports for approval in sufficient time to permit modifications to be made if such are deemed necessary and re-submit them for approval without delaying the initial deliveries or completion of the contract work. The Project Manager's representative shall endeavour to return them within a period of four weeks from the date of receipt.

Three copies of all drawings shall be submitted for approval and three copies for any subsequent revision. The Project Manager reserves the right to request any further additional information that may be considered necessary in order to fully review the drawings. If the Project Manager is satisfied with

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the drawing, one copy will be returned to the Contractor marked with "Approved" stamp. If the Project Manager is not totally satisfied with the drawing, then "Approved Subject to Comment" status will be given to it and a comment sheet will be sent to the Contractor. If the drawing submitted does not comply with the requirements of the specification then it will be given "Not Approved" status and a comment sheet will be sent to the Contractor. In both these cases the Contractor will have to modify the drawing, update the revision column and resubmit for final Approval. Following approval, twenty copies of the final drawings will be required by the Project Manager.

Any drawing or document submitted for information only should be indicated as such by the Contractor. Drawings and documents submitted for information only will not be returned to the Contractor unless the Project Manager considers that such drawing needs to be approved, in which case they will be returned suitably stamped with comments.

The Contractor shall be responsible for any discrepancies or errors in or omissions from the drawings, whether such drawings have been approved or not by the Project Manager. Approval given by the Project Manager to any drawing shall not relieve the Contractor from his liability to complete contract works in accordance with this specification and the condition of contract nor exonerate him from any of his guarantees.

If the Contractor needs approval of any drawing within a period of less than four weeks in order to avoid delay in the completion of supply, he shall advise the Project Manager when submitting the drawings and provide an explanation of the document's late submission. The Project Manager will endeavour to comply with the Contractors timescale, but this cannot be guaranteed.

23. SURFACE TREATMENT

Where galvanised steel armour wire is used then the Contractor shall indicate his galvanising process utilised and its conformance with this specification

23.1. Galvanising

All galvanising shall be carried out by the hot dip process, in accordance with Specification ISO 1460 or IS 2629. However, high tensile steel nuts, bolts and spring washers shall be electro galvanised to Service Condition 4. The zinc coating shall be smooth, continuous and uniform. It shall be free from acid spots and shall not scale, blister or be removable by handling or packing. There shall be no impurities in the zinc or additives to the galvanic bath which could have a detrimental effect on the durability of the zinc coating.

Before pickling, all welding, drilling, cutting, grinding and other finishing operations must be completed and all grease, paint, varnish, oil, welding slag and other foreign matter completely removed. All protuberances which would affect the life of galvanising shall also be removed.

The weight of zinc deposited shall be in accordance with that stated in Standard BS 729, ISO 1460 or IS 2629 and shall be not less than 0.61kg/m2 with a minimum thickness of 86 microns for items of thickness more than 5mm, 0.46 kg/m^ (64 microns) for items of thickness between 2mm and 5mm and 0.33 kg/m2 (47 microns) for items less than 2mm thick.

Parts shall not be galvanised if their shapes are such that the pickling solution cannot be removed with certainty or if galvanising would be unsatisfactory or if their mechanical strength would be reduced. Surfaces in contact with oil shall not be galvanised unless they are subsequently coated with an oil resistant varnish or paint.

In the event of damage to the galvanising the method used for repair shall be subject to the approval of the Project Manager or that of his representative.

Repair of galvanising on site will generally not be permitted.

The threads of all galvanised bolts and screwed rods shall be cleared of spelter by spinning or brushing. A die shall not be used for cleaning the threads unless specifically approved by the Project Manager. All nuts shall be galvanised. The threads of nuts shall be cleaned with a tap and the threads oiled.

Partial immersion of the work shall not be permitted and the galvanising tank must therefore be sufficiently large to permit galvanising to be carried out by one immersion.

After galvanising no drilling or welding shall be performed on the galvanised parts of the equipment excepting that nuts may be threaded after galvanising. To avoid the formation of white rust, galvanised material shall be stacked during transport and stored in such a manner as to permit adequate ventilation. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanisation.

The galvanised steel shall be subjected to test as per IS-2633.

24. COMPLETENESS OF CONTRACT

All fittings or accessories, although not specifically mentioned herein, but necessary or usual for similar equipment and their efficient performance shall be provided by the Contractor without extra charges. The bid shall clearly indicate if any additional equipment or parts would be necessary to give a complete offer and if so, the details and the prices shall be included in the bid.

MORE INFORMATION ON POWER & CONTROL CABLES [FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]

CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1 Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards and for supply for colony lighting from control room.

1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switch yard area/control room except for control/protection purposes.

1.3 For all control/protection/instrumentation purposes PVC insulated control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

The sizes of power cables to be used per feeder in different application shall be as applicable, described here under.

1.5 Bidder may offer sizes other than the sizes specified in clause 1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaserÕs approval.

1.6. Cables shall be laid conforming to IS : 1255.

1.7 While preparing cable schedules for control/protection purpose following shall be ensured:

1.7.1 Separate cables shall be used for AC & DC.

1.7.2 Separate cables shall be used for DC1 & DC2.

1.8 For different cores of CT & CVT separate cable, core wise shall be used .The minimum sizes of the conductor for each terminal shall be 2X2.5 sqmm.

1.9 For control cabling, including protection circuits, minimum 2.5 sq.mm. size copper cables shall be used per connection.

TECHNICAL REQUIREMENTS

2. General

2.1 The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

2. 2 They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

2.3 The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

2.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

2.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

2.6 Progressive sequential marking of the length of cable in metres at every one meter

shall be provided on the outer sheath of all cables.

2.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS : 1554 (Part 1) ï 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

2.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

2.9 All the cables shall pass fire resistance test as per IS:1554 (Part-I)

2.10 The normal current rating of all PVC insulated cables shall be as per IS:3961.

2.11 Repaired cables shall not be accepted.

3. **XLPE Power Cables**

3.1 The XLPE **(90°C**) insulated cables shall be of FR type, C1 category conforming to IS:7098 (Part-I) and its amendments read alongwith this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS:5831. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS:5831 for all XLPE cables.

4. **PVC Power Cables**

4.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.

5. **PVC Control Cables**

5.1 The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour .

6. HV POWER CABLES [FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

6.1. *HV* POWER CABLE FOR AUXILIARY POWER SUPPLY

The HV cable of voltage class as specified for LT transformer shall be, XLPE insulated, armoured cable conforming to IS 7098 (Part-II) or IEC 60502-2 1998. Terminating accessories shall conform to IS 17573-1992 or IEC 614421997/IEC60502-4 1998.

6.2. Constructional Requirements

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound , XLPE insulated, insulation screened with extruded semi conducting compound, armoured with non-magnetic material, followed by extruded PVC outer sheath(Type ST-2), with FR properties .

*6.*3 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

6.4 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

7. TYPE TESTS

7.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IS.

THE SIZES OF POWER CABLES TO BE USED PER FEEDER IN DIFFERENT APPLICATION SHALL BE AS APPLICABLE, DESCRIBED HERE UNDER.

S.No.	From	To	Cable size	Cable type
1.	Main Board Switch	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Board Switch	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Board Switch	Oil Filtration Unit	1-3½C X 300 mm^2	XLPE
4.	Main Board Switch	Colony Lighting	1-3½C X 300 mm^2	XLPE
5.	Main Board Switch	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Board Switch	Main Lighting distribution board	1-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	PVC
8	AC Distribution Board	Emergency Lighting distribution board	1-3½C X 70 mm^2	PVC
9	AC Distribution Board	ICT MB	1-3½C X 70 mm^2	PVC
10	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11	Bay MB	AC Kiosk	1- 3 ½ x 35 mm^2	PVC
12	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13	DCDB	Battery	2-1C X 150 mm^2	PVC
14	DCDB	Battery Charger	2-1C X 150 mm^2	PVC

15	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC

PART 4: SCHEDULES

25. TECHNICAL DATA SCHEDULES

3. 1100V Cable Schedule

Remarks:- a) All the LV Power Cable shall be XLPE with insulated armoured Aluminum Cable.

b) All the Control Cable shall be PVC insulated Cables.

ODISHA POWER TRANSMISSION CORPORATION LIMITED

OFFICE OF THE SR. GENERAL MANAGER,

CENTRAL PROCUREMENT CELL,

JANAPATH, BHUBANESWAR – 751022.

TECHNICAL SPECIFICATION

FOR

SUB STATION LIGHTING

SUBSTATION LIGHTING

TABLE OF CONTENTS

1. GENERAL

The scope comprises design, engineering, supply, installation, testing and commissioning of the following:

- Complete installation and lighting fixtures complete with lamps, supports and accessories;For indoor and outdoor
- Ceiling fans complete with electronic regulators, accessories;
- lighting panels and lighting poles complete with distribution boxes;
- Galvanised rigid steel conduits and fittings, lighting PVC ables GI Earth wire receptacles, switchboards, switches, junction boxes, pull out boxes complete with accessories;
- Lighting transformer.
- Any other items required to complete the indoor and outdoor lighting in complete shape.

The details of area to be illuminated are given in Table 1. along with the required lux levels.

Area	Lux
Control Room	350
PLCC Room	300
LT Room	150
Charger Room	150
Cable Gallery	150
Heating Plant	100
Battery Room	100
Computer Room	300
Entrance lobby	150
Corridor and landing	150
Conference and display	300
Rest Room	250
AHU Room	100
DG Set Building	150
Fire Fighting Pump House	150
Switchyard - Main equipment	50
Switchyard - general equipment and balance	30
Street/Road	30

Table 1. Areas to be lit and required lux levels

Contractor shall submit detailed calculation for verifying that the required lux levels will be attained by the proposed lighting system

Any material, cables, wire, conduits, fittings, accessories etc. whether mentioned specifically or not but required for installation of lighting fixtures are included in the scope of Contractor.

1. SYSTEM DESCRIPTION

1.1 Normal lighting - AC

AC lights will be connected to AC lighting panels. All the lights connected to the AC lighting system in different areas will be connected to the main lighting distribution boards to be supplied.

1.2 Emergency lighting - AC

This system will be available in control room building, switchyard and diesel generator building. AC lighting load will be connected to this system which will be normally óONô. The lighting panels of this system will be connected to the Emergency lighting board which is fed from diesel generator during the emergency.

1.3 Emergency lighting - DC

DC emergency lighting fixtures operated from the DC system shall be provided in strategic locations so that the operating personnel can safely find their way during a total AC failure. These lights will be normally **'OFF'** and will be switched **'ON'** automatically when under voltage occurs in the AC mains lighting distribution board.

1.4 Emergency lighting - portable

Emergency portable light shall be provided as per relevant clause of this section. Three portable lights for control room and two portable lights for PLCC room shall be provided for every substation.

1.5 Temperature Rise

All lighting fixtures and accessories shall be designed to have a low temperature rise according to IEC 598 Part-I/ IS 10322 (Part-4).Temperature rise of panels should be as per IS 8623 (Part-l)/IEC 439-1.

2. LIGHTING FIXTURES

2.1 General

Fixture shall conform to latest IS / IEC .and its latest amendment.

All fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.

All lighting fixtures shall be complete with required lamps such as LED (to be fitted inside switch yard and all street light), & LED light (adopt as per Govt nerms for energy efficiency) for indoor lighting..

LED lamp fixtures shall be complete with all necessary wiring and accessories such as ballasts, ignitors, power factor improvement capacitors etc if required. These shall be mounted in the fitting assembly only. The Contractor shall indicate starting time of these lamps to attain full light output. Curves for starting characteristics with varying supply voltage etc. are to be furnished by the Contractor.

Flood lighting shall have suitable base plate/frame for mounting on structural steel member.

Each fixture (other than bulk head fixtures) shall have terminal blocks suitable for 2.5 mm^2 stranded flexible copper conductor. The internal wiring should be completed by the manufacturer and terminated on the above terminal blocks. The Contractor shall specifically furnish details of internal size of wires and type of insulation. The terminal blocks shall be as specified under General Equipment and Substation Accessories (GESA) section of this Specification.

Each lighting fixture shall be provided with an earthing terminal suitable for connection to 16 SWG GI earthing conductors.

All metal or metal enclosed parts of the housing shall be suitably constructed so as to ensure satisfactory earthing continuity throughout the fixture up to the earthing terminal.

The mounting facility and conduit knock-outs for the fixtures shall be provided and shall be suitable for 20 mm conduit entry.

On completion of manufacture, all surfaces of the fixtures shall be thoroughly cleaned and degreased. The fixtures shall be free from scale, rust, sharp edges and burrs.

The housing shall be stove-enamelled or vitreous enamelled or anodised aluminium as indicated in the specification of the relevant fixture.

All enamel finishing shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 degrees. over 1.5 inch die mandrel.

All light reflecting surfaces shall have optimum light reflecting coefficient so as to ensure the overall light output as specified.

The different types of lighting fixtures to be provided shall be to the approval of the OPTCL.

REMARKS: ALL THE LAMPS TO BE USED INSIDE & OUTSIDE THE SUB-STATION AREA SHALL BE OF "LED" ONLY. BIDDERS ARE ADVISED TO QUOTE ACCORDINGLY.

2.2 Accessories

2.2.1 Reflectors

The reflectors shall be manufactured from sheet steel or aluminium more applicable of not less than 22 SWG thickness. They shall be securely fixed and of captive type.

2.2.2 Lamp holders

Lamp holders shall preferably be for LED lamps etc.. Holders shall be designed and manufactured in accordance with relevant standard to give long and satisfactory service.

2.2.3 Ballasts(if required)

Ballasts shall be designed, manufactured and supplied in accordance with IS 3021 and function satisfactorily under site condition specified. The ballasts shall be designed to have a long service life. The power loss in ballasts (if required)for LED lamps shall not be more than the specified watts as per relevant standard and for the fluorescent lamps it shall be the minimum commercially available in the industry.

Ballasts shall be mounted using self locking anti-vibration fixing and shall be easy to remove without dismantling the fixtures. They shall be totally enclosed units.

The ballasts shall be of the inductive, heavy duty type, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. The ballast wiring shall be of copper wire. Ballasts shall be designed for maximum winding temperature rise of 55C under rated conditions. They shall be free from hum. Ballasts for LED lamps shall be provided with suitable tapping to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure.

Separate ballasts for each lamp shall be provided in case of multi-lamp fixtures.

The Contractor shall submit general arrangement and wiring diagram with all terminal details for approval of the OPTCL.

2.2.4 Capacitors

Capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

Capacitors shall be suitable for operation at the supply voltage as specified and shall have a value of capacitance so as to correct the power factors of its corresponding lamp circuit to the extent of 0.98 lag.

Capacitors shall be hermetically sealed in a metal enclosure.

2.2.5 Lamps

The LED lamps to be supplied shall conform to IS 9974. LED lamps shall be suitable for use in any position. Restrictions, if any, shall be clearly stated. The lamps shall be capable of withstanding small vibrations with out breakage of connections at lead-in wires and filament electrodes.

The constructional features of LED lamps for special applications shall be clearly brought out in the bid.

The Bidder shall furnish typical wiring diagrams for all fittings including all accessories. The diagrams shall include technical details of accessories i.e. ignitors, ballasts, capacitors etc.

2.3 Receptacles

All receptacles shall be of cast steel or aluminium, heavy duty type, suitable for fixing on wall or column and complete with individual switch.

In general the receptacles to be installed are of the following types:

- Type RO-15A, 240V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2 core 6 mm^2 PVC armoured cable and a metallic cover fixed to it with a metallic chain. Receptacles shall be suitable for installation in moist location and/ or outdoor. The switch shall be of rotary type. Receptacles shall be housed in an enclosure made out of 2 mm thick GI sheet with hinged doors with padlocking arrangements. Door shall be lined with good quality gaskets. This shall conform to IP 55.

- Type RI-Combination of 5A and 15A, 240V, 3 pin type with third pin grounded, suitable for flush mounting. The switch shall be of piano key type and shall be flush mounted.

- Type RP-63A, 415V, 3 phase, 4 pin interlocked plug and switch with earthing contacts. Other requirements shall be same as type RO. The receptacle shall be suitable for 3½ core 35mm^2 / 3½ core 70mm^2 aluminium conductor cable entry and shall also be suitable for loop-in-loop-out connection of cables of identical size. Receptacle shall be suitable for outdoor application. Receptacles shall be housed in a box made out of 2 mm thick G. I. sheet, with hinged door with padlocking arrangement. Door shall be lined with good quality gaskets. This shall conform to IP 55.

3. LIGHTING POLES

The Contractor shall supply, the following types of hot dip galvanised steel tubular lighting poles required for street lighting:

a) Type Al street lighting pole - for one fixture

b) Type El post top lantern pole - for one fixture

Street/flood light poles shall conform to the drawings approved by the OPTCL.

Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted above ground level at 1 mtr height from the ground.

The lighting poles shall be steel hot dip galvanised

The galvanised sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP 55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and

fuse base assembly. The terminals shall be stud type and suitable for two nos. 16mm^2 cables. Necessary arrangement for cable glands along with supply of double compression glands are included in Contractorôs scope.

Wiring from junction box at the bottom of the pole (minimum height from the bottom of the pole shall be 1.0mtrs) to the fixture at the top of the pole shall be 2.5 mm^2 wire.

4. LIGHTING WIRES & CABLES

The wiring used for lighting shall be of 1100V grade, PVC insulated cable of standard products of reputed manufacturers.

The conductor sizes for wires used for point wiring beyond lighting panels shall be single core 4 mm^2, 6mm^2 and 10mm^2 stranded aluminium wires and 2.5 mm^2 stranded copper wire.

The wires used for connection of a lighting fixture from area rest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IS 694 with nominal conductor cross sectional areas of 2.5mm^2.

The Contractorôs scope covers supply of all wiring, cabling and accessories.

The wires shall be colour coded as follows:

- Red for R - Phase
- Yellow for Y - Phase
- Blue for B - Phase
- Black for Neutral
- White for DC (Positive)
- Grey for DC (Negative)

5. TESTS AND TEST REPORTS

Type tests, acceptance tests and routine tests for the lighting fixtures and accessories covered by this specification shall be carried out as per the relevant standard for the respective fixtures and their accessories.

Manufacturerôs type and routine test certificates shall be submitted for the fixtures and accessories. Type test certificates shall be furnished along with the bid.

Rates for type tests for all types of fixtures and accessories for light fittings as required under relevant section of this specification shall be provided in the relevant price schedules.

6. LIGHTING SYSTEM INSTALLATION WORKS

6.1 General

In accordance with the specified installation instructions as shown on manufacturerôs drawings or as directed by Project Manager. Contractor shall supply, erect, install, test and put into commercial use all the electrical lighting equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Tolerances shall be as established in manufacturerôs drawings or as stipulated by Project Manager.

The Contractor shall prepare the lighting layout and erection drawings and obtain the Project Managerôs approval before commencing the erection works.

6.2 Flood lights.

Contractor shall install flood lights on switchyard structures to be erected inside switchyard. The GI structural are also suitable for protection from lightening by providing spikes cones at all the column peak. Proper design in this respect to be carried out along with numbers of such towers required. Plotting of lightening protection area showing details of equipment installed in switch yard. A platform provided in the mast tower shall be used for fixing of lighting fixtures.

Fixtures shall be mounted on galvanised making use of shop provided holes or by suitable clamps. No cutting or drilling of galvanised structure is permitted.

The Contractor shall mount the assembled fittings and install necessary cabling.

6.3 Lighting fixtures for flood lights

Flood lights shall be mounted on steel base facing the tentative direction shown on drawings. Fixing holes shall be provided with slot to turn the fixture by approximately 5 degrees on both sides. Bolts shall be finally tightened with spring washer. The Contractor shall supply and install the steel base, channels, angles etc. for fixing the flood light on the flood light towers. Terminal connection to the flood light shall be through flexible conduits, and these flexible conduits shall be included in the installation rate of fixture itself.

The scope of Contractor shall include the supply of necessary brackets and sundry material, for installation of lighting fixtures.

6.4 Lighting panels

Lighting panels shall be erected at the locations to be indicated in the approved drawings.

Necessary foundations and/or supporting structures for all outdoor type lighting panels and necessary supporting structures for indoor lighting panels shall be provided by the Contractor.

6.5 Street lighting poles

Street lighting poles shall be installed as per the approved drawings.

Steel tubular hot dip galvanised pole,s which are specified for the above purpose are to be installed as per the approved lay out for street lighting system. Contractor shall erect the poles (including foundation works), mount the assembled fittings and install necessary cabling.

7. TECHNICAL PARAMETERS OF LIGHTING TRANSFORMERS

i)	Type of transformer	Dry type natural air
ii)	Rating	1 00 kVA or 75kVA
iii)	Voltage ratio	415/415 volts
iv)	No. of phase	Three
v)	Frequency	50Hz
vi)	Winding connection	Dyn 1
vii)	Class of insulation	B class
viii)	Percentage Impedance	4%, ±10%
ix)	No. of taps and steps	5 in steps of 2.5%
x)	Reference standard	IS 2026
xi)	Any latest amendment standards of the above.	

Transformers shall be located in ACDB room, in separate enclosure. Enclosure shall have degree of protection not less than IP 42 as per IS 2147.

8. EMERGENCY PORTABLE LIGHTING FIXTURES

The portable emergency lighting fixtures supplied shall have a built in battery rated for six hours and be complete with battery chargers and solid state inverters, and be supplied with all necessary supporting brackets of galvanised steel suitable for wall/column mounting..

The portable emergency lighting fixtures shall be of a single unit, completely tropicalised, suitable for prolonged use with no maintenance, and shall light up automatically in the event of failure of normal supply.

The Contractor shall submit schematic along with all details and general arrangement drawing for approval.

9. CEILING FANS AND REGULATORS

The Contractor shall supply 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories.

The Contractor shall supply the switch, electronic regulator and board for mounting switch and electronic regulator.

Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

Electronic regulator with smooth control shall be provided.

Precautions shall be taken in manufacture of fans and regulators to ensure reasonable degree of silence at all speeds.

Type tests, acceptance tests and routine tests for the fans and regulators shall be carried out as per latest relevant standard.

Fans and electronic regulators shall be from established manufacturers or brands.

10. FOUNDATION AND CIVIL WORKS

All foundations and civil works shall be included in the Contractorôs scope of work. Civil works shall be in accordance with the relevant part of this specification.

11. GROUNDING

All lighting panels, junction boxes, fixtures, conduits etc. shall be grounded in compliance with the provision of I.E. Rules.

Ground connections shall be made from nearest available station ground grid. All connections to ground grid shall be done by arc welding.

Lighting panels shall be directly connected to ground grid by two 50 x 6mm G.S. flats.

A continuous ground conductor of 16 SWG GI wire shall be connected to each panel ground bus. All junction boxes, lighting fixtures shall be connected to this 16 SWG ground conductor.

All lighting poles shall be earthed as per standard. 16 SWG GI wire shall be taken up to junction box from the lighting fixture.

12. TESTING AND COMMISSIONING

On completion of erection work, the Contractor shall request the OPTCL to undertake the inspection as required by this Specification.

The OPTCL shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Contractor.

The installation shall be tested and commissioned in the presence of the Contractor and OPTCL

The Contractor shall provide all men, material and equipment required to carry out the tests.

All rectification, repairs or adjustment work found necessary during inspection, testing and commissioning shall be carried out by the Contractor, without any extra cost to the Employer.

The Contractor shall measure and furnish to the Project Manager, the actual lux level in all the areas of the substation to prove compliance to this specification.

**** Armoured PVC cables are to be used for the switch yard lighting, street lighting and any other out door lighting system.**

**** For indoor lighting ,each fixture shall be controlled by one switch.**

**** Minimum two nos 5 Amp multi purpose power sockets with switch are to be provided in each switch.**

***** Contractor to furnish the design details for the locations (like Switch yard area,Road street light,Control room building area,Quarter ,Gate etc), which can be adopted after approval from OPTCL. Design to be carried out as per the LUX level indicated at the beginning of this chapter.**

TECHNICAL SPECIFICATION FOR LED FLOOD / NORMAL LIGHT FITTINGS 1 PH A.C OPERATION

1.GENERAL DESCRIPTION

LED Flood/Normal Light luminaries of 240V, A.C,50 Hz ,suitably decided the wattage of the lamp (to be decided after detail Engineering) in Single piece High Pressure Die Cast Aluminium alloy Housing having high conductivity acting as heat sink, with Powder coating with suitable colour with distortion free, clear, Heat Resistant Toughened UV stabilized Glass in the front fixed to the die cast Aluminium frame which shall be fixed to the housing with high quality long lasting Neoprine Rubber gasket duly impregnated with insecticide and water repellant chemical on the periphery of lamp compartment by means of stainless steel screws to render it dust proof, water proof and vermin proof and having minimum IP-65 Protection conforming to IS:10322 (part-2) ï 1982.

Note: The capacity LED Luminary is to be suitably decided after conducting the detail Engineering for the locations , where these Luminaries are to be used. The Locations are generally in EHV grade Sub-station switch yard area,Street Lighting, Control Room Building, Colony Quarters etc. Details design for adoption of LED Luminary system to be furnished for review of design and its acceptance. Latest practice of adoption of these system are to be strictly followed.

2. TRAINING :

Train the staff on Hardware /Software ,installation, commissioning and maintenance of the Luminaries at different locations (Different Sub-stations).

3. TECHNICAL SPECIFICATIONS:

The LED Luminaries are as per the following parameters

a	**Mid Power White LED's**	Should be of reputed make as indicated in the Tender specification.
b	Wattage of Mid Power White LED,s offered	Low power LED 5252 0.3W
c	LED Lumens	
d	Life span as per LM70(@70%) light output	>50000 Hrs. 0r Better
	Lux at centre at height of 4.5 meter	>150 LUX 0r Better
e	Uniformity Ratio(Emin./Emax.)(mounted at 4.5m height @90 Angle)	>0.35 0r Better
f	Luminary Efficacy	>65 0r Better
g	Control of Distribution	Fully Cutoff
i	Driver current(With Constant Current Driver)	<100mA/LED 0r Better
j	**Electronic** Efficiency@230V	**>85% 0r Better**
k	Beam angle of the Luminary	> 120° 0r Better

l	color Temperature of LEDs	6500K to 7500K 0r Better
m	P/N junction temperature (High thermal conduction must be achieved by silicon heat conducting greases as adhesive	<85 ºC 0r Better
n	Luminary Body Temperature	The Body Temperature shall be <(Ambient+35º C) even after continuous burning of Luminary for 24 Hrs.**0r Better**
o	color Rendering Index(CRI)	>70 **0r Better**
p	weight	Preferably less weight & may be of Maximum up to 4 Kgs (comfortably can be carried and fixed)
B	**ELECTRICAL**	
a	AC Input Voltage Range	100V TO 270V AC
b	AC Input frequency .(The LED circuitry shall function at an operating frequency that must be greater than 120 Hz to prevent perceptible flicker to the unaided eye over the entire voltage range specified above.)	47 ~ 53Hz
c	Power Factor (Source Power Factor varies from 0.5 Lag to 0.5 Lead)	> 0.95 **0r Better**
d	Luminary Wattage variance at 100 V to 270 V	± 10%
e	Luminary Lux Levels Variance at 100 V to 270 V	± 5%
f	Total Harmonic Distortion(THD)	< 15% **0r Better**
g	Electrical Connection System	3 wire system (Phase,Neutral & Gnd)
h	System of earthing (The luminaries offered shall conform to Level-1 classification)	Solidly grounded
i	There shall be electrical isolation between input and output circuits of the driver.	
C	**MECHANICAL**	
a	Construction of Casing	High Pressure Die Cast Aluminum. Should be durable for extreme climatic
b	Finish	Powder Coating and gray/black color and should be durable. The colour should not fade in extreme climate conditions.

c	Heat Sink type (It shall be designed in such a way that the heat generated within the LED source is efficiently dissipated to the surrounding atmosphere without abnormal rise in temperature. Any debris build up shall not degrade heat dissipation performance of the luminaries.	Aluminium Metal Core PCB
d	Lamp Cover	Toughened Glass or any suitable material which can be used in the extreme climate and should be durable
e	Gross Weight and Dimensions (L x W x T) mm of Luminaries (Efforts shall be made to keep the overall outer dimensions as minimum as possible with out compromising on the performance, mainly thermal management of the luminary)	
f	Heat Dissipating Area (Luminary Rating wise)	
g	IP Level ï Minimum IP 65	

18W AC DOWN LIGHT

DATASHEET

Applications :

Area: Indoor
Purpose: Home and Office Lighting.

Features:

(1) Optical

- » Optical pattern meets all standard Home and Office Light Standards.
- » Uniform illuminance distribution.

(2) Power

» Switched mode constant current power supply.
» Over-heat, Over-voltage, Over-current protections are provided.
» Lightning Protection provided.

(3) Thermal

» Luminaire surface temperature is 48°C @ Ta=30°C, the temperature variation is controlled under 5°C.
» Junction temperature is controlled ot 70°C @ Ta=30.
» Overheat protection will operate to adjust as the LED module surface reaches 80°C.

(4) Luminaire

» Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
» Dust and water protection design meeting IP65 standards.
» Super-high luminaire efficacy.

DETAILED TECHNICAL SPECIFICATION

Electrical Characteristics:

PARAMETER	DRIVER RESULT
Input Voltage	160 -300 V AC
Rated Power	18Watt
Maximum Power	21Watt
Efficiency	>85%
Power Factor	>0.9
Voltage Harmonics (THD)	<5%
Current Harmonics (THD)	<10%

Operating Conditions:

Operating Frequency	100kHz to 200KHz
Operating Temperature Range	-25°C to +70°C
Storage Temperature Range	-65°C to 125°C
Humidity	95% RH

LED Details:

Led Make	As per approved vendor
No Of LEDs	12
Led Viewing Angle	120º by using reflector
Colour Temperature	Cool White (5500 to 6500K)

Luminous Flux	>2160 Lumens
Life Span	> 80,000 Hours
Colour Rendering Index	>70 Ra

LED Luminary Details:

Body	Alluminium Body
Heat Sink	Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
Dust and Water protection	IP 65 Standards

Protection Parameters:

Over-Current Protection	Inbuilt
Short-Circuit Protection	Inbuilt
Over-Voltage Protection	Inbuilt
Over-Temperature Protection	135 °C
Dust and Water Protection	IP 65
Lightning Protection	Inbuilt

50W AC LOW BAY LIGHT

LED bay light fixture is designed and developed to replace traditional high bay or low bay fixtures for industrial and other rugged applications. Light weighted and easy for installation, the LED High Bay/Low Bay fixtures are all designed to offer maximum energy saving, substantially reduced maintenance costs and superior quality.

Major Applications :

Factory production floors, Workshop, Warehouses, Road toll gates, Petrol stations, Supermarkets, Sports stadiums, Convention center halls, Airport passenger halls, etc., where high ceiling lighting required.

Features :

1)Low power consumption. More than 60% energy saving compared to conventional HID/HPS.

2) Environmental friendly. Lead and mercury free. Long operation life time, above 50,000hours. Low maintenance costs.

3)Voltage input 160-300 V AC,

4)Instant ON/OFF operation.

5)Superior color rendition compared to conventional industrial luminaries.
6)Selectable color temperature.
7)Single piece 30W-100W high power LED light source with unique multi-chip integration design ensure high light purity, high heat conduction and slow brightness derating.
8)Unique heat sink design ensures superior heat management.
9)Resistant to shock and vibration.

Specifications :

Input Voltage	AC 160-300V
Power Frequency of Driver	47～63Hz
Power Efficiency of Driver	Ó85%
LED Power Consumption	50w
Power Factor(PF)	Ó0.90
Total Harmonic Distortion	Ò10%
Luminaries Efficiency	Ó90%
Flux (Lumens)	4000
Color Rendering Index	Ó80
Color Temperature	2700～7000K Optional
Beam Angle	90/120 Degree Optional
Light Effect	70～80lm/W
Working Ambient Humidity	-25℃～+45℃
Working Ambient Humidity	15%～90%RH
IP Rating	IP30/IP54 Optional
Service Life	Ó50000 Hours
Light Fixture Material	Aluminum Alloy

100W AC LED STREET LIGHT

DATASHEET
Applications :
Area: Outdoor
Purpose: Street and Roadway Lighting.

Features:
(1) Optical

» Optical pattern meets all standard Street Light Standards.
» Uniform illuminance distribution.

(2) Power

» Switched mode constant current power supply.
» Over-heat, Over-voltage, Over-current protections are provided.
» Lightning Protection provided.

(3) Thermal

» Luminaries surface temperature is 48°C @ Ta=30°C, the temperature variation is controlled under 5°C.
» Junction temperature is controlled ot 70°C @ Ta=30.
» Overheat protection will operate to adjust as the LED module surface reaches 80°C.

(4) Luminaire

» Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
» Dust and water protection design meeting IP65 standards.
» Super-high luminaire efficacy.

DETAILED TECHNICAL SPECIFICATION

Electrical Charatcteristics

PARAMETER	PROMPT DRIVER RESULT
Input Voltage	160 -300 VAC
Rated Power	100W
Maximum Power	115W
Efficiency	>85%
Power Factor	>0.9
Voltage Harmonics (THD)	<5%
Current Harmonics (THD)	<10%

Operating Conditions:

Operating Frequency	100kHz to 200KHz
Operating Temperature Range	-25°C to +70°C
Storage Temperature Range	-65°C to 125°C
Humidity	95% RH

LED Details:

Led Make	As per approved vendor
No of LEDs	48-70
Led Viewing Angle	120º by using reflector
Colour Temperature	Cool White (5500 to 6500K)
Luminous Flux	>8500 Lumens
Life Span	> 50,000 Hours
Colour Rendering Index	>70 Ra

LED Luminary Details:

Body	Alluminium Die casting Body

Heat Sink	Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
Protection	IP 65 Standards for Dust and Water

Protection Parameters:

Over-Current Protection	Inbuilt
Short-Circuit Protection	Inbuilt
Over-Voltage Protection	Inbuilt
Over-Temperature Protection	135 °C
Dust and Water Protection	IP 65
Lightning Protection	Inbuilt

120/150W AC LED FLOOD LIGHT

DATASHEET
Applications :
Area: Outdoor
Purpose: Street and Roadway And Area Lighting.

Features:

(1) Optical
- » Optical pattern meets all standard Street Light Standards.
- » Uniform illuminance distribution.

(2) Power
- » Switched mode constant current power supply.
- » Over-heat, Over-voltage, Over-current protections are provided.
- » Lightning Protection provided.

(3) Thermal
- » Luminaries surface temperature is 48°C @ Ta=30°C, the temperature variation is controlled under 5°C.
- » Junction temperature is controlled ot 70°C @ Ta=30.
- » Overheat protection will operate to adjust as the LED module surface reaches 80°C.

(4) Luminaire

» Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.

» Dust and water protection design meeting IP65 standards.

» Super-high luminaire efficacy.

DETAILED TECHNICAL SPECIFICATION

Electrical Charatcteristics

PARAMETER	PROMPT DRIVER RESULT
Input Voltage	160 -300 VAC
Rated Power	120W
Maximum Power	140W
Efficiency	>85%
Power Factor	>0.9
Voltage Harmonics (THD)	<5%
Current Harmonics (THD)	<10%

Operating Conditions:

Operating Frequency	100kHz to 200KHz
Operating Temperature Range	-25°C to +70°C
Storage Temperature Range	-65°C to 125°C
Humidity	95% RH

LED Details:

Led Make	As per approved vendor
No of LEDs	48-70
Led Viewing Angle	120º by using reflector
Colour Temperature	Cool White (5500 to 6500K)
Luminous Flux	>8500 Lumens
Life Span	> 50,000 Hours
Colour Rendering Index	>70 Ra

LED Luminary Details:

Body	Alluminium Die casting Body
Heat Sink	Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
Protection	IP 65 Standards for Dust and Water

Protection Parameters:

Over-Current Protection	Inbuilt
Short-Circuit Protection	Inbuilt
Over-Voltage Protection	Inbuilt
Over-Temperature Protection	135 °C
Dust and Water Protection	IP 65
Lightning Protection	Inbuilt

ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

TESTING INSTRUMENTS AND MAINTENANCE KITS
OTHER TOOLS & PLANTS
&
FURNITURE

TESTING INSTRUMENTS AND MAINTENANCE KITS AND OTHER T&P'S & FURNITURE

TABLE OF CONTENTS

1. GENERAL

The testing and maintenance equipment covered here are generally meant for carrying out testing and measurement at site and shall be complete with all materials and accessories. These shall be robust in design, so that they give accurate results even in adverse site conditions.

All equipment furnished shall be of reputed make, type tested and shall be subjected to acceptance and routine tests in accordance with the requirements stipulated under respective equipment specification.

At least two sets of descriptive leaflets, catalogues, outline drawing, principles of operation etc. shall be sent along with the offer, for all the equipment offered. Weight and dimensions of items should also be mentioned.

Four sets of inspection and calibration report, operation and maintenance manual shall be sent along with Despatch documents. One set will be kept inside the equipment.

In the event of bidder offering equipment manufactured by different manufacturers, it will be his responsibility to fully co-ordinate the activities of each manufacturer in such a way that the complete equipment contracted for, is manufactured, supplied and guaranteed for successful operation.

2. TRAINING

Necessary training shall be provided to Employer's personnel for using and maintaining the equipment at Employer's premises.

3. CLIMATIC CONDITION

The equipment covered under this specification shall be suitable for operation under climatic condition stated else where in the specification. The offered equipment as such shall be suitable for satisfactory operation under the tropical climate.

3. 100 KV TRANSFORMER OIL BREAKDOWN VOLTAGE TEST SET

The equipment offered shall be suitable for determination of electric strength (breakdown voltage) of insulating oil upto 100 KV to IS:335 when measured in accordance with IS:6792.

The test cell shall be as per IS:6792 suitable for BDV upto 100 KV without external flashover.

The unit shall be of composite type having control unit and high voltage transformer in a common cabinet with necessary partition. HV chamber interlocking and zero start interlocking shall be provided.

The unit shall have motorised drive to increase voltage linearly as per the rate specified in IS:6792. Provision should also be available for manual increase of voltage. The unit shall be complete with test cell, stirrer and "GO" and "NO GO" gauge for adjusting the gap.

The instrument shall have

a) Operating temperature: 0 ï 50 deg C

b) Humidity > 90% and nearly equals to 99%

c) Low/High level interlocking for drive motor. Earth open interlocking,reverse interlocking.

d) Protection: Quick acting D.C relay to isolate the H.T.

e) Test cup: The test cup with cover shall be made of Methyle Mathacrylate(Acrylic) having oil between 300 and 500 ml, with adjustable and removable mushroom head and ground to adjust the electrode gap distance.

f) Motorised and manual operation.

g) A linear scaled A.C rectifier voltmeter marked kV to measure output voltage.

h) Shall have magnetic strainer provision for removing the bubbles.

The equipment shall be suitable for operation at 240 volts 50 Hz. Single phase AC supply.

4. INSULATION RESISTANCE TESTER (MEGGER)

The equipment offered shall be used for measurement of insulation resistance of electrical equipment.

4.1 Technical Requirements

• Rated voltage selection	: 1, 2, 3, 4, and 5 kV (DC Volts)
• Rated resistance (megohms)	0 to 100000 multi-range type. Resistance range for each rated voltage shall be indicated in the offer.
• Type	Portable, compact and direct reading type of multi-voltage with multi-rated resistance ranges. The tester shall be suitable for hand operation as well as operation by a continuously rated motor with AC mains supply of 230V, single phase, 50 Hz.
• Ambient temperature	0 to 50C
• Infinity adjustment	There should be provision
• leather carrying case	The instrument shall be supplied with 7 metre long mains leads (shall have insulation level as per required) and leather carrying case.
• Standards	The tester shall generally comply with the requirements of IS:2992-1987 and IS:11994-1986 and latest.
• Preferable make	The equipment offered shall be of reputed make preferably Megger/ Avo International make or equivalent(on approval of OPTCL)
• Other required spec.	High voltage indication by LED for user safety
•	Auto discharge of capacitive load with indication after the IR test.

- Recessed terminals and shrouded leads for enhanced user safety.
- Linear and accurate reading
- Protected against accidental connection to 230/440 V AC supplies.
- Portable and light weight suitable for field and Lab use.

4.2 Test Requirements

Type test certificate for all ten tests as per Cl.11.1 of IS:2992.

All routine tests as per Cl.11.3 of IS:2992 shall be conducted.

5. OIL SAMPLING BOTTLE

Oil Sampling bottles shall be suitable for collecting oil samples from transformers, for testing of the oils (BDV, Dissolved Gas Analysis, resistivity etc). Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1 litre.

Oil sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle and seal shall be such that loss of hydrogen shall not exceed 5% per week.

An impermeable oil-proof, plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

6. RELAY TOOLS KITS (ALSO REFER THE SPECIFICATION OF PCM)

The relay test kit shall consist of the following minimum items:

1. Test plugs for use with testing equipment
2. Special type test plugs for using with modular type cases
3. Screw driver set with multiple fixing feature
4. Long nose pliers
5. Wire cutting pliers and stripper
6. Ordinary pliers
7. Adjustable wrench
8. Soldering irons of
    - Watts rating - 1 No.
    - Watts rating - 1 No.
    - Watts rating - 1 No.
9. De-soldering pump
10. Printed Circuit Card-extender; Printed circuit card - `Puller' Suitable for all supplied relays
11. Test leads (Pair with 2 Mts. length) - 1 set
12. Shorting plugs, `pistol' prods (2 Nos.) - 1 set

7. SF6 GAS LEAK DETECTOR

The SF6 gas leak detector shall meet the following requirements

The detector shall be free from induced voltage effects.

The sensing probe shall be such that it can reach all the points on the breaker where leakage is to be sensed .Latest standard in this effect may be followed..

8. Digital Multimeter

The digital multi meter shall have a LCD screen for displaying 3 and 3/4 digits and having auto ranging facility. Instrument shall have single rotary selection switch. Instrument shall have automatic polarity, low battery and over range indication and a range of 0.1mV to 1000V DC, 0.1mV to 750V AC, 0 -10A DC , 0-10 A ,AC and 0-10 mega ohm . Instrument shall have auto selection of AC/DC ampere and AC/DC Voltage. It shall have auto power off and data hold facility. Instrument shall have rugged casing and other measurement facilities (resistance, diode, continuity etc measurement) as per standard.

9. Digital clamp-on- meter: (AC)

The digital clamp meter shall have LCD screen for displaying 3 and 3/4 digits, multifunction, 1000 Ampere range of AC current at (i) 0.01 Amp to 20 Amp, (ii) to 200Amp and (iii) to 1000Amp; AC/DC voltage range 0.01 V to 200V and in the other scale up to 1000V, Provision of measurement of resistance up to 0 ï 10 mega ohms at different scale selection and also other facilities. Instrument shall have single rotary selection switch. It shall have auto power off and data hold facility. Instrument shall have rugged casing and other measurement facilities (resistance, diode, continuity etc measurement) as per standard.

10. Digital Earth Tester.

The digital earth tester shall have 4 points ,three range (0 .01 ohms to 20 ohms, 200 ohms and up to 2000 ohms) type. Battery operated type instrument.3 and 1/2 digit LCD display with maximum reading 1999 ohms. Instrument shall have rechargeable internal Ni-MH Battery. Instrument shall be of 4 wire soil resistivity measurement. Type tested as per IS-9223.Instrument shall have low bat indication and data hold facility. Instrument shall have over range indication. Single, measuring time below 1 minute. Instrument shall consist of required nos of standard length of spikes (minimum 1 mtr), flexible copper PVC wires of required length (minimum length shall be 30mtrs two pieces and 15 mtrs two pieces ,and two more pieces for connecting to the instrument), one no. suitable hammer for hammering the spike for inserting into the earth. There shall be crocodile clamps on one side of each wire and round clips on the other side for connecting to the instrument.

11. Discharge Rods:

Discharge rods shall be good quality and as per the latest relevant standard. Required length of PVC good insulation flexible copper cable, required clamp connected at the end of wire shall be connected. The top portion of the discharge rod shall be adjustable to fit in for proper gripping by screwing from the bottom side. The entire handle shall be of latest insulating materials for the safety of the user. The discharge rod shall be reliable, durable and shall meet the safety requirement of the users.

12. Rubber Hand Gloves:

Good quality rubber gloves for using during operation of isolators and earth switch. Latest standard for the rubber gloves shall be followed. The gloves shall be reliable, durable and shall meet the safety requirement of the users.

13 Portable Emergency Light:

Reputed make (BPL/CGL/Bajaj) portable emergency light, having twin tube, shall be supplied to each sub-station. It shall have chargeable battery (durable) and having provision of selection switch for selecting single or double tube. It shall have chargeable feature during not in use and automatically switch

on in the event of power failure. CFL tubes are preferred. It shall have provision of wall hanging/table mounting and shall be durable one. Latest standard in this effect shall be followed.

14. SCHEDULE OF REQUIREMENTS OF MAINTENANCE TESTING EQUIPMENT

ANNEXURE – I

Item nos.	**Units**	**ALL 132/33KV**	**ALL 220/132/33 KV S/S**	**220/33 KV S/S Gopinathpur (keonjhar)**
100 kv transformer oil breakdown voltage test set	Nos	1	1	1
Insulation resistance tester (megger)	Nos	1	1	1
Oil sampling bottle	Nos	4	4	4
SF6 gas leak detector	Nos	1	1	1
LCD, digital multimeter	Nos	2	2	2
Analogue Multimeter(features same as digital multimeter)	Nos	1	2	1
LCD, clamp on meter	Nos	2	2	2
Digital earth tester	Nos	1	1	1
Discharge rod as per standard for carrying out the switch yard maintenance work	Nos	6	6	6
Rubber gloves of operation of isolators and earth switch	Pairs	2	2	2
Relay tools kit	Sets	1	1	1
Portable emergency light	Nos	4	4	4
Latest version desktop PC of reputed make with all its accessories including CPU, Monitor, UPS and having all latest loaded software and also its back up in shape of CD and separate pen drive . suitable for loading of software as recommended by the relay manufacturer. It includes supply of one no portable laser printer of reputed make. Make of PC and printer: HP/DELL	Set	1	1	1

** The multimeters (both digital and analogue), clamp on meters, earth tester shall preferably of ñMotwaneò make. Prior approvals of OPTCL for all the testing equipments are to be taken.

15. OTHER TOOLS AND PLANTS (T&P'S) REQUIREMENT:

(ANNEXURE- II)

Following T&Pôs of reputed make are also in the scope of this contract.

Sl No	Description of Items	unit	Quantity against Each Package		
			ALL 132/33 KV	**ALL 220/132/33 KV S/S**	**220/33 KV S/S Gopinathpur(keonjhar**
1	Set of ñDò spanner(6mm ï 42mm)	Set	1	1	1
2	Set of ñRingò spanner(6mm ï 42mm)	Set	1	1	1
3	Socket wrench with sockets,handles,and other attachment(6mm-42mm)	Set	1	1	1
4	Insulated cutting plier	Nos	2	2	2
5	Insulated nose plier	Nos	2	2	2
6	Monkey plier	Nos	1	1	1
7	Circlip plier	Nos	1	1	1
8	Pipe wrench a)12 inch ï 1 no b)18 inch ï 1 no	Set	1	1	1
9	Sly wrench a)12inch ï 2 nos b)18inch ï 1 no	Set	1	1	1
10	Insulated handle screw drivers of different sizes as per required a)12inch plain head ï 2 nos b)8inch plain head ï 2 nos c) 12inch star head ï 1 no d) small size6inch plain and star head ï 2 each e)Complete set of different head in one box/set -1set	Set	1	1	1
11	ñLò-N keys set of different sizes in one box/set	Set	1	1	1

12	M.S Files(12inch and 6inch sizes) Round files and flat files-one each of different sizes)	set	1	1	1
13	Hammar with handle a)1 lb ï 2 nos b)1/2 lb-2 nos c)2 lb-1 no	Set	1	1	1
14	Crow bar a)5 ft ï 2nos b)3ft-2 nos	set	1	1	1
15	Steel scale(12inch)	Nos	2	2	2
16	Steel tape a)5 mtrs-2 nos b)30mtrs-1 no	Set	1	1	1
17	Oil cane	Nos	2	2	2
18	Spirit level (8inch)	No	2	2	2
19	Plumb head with string and attachment	No	1	1	1
20	Maintenance safety belt with all attachment and helmets(complete one set)	Set	3	4	3
21	Hand drill machine with different bits and key.(Wolf make)	No	1	1	1
22	Vacuum cleaner having hot blower provision with all attachments (Eureka Forbes make)	No	1	1	1
23	230-250VAC,80W,450mm sweep,1400 rpm stand(rugged) FAN Make: Almonard,CGL	No	2	4	2

** All the T&Pôs shall be of Taparia make. The hand drill and vacuum cleaner shall be wolf and Eureka Forbes make.

16. OFFICE FURNITURE:

Supply and installations of the office furniture are in the scope of this contract. All the furniture shall be of Godrej & Boyance make. Before supply of the furniture to the sub-station, approval from OPTCL is required. Details of the scope of supply are as indicated below.

ANNEXURE – III.

Sl No	Description of Items	unit	Quantity against Each Package		
			ALL 132/33 KV	**ALL 220/132/33 KV S/S**	**220/33 KV S/S**
1	5ftX3ft executive table with drawer both sides	Nos	5	6	5
2	3ftX2&1/2ft Table with one side drawer	Nos	7	8	7
3	Computer table suitable keeping monitor,CPU,UPS and printer with two nos revolving arm chair suitable for computer use.	Set	1	1	1
4	Executive revolving ,adjustable(height) chairs with arm	Nos	5	6	5
5	Cane gutting ñSò type steel chairs with arm	Nos	18	24	18
6	6ftX3ft conference table	Nos	1	1	1
7	Cushion arm steel chairs for conference table purpose	Nos	6	8	6
8	6ft height steel almirah (only with selves) for keeping records and other valuable items	Nos	4	6	4
9	6ft height steel almirah with glass doors for library purpose	Nos	2	2	2
10	6ft height (having minimum 6 lockers facility) steel cupboard with locking arrangement	Nos	2	2	2
11	4ft steel rack (minimum three selves) for keeping the files and other items	Nos	8	10	8

ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR CONSTRUCTION OF

1)132 KV SC/DC,
2)220 KV SC/DC AND
3)400 KV DC

TRANSMISSION LINES

Nature of work

The work covered by this Specification is for 400 kV and/or 220 kV and/or 132 kV transmission lines as specified herein and in the attached Schedules. The overhead transmission lines will form part of the OPTCL Transmission System.

General particulars of the system

The following are the general particulars governing the design and working of the complete system of which the Works will form a part ð

a) Electrical energy is generated at interconnected power stations as three-phase current at a frequency of 50 Hz, and transmitted therefrom by means of overhead lines.

b) The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons

1.0 SCOPE-

Construction of 400 KV, 220 KV and 132 KV

As indicated in the Bidding Proposal Sheet & scope of work.

Important: Contractor has to obtain project license from the competent authority in respect of the mentioned works prior to commencement of the works. The expenses towards the project license have to be borne by the contractor.

2.0 SURVEY (detail & check, estimating of quantities & spotting of towers)

2.1.1 General: Preliminary route alignment in respect of the proposed transmission lines has been fixed by the employer subject to alteration of places due to way leave or other unavoidable constraints. The Right of way shall be solved by the contractor and all expenses there of shall be borne by him. However, OPTCL shall render all helps in co-ordination with law and order department for solving the same. Forest clearance if any shall be arranged by OPTCL.

2.1.2 Provisional quantities/numbers of different types of towers have been estimated and indicated in the BOQ Schedule given. However final quantities for work shall be as determined by the successful bidder, on completion of the detail survey, preparation of route profile drawing and designing of the different types of towers as elaborated sin the specification and scope of work.

2.1.2.1 The contractor shall undertake detailed survey on the basis of the tentative alignment fixed by the employer. The said preliminary alignment may, however, change in the interest of economy to avoid forest and hazards in work. While surveying the alternative route the following points shall be taken care by the contractor.

(a) The line is as near as possible to the available roads in the area.

(b) The route is straight and short as far as possible.

© Good farming areas, religious places, forest, civil and defence installations, aerodromes, public and private premises, ponds, tanks, lakes, gardens, and plantations are avoided as far as practicable.

(d) The line is far away from telecommunication lines as reasonably possible. Parallelism with these lines shall be avoided as far as practicable.

(e) Crossing with permanent objects are minimum but where unavoidable preferably at right angles.

(f) Difficult and unsafe approaches are avoided.

(g) The survey shall be conducted along the approved alignment only in accordance with IS: 5613 (Part-II/Section-2), 1985.

(h) For river crossing/ Crossing of Nallas : Taking levels at 25 metre interval on bank of river and at 50 metre interval at bed of river so far as to show the true profile of the ground and river bed. The levels may be taken with respect to the nearest existing towers, pile foundation of towers, base or railway/road bridge, road culvert etc. The levels shall be taken at least 100 m. on either side of the crossing alignment. Both longitudinal and cross sectional shall be drawn preferably to a scale of 1:2000 at horizontal and 1:200 vertical.

After completing the detailed survey, the contractor shall submit the final profile and tower schedule for final approval of the employer. The final profile and tower schedule shall incorporate position of all type of towers. To facilitate checking of the alignment, suitable reference marks shall be provided. For this purpose, concrete pillars of suitable sizes shall be planted at all angle locations and suitable wooden/iron pegs shall be driven firmly at the intermediate points. The contractor shall quote his rate covering these involved jobs.

Only approved sag template shall be used for tower spotting and the final profiles.
However preliminary survey has been done by OPTCL and any further survey required shall be done by the contractor.

2.1.2.2 PROFILE PLOTTING AND TOWER SPOTTING

The profile shall be plotted and prepared to the scale 1 in 2,000 for horizontal and 1 in 200 for vertical on squared (mm) paper. If somewhere the difference in levels be too high, the chart may be broken up according to the requirements. A 10 mm overlap shall be shown on each following sheet. The chart shall progress

from left to right for convenience in handling. The sheet size may be conveniently chosen.

With the help of sag template, final tower location shall be marked on the profiles and while locating the tower on survey chart, the following shall be kept in mind:

(a) The number of consecutive span between the section points shall not exceed 10 in case of straight run on a more or les plain stretch.

(b) Individual span shall be as near as to the normal design ruling span.

In different crossing the contractor shall take into consideration the prevailing regulations of the respective authorities before finalizing type and location of the towers. While carrying out survey work, the contractor has to collect all relevant data, prepare and submit drawings in requisite number for obtaining clearance from the PTCC, road, aviation, railways, river and forest authorities.

The contractor shall remain fully responsible for the exact alignment of the line. If after erection, any tower is found to be out of alignment, the same shall have to be dismantled and re-erected after corrosion by the contractor at his own cost, risk and responsibility, including installation of fresh foundation, if belt necessary by the employer.

After peg marking of the angle tower or tension towers, the contractor shall obtain approval from the employer and thereafter pegging of suspension type tower shall be done by the contractor and pegging of all the four legs of each type of towers at all the locations shall be done.

2.1.2.3 SCHEDULE OF MATERIALS

When the survey is approved, the contractor shall submit to the employer a complete detail schedule of all materials to be used in the line. Size and length of conductor etc. are also to be given in the list. This schedule is very essential for finalizing the quantities of all line material. The contractor shall furnish the same.

2.1.2.4 CHECK SURVEY

The contractor shall undertake the check survey during execution on the basis of the alignment profile drawing and tower schedule approved by the employer. If during check survey necessity arises for minor change in route to eliminate way leave or other unavoidable constraints, the contractor may change the said alignment after obtaining prior approval from the employer.

The contractor, while carrying out the check survey, shall peg mark the power position on ground conforming to the survey charts. In the process, it is necessary to have the pit centers marks according to the excavating marking charts to be

prepared by the contractor and approved by the employer. The levels up or down of each pit center with respect to the center of the tower location shall be noted and recorded for determining the amount of earth work required to meet the design. At the charting point of the route survey, an angle iron spite shall be driven firmly into the ground showing a little above the ground level.

2.1.2.5 WAY-LEAVE AND TREE CUTTING

Way-leave permission which may be required by the contractor shall be arranged at his cost. While submitting final-survey report for approval, proposals for way-leave right of way shall be submitted by the contractor. Employer may extend help to get the permission within a reasonable time as mutually agreed upon for which due notice shall be given by the contractor in such a way so that obtaining permission from appropriate authority do not hinder the continued and smooth progress of the work.

The employer shall not be held responsible for any claim on account of damage done by the contractor or his personnel to trees, crops and other properties.

The contractor shall take necessary precaution to avoid damage to any ripe and partially grown crops and in the case of unavoidable damage, the employer shall be informed and necessary compensation shall be paid by the contractor.

All the documents required for application to the statutory authorities must be prepared by the contractor & submission to the employer for Submission of the application towards approval of PTCC, Railway Crossing etc. However, the responsibilities lies with the contractor to get the clearance.

Trimming of tree branches or cutting of a few trees en-route during survey is within the scope of survey to be done by the contractor. Contractor shall arrange for necessary way-leave and compensation in this regard. During erection of the line, compensation for tree cutting, damage caused to crops, actual cutting and felling of the trees including way-leave permission for such route clearance shall be arranged by the contractor at his cost. The contractor will identify the number of trees and detail of obstructions to be removed for erection of the line and intimate the employer well in advance in case of any help. Other related works like construction of temporary approach roads, etc. as required, shall be done by the contractor and the same will lie within the scope of contractorôs work and such cost shall be considered to be included in the rates quoted by him.

While quoting the rate for detailed and check survey as per bidding activity schedule, the contractor shall include all costs involved in different activities described herein earlier.

2.0 SUB-SOIL INVESTIGATION

To ascertain soil parameters in various stretch inter, the contractor shall carry out sub-soil investigation through reputed soil consultant as approved by the employer.

2.1 SCOPE OF WORK

The scope of sub-soil investigation covers execution of complete soil exploration for the transmission line under this contract including boring, drilling, collection of undisturbed soil sample where possible, otherwise disturbed samples, conducting laboratory test of soil samples to find out the various parameters as detailed in this specification and submission of detailed reports in 6 copies along with specific recommendation regarding suitable type of foundation for each bore-hole along with recommendation for soil improvement where necessary.

2.1.1 QUALIFYING REQUIREMENTS OF SOIL CONSULTANTS

The soil consultants shall provide satisfactory evidence concerning the following as and when asked for.

That, he/they has/have adequate technical knowledge and previous practical experience in carrying out complete soil investigation jobs in any kind of soil.

That he/they has/have well equipped, modernized soil testing laboratory of his/their own. If asked for by the employer, the contractor shall arrange inspection of such laboratory of the soil consultant by the representative of the employer.

If in the opinion of the employer, the soil consultant (proposed by the contractor) is not well equipped or capable to undertake the sub-soil investigation job relating to this contract, then such soil consultant shall not be engaged to undertake the job. In that case, they shall have to engage other agency as will be approved by the employer.

2.1.3 TEST BORING

The boring shall be done at the major locations/crossing, special towers. However, it is desirable that there should be at least one sub-soil investigation bore-hole for the line. Such locations for sub-soil investigation shall be selected and finalized in consultation with the employer.

The test boring through different layers of all kinds of soil shall have to be carried out by the contractor through the approved soil consultant as briefed hereunder.

(a) Method of boring, selection of sampling tubes, sampling, recording of boring, protection, handling, leveling of samples shall be done as specified in IS: 1892/1977, if any, after obtaining approval from the employer. The contractor/consultant shall furnish in the soil report in details, the equipment and method of boring actually adopted.

(b) Depth of boring below ground level shall be 15 M. only unless continuous bedrock is encountered earlier. In case rock is encountered at any depth within 15 M. adequate study of rock and assessment of strength characteristics shall be done and recommendation shall be given.

(c) Undisturbed soil samples shall be obtained for the initial 4M depths at every 1.5M interval and at change of strata. After these initial 4M depths, samples shall be obtained preferably at every 3M or where there is a change of strata, or as advised by the employer.

(d) In case collection of undisturbed samples becomes difficult/impossible detailed soil testing on remoulded soil samples is to be considered and reported in the soil report.

(e) Standard penetration test as per IS: 2131 with latest amendment shall have to be conducted in different strata and recorded properly.

(f) The ground water table shall be recorded during boring operation and incorporated in the bore log. If possible, the position of the water table just after monsoon period be ascertained from local people and indicated in the report.

(g) Plate Load test shall have to be conducted at special tower location.

3.0 LABORATORY TESTS OF SOIL SAMPLES

The method and procedure of testing of soil sample to be followed shall be as per relevant IS codes. Adequate volume of test samples shall be collected from site. Ample shall be properly sealed immediately after recovery as specified in relevant IS code and transported carefully to laboratory for carrying out necessary laboratory tests to find out the following parameters of every samples. Data and time of taking of the sample shall be recorded in the test report.

(a) Natural moisture content, Liquid limit, Plastic limit and Plasticity index.
(b) Bulk, dry and buoyant density of soil.
(c) Void ratio (e-long P curve shall be submitted)
(d) Specific gravity.
(e) Grain size distribution (Sieve analysis and hydrometer analysis)
(f) Tri-axial and consolidation tests (consolidation undrained and consolidated drained as and when application in table, graph and drawing.
(g) Permeability tests
(h) Chemical tests for both water and soil samples at different layers.
(i) Evaluation of safe bearing capacity at different strata for square footings shall be done for a maximum value of 25-mm. settlements.
(j) At depts. From 3M to 10M be different strata.
(k) Factor of safety shall be considered as 3 for evaluation of safe bearing capacity of soil.
(l) Unconfined compression test for cohesive soil (=0) if encountered.

3.1 REPORT ON SUB-SOIL INVESTIGATION

The contractor shall make analysis of soil samples and rock cores as collected by him in the field and approved by the employer as collected by him in the field and approved by him in the field and approved by the employer as well as field tests and laboratory tests. A comprehensive report shall have to be prepared by him,

finally incorporating all the data collected in proper tabular forms or otherwise along with the analysis.

The 3(three) copies of report in the draft form shall be submitted for employerôs approval. 6(six) copies of final report incorporation employerôs comments, if any shall be submitted within 3(three) weeks after completion of this work.

Recommendations shall include but not be limited to the following items (a) to (p)

(a) Geological information of the region.
(b) Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.
(c) Procedure of investigations employed and field and field as well as laboratory test results.
(d) Net safe bearing capacity and settlement computation for different types of foundations for various widths and depths of tower and building.
(e) Recommendations regarding stability of slopes, during excavations etc.
(f) Selection of foundation types for towers, transformers and buildings etc.
(g) Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata etc.
(h) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how the soil/rock strata are varying vertically and horizontally.
(i) Modulus of sub grade reaction from plate load test for pressure ranging up to 6 kg/cm. The recommended values shall include the effect of size, shape and depth of foundations.
(j) Deformation modulus from plate load test in various test depth/stratification.
(k) Coefficient of earth pressure at rest.
(l) Depth of ground water table and its effect on foundation design parameters.
(m) Recommendations regarding stability of slopes, during shallow excavation etc.
(n) Whether piles are necessary or not. If piles are necessary, recommendation of depth, diameter and types of piles to be used.
(o) Recommendations for the type of cement to be used and any treatment to the underground concrete structure based on the chemical composition of soil and sub-soil water.

3.1.2 MEASUREMENT OF SOIL RESISTIVITY

For the purpose of grounding design, soil resistance measurement shall be taken in the locations as stated under clause 1.0 above and based on which the value of soil resistance shall be derived.

Wennerôs four (4) electrode method shall be used for earth resistance measurement in accordance with the procedure and the calculation detailed in IS:3043 1987. At least 8(eight) test direction shall be chosen from the center of the locations to cover the whole site.

The employer reserves the right to carry out separate soil investigation at his cost by engaging a separate agency for cross checking the result obtained by the contractor.

In case the results are at variance, the soil parameters to be adopted for final design will be at the sole discretion of the employer and such will be binding upon the contractor.

IMP:-The material and services covered under these specifications shall be performed as per requirements of the relevant standards and codes referred hereinafter against each set of equipment and services. In case of a conflict between such codes and/or standards and the Specifications, the latter shall govern. Other Internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

SL. No.	Indian Standards	Title	International & Internationally recognised Standards.
1.	2.	3.	4.
1.	IS 209-1979	Specification for Zinc	ISO/R/752-1968 ASTM B6
2.	IS 226-1975	Structural steel (Standard quality)	ISO/R/630-1967 CAN/CSA G40.21 BSEN 10025
3.	IS 269-1976	Ordinary rapid hardening and low heat Portland cement.	ISO/R/597-1967
4.	IS 383-1970	Coarse and fine aggregates from natural sources for concrete.	CSA A23.1 /A23.2
5. a)	IS 398-1982 Part-I	Specification for aluminium conductors for overhead transmission purposes	IEC 1089-1991 BS 215-1970
b)	IS 398-1982 Part-II	Aluminium conductor galvanised steel reinforced	BS 215-1970 IEC 1089-1991
c)	IS 398-1994 Part-IV	Aluminium alloy stranded conductor	BS 3242-1970 IEC 1089-1991 ASTM 8393M86
d)	IS 398-1982 Part-V	Aluminium conductor galvanised steel reinforced for Extra High Voltage (400kV	BS 215-1970 IEC 1089-1991

		and above)	
6.	IS 278-1978	Specification for barbed wire.	ASTM A 121
7.	IS 406-1964	Method of chemical analysis of Zinc slab	
8.	IS 432-1966 (Part 1 & 11)	Mild steel and medium tensile bars and hard drawn steel wire for concrete reinforcement.	BS 4449 CSA G-30. BS 4482
9.	IS 456-1978	Code of practice for plain and reinforced concrete.	ISO 3893-977
10.	IS 731-1971	Porcelain insulators for overhead power lines with nominal voltage greater than 1000 Volts.	BS 137-1982 (Part-I & II) IEC 383-1993 (Part-I& II)
11.	IS 800-1962	Code of practice for use of structural steel in general building cons-ruction.	CSA S 16.1 BS 5950
12.	a) IS 802-1995 (Part-I/Sec.I) (Part-I/Sec.II) -1992	Code of practice for use of structural steel in overhead transmission Line: materials, loads and permissible stresses.	IEC 826 ANSI/ASCE 10-90 (1991) BS 8100
	b) IS 802-1978 (Part-II)	Code of practice for use of structural steel in overhead transmission line: Fabrication, galva-nising, inspection and packing.	ANSI/ASCE 10-90 (1991)
	c) IS 802-1978 (Part-III)	Code of practice for use of structural steel in over-head transmission line towers: Testing.	ANSI/ASCE 10-90 (1991) IEC 652
13.	IS 1139-1966	Hot rolled mild steel, medium tensile steel and high yield strength deformed bars for con-crete reinforcements.	CAN/CSA G30.18 ASTM A615 BS 4449
14.	IS 1367-1967	Technical supply conditions for threaded fasteners	

15.	IS 1489-1976	Portland pozzolena cement.	ISO/R 863-1968
16.	IS 1521-1972	Method of tensile testing of steel wires	ISO 6892-1984
17.	IS 1573-1976	Electroplated coating of zinc on iron and steel	
18.	IS 1786-1966	Cold twisted steel bars for concrete reinforcement.	
19.	IS 1778-1980	Reels and drums for bare conductors	BS 1559-194
20.	IS 1893-1965	Criteria of earthquake resistant design of structures.	IEEE 693
21.	IS 2016-1967	Plain washers	ISO/R 887-1968. ANSI B18.22.1
22.	IS 2071 Part-I-1974 Part-II-1974 Part-III-1976	Method of high voltage testings	IEC 60
23.	IS 2121	Specification for conductor and earthwire accessories for overhead power lines.	
	a) Part-I -1981	Armour rods, binding wires and tapes for conductors.	
	b) Part-II -1981	Mid-span joints and repair sleeve for conductors.	
	c) Part-III-1992	Accessories for earthwire.	
	d) Part-IV-1991	Non-tension joints.	
24.	IS 2131-1967	Method of standard penetration test for soils.	ASTM D 1 883
25.	IS 2551-1982	Danger notice plates	
26.	IS 2486	Specification for insulator fittings for overhead power lines with a nominal voltage greater than 1000 Volts.	
	Part-I	General requirements and tests.	BS 3288 IEC 1284
	Part-II	Dimensional requirements	IEC 120-1984
	Part-III	Locking devices	IEC 372-1984
27.	IS 2629-1966	Recommended practice for hot dip galvani-sing of iron and steel.	ASTM A123 CAN/CSA G 164 BS 729
28.	IS 2633-1972	Method of testing uniformity of coating	ASTM A123 CAN/CSA G164

		of zinc coated articles.	
29.	IS 3043-1972	Code of practice for earthing(with amend-ment No.1 and 2).	
30.	IS 3063-1972	Single coil rectangular section spring washers for bolts nuts, screws.	DIN 127-1970
31.	IS 3188-1965	Dimensions for disc insulators.	IEC 305-1978
32.	IS 4091-1967	Code of practice for design and construction of foundation for trans-mission line towers and poles.	ASCE/IEEE 691
33.	IS 4826-1979	Galvanised coating on round steel wires.	IEC 888-1987 BS 443-1982
34.	IS 5358-1969	Hot dip galvanised coat-ings on fasteners.	CAN/CSA G 164 ASTM A153
35.	IS 5613 (Part-II/Sec-1) -1985 (Part-III/Sec.1) -1989	Code of practice for design, installation and maintenance of overhead power lines (Section-I: Designs)	ANSI/ASCE 10-90(1991)
36.	IS 5613 (Part-II/Sec-2) -1985 (Part-III/Sec.2) -1989	Code of practice for design, installation and maintenance of overhead power lines (Section 2: Installation and maintenance)	
37.	IS 6610-1972	Specification for heavy washers for steel structures.	
38.	IS 6639-1972	Hexagonal bolts for steel structure.	ISO/R 272-1968 ASTM A394 CSA B33.4
39.	IS 6745-1972	Methods for determination of weight of zinc coating of zinc coated iron and steel articles.	ASTM A90 ISO 1460
40.	IS 8263-1976	Method of radio interference tests on high voltage insulator	IEC 437-1973 NEMA 107-1964
41.	IS 8269-1976	Method of switching impulse tests on HV insulators.	IEC 506-1975
42.	IS 8500-1977	Specification for weldable structural steel (medium and high strength qualities)	BSEN 10025

43.	IS 9708-1980	Specification for Stock Bridge vibration dampers for overhead power lines.	
44.	IS 9997-1988	Aluminium alloy redraw rods	IEC 104-1987
45.		Hard drawn aluminium wires for overhead line conductors.	IEC 889-1987
46.		Thermal mechanical performance tests and mechanical performance tests on string insulator units.	IEC 575-1977
47.		Salt fog pollution voltage withstand tests.	IEC 507-1991
48.		Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric.	IEC 797-1984
49.		Guide for the selection of insulators in respect of polluted conditions.	IEC 815-1986
50.		Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 Volts.	IEC 383-1993 (Part I and II)
51.		Ozone test on elastomer	ASTM D-1171
52.	IS 1363	Hexagonal head bolts, screws and nuts of product Grade - C	
	Part - 1	Hexagonal head bolts	ISO 4016
	Part - 3	Hexagonal nuts	ISO 4034
53.	IS 1367	Technical supply conditions for threaded steel fasteners	
	Part III	Mechanical properties and test methods for bolts, screws and studs with full loadability	ISO 898-1
	Part VI	Mechanical properties and test methods for nuts with full loadability	ISO/DIS 898/II
		54.	Indian Electricity Rules - 1956
55.		Indian Electricity Act - 1910	
56.	IS 1498-1970	Classification and identification of soil for general engineering purposes	

57.	IS 1888-1982	Method of load test on soils		
58.	IS 1892-1979	Code of practice for subsurface investigation for foundation		
59.	IS 2911-1979 (Part-I)	Code of practice for design and construction of pile foundations		
60.	IS 4453-1980	Code of practice for exploration by pits, trenches, drifts and shafts		
61.	IS 6935-1973	Method for determination of water level in a bore hole		
62.	IS 8009-1976 (Part-I)	Code of practice for calculation of settlement of foundation subjected to symmetrical vertical loads (Shallow Foundation)		
63.	IS 2386-1963 (Part-3)	Methods of test for aggregates for concrete : Specific gravity, density, voids, absorption and bulking		
64.	IS 14000-1994	Quality management and quality assurance standards	ISO 9000-1994	
65.		GRIDCO Safety Manual (draft)-1997		
66.		Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V : Definition, test methods and acceptance criteria	IEC 1109-1992 ANSI C29-11 IEEE 987	

SUPPLY OF TOWER STRUCTURES FOR THE TRANSMISSION LINES

1.0 SCOPE

1.1 This specification provides for design, proto fabrication, galvanizing and delivery FOR (destination) of transmission line towers including super-structure stubs, tower extensions, stub-templates, tower accessories (Hangers, U-bolts, bird guards, anti-climbing devices), bolts and nuts, step bolts, flat and spring washers etc. as described hereinafter in this volume.

THE PRELIMINARY SURVEY WORK HAS ALREADY DONE AND THE FOLLOWING TOWERS HAVE BEEN DECIDED.

The contractor shall design the tower foundation and the concreting shall be done by M-20 grade concrete.

a) Wind effects:

Tower shall be designed for **reliability Level-I, Terrain category-I & Wind Zone-V** Design wind pressure on towers, conductors, earth wire and insulator string in the range of 30.45 mt. And above 45 mt. Height shall be computed as per IS-802(Part/Sec-I) 1995 Bidder shall furnish the maximum wind pressure adopted in their design against each component mentioned above.

b) Design Temperatures:

The following temperature range for the power conductor and ground wires shall be adopted for the line design:

(i) Minimum temperature: 5 deg. C

(ii) Everyday temperature of conductor: 32 deg. C

(iii) Maximum temperature of :

a) Conductor:ACSR 75 deg. C for ACSR

Moose/Zebra/Panther 90 deg. C for AAAC.

(**Double Moose conductor in 400 KV system)

b) Ground wire exposed to sun. 53 deg. C

The above values are subject to latest revision if any made in IS-802 (part-I/Sec-I) 1995

Maximum Tension:

Maximum tension shall be based on either:

a) at 5 deg. C with 2/3rd. full wind pressure or Conform to IS 802-1995

b) at 32 deg. C with full wind pressure whichever is more stringent. Part-I/Sec-I-Clause No.10.3

Factors of Safety & Span details:

Factor of Safety: Should conform to IS-802 Part-I-1995

Normal span: The normal span of the ine shall be 350 meters of 220KV and 320 meters for 132 KV.

Wind & Weight Span:The wind and weight span to be adopted in the design of the structures shall be as follows:

(i) Wind span: The wind span is the sum of the two half spans adjacent to the support under consideration. In case of towers located on a perfectly horizontal terrain,

this shall be the normal span. For design purpose the wind on conductor shall be calculated on a wind span of at least 1.1 times the normal span.

Weight Span: The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. All C and D type towers shall be designed for uplift spans (minimum weight spans in the following table) also. These are applicable both for pointed and square cross arms.

For details of cross arms and towers , the span limits given below shall prevail.

Tower type.	400KV/220 KV				132 KV			
	Normal condition.		Broken wire condition.		Normal condition.		Broken wire condition.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A/DA & B/DA	525	100	315	100	500	100	300	100
C/DC & D/DD	600	100	360	100	500	100	300	100

1.1.1 The design of towers and their extensions shall be done conforming to the design parameters specified herein, the scope of design also includes supply of design calculation for towers and extensions including detailed structural/shop drawings of towers extensions and stub setting templates. The bidder, who has already type tested the various tower viz: 0-2ę, +3, +6; 0-15ę, +3, +6; 0-30ę, +3, +6; 0-60ę, +3, +6 (400/220/132 KV) in any nationally or internationally recognized laboratories, and conforming to our specification, may also offer the same.

1.1.2 STANDARDS

Except as modified in this specification, the material and work covered under this specification, shall conform to the latest revision with amendments thereof of the following of Indian Standards and equivalent International Standards whenever indicated below.

Sl. No.	Bureau of Indian standards (BIS)	Title	International & Internationally recognized standard
1.	IS:209	Specification for Zinc	ISO/R/752
2.	IS: 2062	Structural steel (Standard quality)	ISO/R/660
3.	IS: 432	Mild steel and medium tensile bars and for concrete reinforcement	BS-785CSA-G-30
4.	IS: 802	Code of practice for use of structural steel in overhead transmission line Part-I/Section-I & Section2: Load and permissible stresses Part-II: Fabrication Galvanizing Inspection and Packing	
		PART-III: TESTING	
5.	IS: 1367	Technical supply conditions for threaded fasteners	
6.	IS: 1893	Criteria of Earthquake resistant design structures	
7.	IS: 2016	Plain washers	ISO/R/987
8.	IS: 2551	Danger Notice Plates	
9.	IS: 2629	Recommended practice for hot dip galvanizing of iron and steel	
10.	IS: 2633	Method of testing uniformity of casting of zinc coated articles	
11.	IS: 3063	Single coil rectangular section spring washers for bolts, bolts, screws	DIN-127
12.	IS: 5358	Hot dip galvanized coatings on fasteners	
13.	IS:5613 Part-1 & 2 Of Section-I	Code of Practices for design, installation & maintenance of overhead power line	

14.	IS: 6610	Specification for heavy washers for stell structures.
15.	IS: 6745	Methods of determination of weight of zinc coating of zinc coated iron and steel articles.
16.	IS: 12427	Hexagonal bolts for steel structures
17.		INDIAN ELECTRICITY RULES 1956
18.		Publication for Regulation for electrical crossing or railway tracks

1.1.3 The standards mentioned above are available from

Reference/ Abbreviation	Name and Address from which the Standards are available
IS	BUREAU OF INDIAN STANDARDS Manak Bhavan, 9, Bahadur Shah Zafar Marg, NEW DELHI(India)
ISO	INTERNATIONAL ORGANISATION FOR STANDARDISATION, Danish Board Standardisation, Danish Standardisening Street, Aurehoegbvej-12, DK-2900, Helleprup, DENMARK
CSA	CANADIAN STANDARD ASSOCIATION 178, Rexdale Boulevard, Rexdale, Ontario, CANADA M9W IR
BS	BRITISH STANDARDS British Standard Institution, 101, Pentonvile Road, N-19-ND-UK
DIN	DEUTSCHES INSTITUTE FIIR NOR Gurggrafenstrasse 5-10 Post Fach 1107 D-1000, Berlin ï 30
INDIAN ELECTRICITY RULES 1956, REGULATION FOR	KITAB MAHAL Baba Kharak Singh Marg,

1.1.4 PRINCIPAL PARAMETERS

1.1.5 Electrical System Date:

a)	System voltage (kV rms)	400/220/132
b)	Max. voltage (kV rms)	420/245/145
c)	Lightning impulse withstand voltage (dry & wet) (kVp)	1550/1050/650
d)	Power frequency withstand voltage (wet) (KV rms)	630/395/275
e)	Short circuit level (KA for 1 sec.	40/40/31.5

1.1.6 Line data /

1.1.7 Conductor

a)	Name	ACSR Zebra	ACSR Moose	ACSR Panther
b)	Strength & wire dia			
i)	Aluminium	54/3.18	54/3.53	30/3.00
ii)	Steel	7/3.18	7/3.53	7/3.0
c)	Conductors per phase 1) 400 KV 2)220 KV 3)132 KV	Single	Double	Single
d)	Spacing between the conductors of same phase (sub-conductor spacing) (mm)	----	As per standard	----
e)	Inter-phase spacing (mm)	8,400	8,400	6800
f)	Configuration			

i)	Single circuit	Delta	Delta	Delta
ii)	Double circuit	Vertical	Vertical	Vertical
g)	Nominal Aluminium area (mm²)	420	528.5	212.1
h)	Section area of Aluminium (mm²)	428.90	597	261.5
i)	Total sectional area (mm²)	484.50	597	262
j)	Calculated resistance at 20 c (Max.) ohm/km per conductor	0.06915	0.05552	0.140
k)	Approx. calculated breaking load (KN)(Minimum)	130.32	161.2	89.67
l)	Modulus of elasticity (GN/M²)	69	69	82
m)	Co-efficient of linear exp. Per degree cent.	$19.3X10^{-6}$	$19.3X10^{-6}$	$17.8X10^{-6}$
n)	Mass of zinc in gms/sqm	é é é é é é	275é é é é é é	
o)	Overall diameter (mm)	28.62	31.77	21.00
p)	Weight (kg/km)	1621	2004	974
q)	Minimum ultimate tensile strength (KN)	130.32	161.2	89.67
r)	Conductor tension at 32ę C without external load			
i)	Initial unloaded tension	é é é é é é	..35%é é é é é é	
ii)	Final unloaded tension	é é é é é é é	25%é é é é é .	

1.1.8 Galvanized Steel Ground Wire

a)	Size (no. of strands/strand dia)	7/3.15 for 132 and 220 KV, and 7/3.66 for 400 KV
b)	Overall diameter (mm)	9.45(7/3.15) and 10.98(7/3.66)

c)	Standard weight (Kg/km)	432(7/3.15) and 583(7/3.66)	
d)	Location of ground wire	One continuous ground wire Wire to run horizontally on the top of the towers for 132 and 220 KV and two ground wire for 400 KV lines.	
e)	Tensile load in each ground wire (to be furnished by the Bidder)		
i)	At min. temp. of 5ę C and in still air (kgs)		
ii)	At every day temp. of 32ę C and still air (kgs)		
iii)	At 5ę C and 2/3rd of full wind (kgs)		

1.1.8.1 Towers

a)	Span lengths in metres	ACSR Zebra	ACSR Moose	ACSR Panther
i)	Ruling design span	300	300	250
b)	Wind load (kg/sqm) on conductor	52	52	52
c)	Shielding angle with vertical	20ę	20ę	20ę
d)	Towers to be designed for heavy wind zone	V-zone	V-zone	v-zone

1.1.8.2 Insulator Strings(Disc)(Antifog type)

Sl. No.	Particulars	Single Suspension string	Double suspension string	Single Tension string	Double Tension string
1.	No. of standard Discs (nos)				
	1) 400 KV	1X25	2X25	1X25	2X25
	2) 220 kV	1X15	2X15	1X15	2X15
	3) 132 Kv	1X10	2X10	1X10	2X10
2.	Size of Disc (400kv/220kV/132 kv)	280x145/ 255X145/ 255X145	280x145/ 255X145/ 255X145	305x170/ 305x170/ 280x145	305x170/305x170/280x145
3.	Electromechanical strength (KN)	120/90/90	120/90/90	160/160/120	160/160/120

(400 KV/220 kV/132 KV)

4.0 GENERAL TECHNICAL REQUIREMENTS

4.1 Tower Design ï General

The employer is looking for a structurally safe design of transmission line towers to be installed on EHV lines keeping the loadings and line parameters detailed in this specification and in compliance with IS: 802 (Part-1/Sec-1)-1995, IS: 802(Part-1/Sec-2)-1992.

The Bidder may offer economical designs with rational sections or offer towers of recent design, proven in service and accepted by other reputed Central and State Sector Utilities and by OPTCL (Previously OSEB) confirming to this technical specification.

The technical particulars for vibration analysis and damping design of the system are as follows:

FOR 400kV LINES.

SL. No.	Description	Technical Particulars
1.	Configuration	Double Circuit Twin ACSR Moose 54/7//3.53 mm, conductor bundle per phase in horizontal formation and all three phases of each circuit in vertical configuration on each side of tower.
2.	Span length in meters	
	(i) Ruling design span	400 meters
	(ii) Maximum span	1100 meters
	(iii) Minimum span	100 meters
3.	Tensile load in each sub-conductor for ruling span	Wind Zone : 5 (50 m/s).
	a) At temperature of 5 deg-C and still air	3267 Kgf.
	b) At temperature of 5 deg.C and 36% full wind	4646 Kgf.
	c) At temperature of 32 deg.C and full wind	7805 Kgf.

4.	Armour rods used	Standard preformed armour rods/AGS
5.	Maximum permissible dynamic strain	+/- 150 micro strains

FOR 220 kV and 132 kV LINES

SL.NO.	Description	Technical Particulars	
		220kV **ACSR ZEBRA** 54/7/ 3.18mm	132kV **ACSR PANTHER** 30/7/3.0mm
1.	Configuration	Double Circuit Single ACSR conductor per phase in verti-cal formation	Double Circuit Single ACSR conductor per phase in verti-cal formation
2.	Span length in metres		
	(I) Ruling design span	350 metres	300 metres
	(ii) Maximum span	1100 metres	1000 metres
	(iii) Minimum span	100 metres	100 metres
3.	Tensile load in each conductor for ruling span	Wind Zone:5 (50 m/s.)	Wind Zone:5 (50 m/s.)
	a) At temperature of 5 deg.C and still air	2919 Kgf.	1791Kgf.
	b) At temperature of 5 deg.C and 36% full wind	4090 Kgf.	2735Kgf.
	c) At temperature of 32 deg-C and full wind	6551 Kgf.	4469 Kgf.
4.	Armour rods used	Standard performed armour rods/AGS	Standard performed armour rods/AGS
5.	Maximum permissible dynamic strain	± 150 micro-strains	± 150 micro-strains

4.0 **DETAILS OF SOLID CORE LONG ROD INSULATORS**:

5.1 The insulator shall consist of standard-discs for a three-phase 50 Hz effectively earthed 220 KV transmission system heavily polluted atmosphere. The insulator shall be ball and socket type.

5.1 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanically strength and mechanical strength of insulator string alongwith hardware shall be as follows:

Sl. No.	Type of string.	Size of long rod insulator (mm)/(Unit) 132/220 KV	Minimum creepage distance (mm) 132/220 KV	No.of unit 132/220 KV)	Electromechanical strength of insulator (KN) 132/220 KV)
1.	Single suspension	200X 1305 /210X2030	4000 / 6125	'1/2	90 KN
2.	Double suspension	-do-	-do-	'2/4	90 KN
3.	Single tension.	205 X 1450 / 215X2550	4300/7130	'1/2	120 KN/160 KN
4.	Double Tension.	-do-	-do-	'2/4	120 KN/160 KN

5.0 **SPECIFICATION DRAWINGS**:

6.1 A list of specification drawings in respect of the long rod insulators indicated above is given at Annexure-II. These specification drawings are attached herewith for information and guidance of the bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and shall be distinct and separate from these specification drawings.

6.0 **GENERAL TECHNICAL REQUIREMENT**:

7.1 **PORCELAIN**:

The porcelain used in the manufacture of the shell shall be ivory white, nonporous of high dielectric, mechanical and thermal strength free from internal stress blisters and thermal strength from internal stresses blisters, laminations, voids, foreign matter. Imperfections or other defects, which might render it in any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid alkalis, and zinc of dust. The manufacturing shall be by the wet process and impervious character obtained by through vetrification.

7.2 **PORCELAIN GLAZE**:

Surfaces to come in contact with cement shall be made rough by stand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of the glaze shall be uniform throughout and the colour of the glaze shall be brown. The glaze shall have a visible luster and smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain

under compression on the porcelain body throughout the working temperature range.

7.3 METAL PARTS:

7.3.1 Cap and Ball pins:

Twin Ball pins shall be made with drop forged steel and caps with malleable cast iron. They shall be in one single piece and duly hot dip g galvanized. They shall not contain parts or pieces joined together, welded, shrink fitted or by any other process from more than one piece of material. The pins shall be of high tensile steel, drop forged and heat malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity with minimum of 6 dips. The bidder shall specify the grade, composition and mechanical properties of steel used for caps and pins.

7.3.2 **SECURITY CLIPS**:

The security clips shall be made of phosphor bronze or of stainless steel.

7.4 **FILLER MATERIAL**:

Cement to be used as a filler material shall be quick setting, for curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contract with it and its thickness shall be as small and as uniform as possible.

7.0 **MATERIAL DESIGN AND WORKMANSHIP**:

8.1 **GENERAL**:

i) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw materials quality control and to stage testing quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

ii) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion good finish, elimination of sharp edges and corners to limit corona and radio interference voltage

8.2 **INSULATOR SHELL**:

The design of the insulator shell shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

8.3 **METAL PARTS**:

a) The twin ball pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces

concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the insulator or is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

b) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting parts or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly. Pins shall not show any macroscopically visible cracks, insulations and voids.

8.4 **GALVANIZING**:

All ferrous parts shall be hot dip galvanized six times in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.5 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from impurities such as flux ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

8.4.1 **CEMENTING**:

The insulator design shall be such that the insulating medium shall not directly engage with hard metal. The surfaces of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials.

8.5 SECURITY CLIPS (LOCKING DEVICES

The security clips to be used as locking device for ball and socket coupling shall be of Rôshaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for sore adding after installation to prevent complete withdrawal from the socket. The locking device shall be resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation when placed in position and under no circumstances shall it allow separation of insulator units and fitting of Wôtype security clips are also acceptable. The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked position shall not be less than 50 N (5 Kgs.) or more than 500N (50 Kgs.)

8.6 **BALL AND SOCKET DESIGNATION**:

The dimensions of the balls and sockets for 80 KN long rod insulators shall be of 16mm and for 120 KN shall be of 20mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-III).

8.7 DIMENSIONAL TOLERANCE OF INSULATORS DISCS

It shall be ensured that the dimensions of the long rod insulators are within the limits as per relevant IEC/ISS.

Bundle spacer (only for 400kV lines)

Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors.

The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

The placement chart shall be provided for spans ranging from 100m to 1100m. The number of spacers recommended for a nominal ruling span of 400m shall however be not-less than six.

The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the Bid.

Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm. Bidder shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers. For slack span also rigid spacers shall be used with maximum spacing of 30 metres.

The spacer offered by the Bidder shall satisfy the following requirements:

Spacers shall restore normal spacing of the subconductors after displacement by wind, electromagnetic and electrostatic forces under all operating conditions, including the specified short circuit level, without permanent deformation or damage either to conductor or to the assembly itself. They shall have uniform grip on the conductors.

For spacers requiring preformed retaining rods, the retaining rods shall be designed for the specified conductor size. The rods shall be made of high strength special aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The ends of retaining rods shall be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.

Four rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall 7.87 +/- 0.1 mm. and the length of the rods shall not be less than 1100 mm.

Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert shall be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded. Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened. The clamp grooves shall be in uniform contact

with the conductor over the entire clamping surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material, which may cause damage to the conductor when the clamp is installed. For the spacers involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation. Universal type bolted clamps, covering a range of conductor sizes will not be permitted. No rubbing, other than that of the conductor clamp hinges or clamp swing bolts shall take place between any parts of the spacer. Joints incorporating a flexible medium shall be such that there is no relative slip between them.

The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service. Rigid spacers shall be acceptable only for jumpers. The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance. The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep. The spacer assembly shall not have any projections, cuts, abrasions or chattering parts which might cause corona or RIV. The spacer tube shall be made of aluminium alloy of type 6061 or equivalent aluminium alloy. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacers involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 amps., 50 Hz alternating current per subconductor. Elastomer, if used, shall be resistant to the effects of temperature up to 85 deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.

The spacer assembly shall have complete ease of installation and shall be capable of removal and reinstallation without any damage. The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.

Spacer damper (only for 400kV lines)

As an alternative to vibration dampers and bundle spacers combination, suitable spacer dampers for twin bundle AAAC 61/3.45 conductor may be offered. The spacer damper covered by this Specification shall be designed to maintain the bundle spacing of 450mm under all normal operating conditions and to effectively control aeolian vibrations as well as subspan oscillations to nominal conductor spacing after release of any external extra-ordinary load.

The spacer damper shall restore the normal subconductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.

The design offered shall be presented as a system consisting of a recommended number of spacer dampers together with their spacing schedule for spans ranging from 100m to 1100 m.

Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line in order to

prevent damage to conductor at suspension clamps, dead end clamps and at the spacer clamps.

The spacer damper system shall also control the sub span oscillations in order to prevent conductor damage due to chafing and due to severe bending stresses at the spacer damper clamps as well as suspension and dead end clamps and to avoid wear to spacer damper components.

The spacer damper shall consist of a rigid central body called the frame, linked to the conductors by two articulated arms terminated by suitable clamping system. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.

The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.

The clamp of the spacer damper, when installed, shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation. The slip strength of the clamp shall be maintained between 2.5kN to 5kN. The tightening torque for the bolts, if applicable, shall be specified by the manufacturer to achieve the above slip strength.

Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices using small loose components shall not be accepted.

Bolts and nuts shall be of mild steel, stainless steel, or high strength aluminium alloy in accordance with the design of the spacer damper.

Where elastomer surfaced clamps are used, the elastomer elements shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.

If clamps involving preformed rods are used, these rods shall be designed for specific conductor size. They shall be made of high strength aluminium alloy of type 6061 or equivalent aluminium alloy having a minimum tensile strength of 35 kg/sqmm. The rods shall be ball ended. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service.

The spacer damper body shall be cast/forged from suitable high strength corrosion resistant aluminium alloy. The aluminium alloy shall be chosen in relation with the process used. However a combination of aluminium alloy and steel shall also be accepted.

The rubber components like damping elements involved in the design shall be made with rubber compound selected specifically for that particular application. The Bidder shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable ASTM or other Internationally recognised standards.

The rubber compounds used shall have good resistance to the effects of temperature up to 85 deg.C and to ultra violet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

The spacer damper involving ferrous material shall not have magnetic power loss more than one watt at 600 amps., 50 Hz alternating current per sub conductor.

The spacer damper assembly shall have electrical continuity. The electrical resistance between the subconductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.

The spacer damper assembly shall have complete ease of installation and shall be capable of removal and reinstallation without any damage.

The spacer damper assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.

The Bidder shall recommend the spacing between spacer dampers on the line which shall ensure the most satisfactory fatigue performance of the line as specified. The scheme shall indicate the number of spacer dampers per phase per span and the sub-span lengths to be maintained between spacer dampers when installed on the twin bundle conductors.

The number of spacer dampers and their spacing shall be provided for spans ranging from 100 to 1100m. The number of spacer dampers for a nominal ruling span of 400 m shall be not less than six.

No sub-span shall be greater than 70m and no end sub-span shall be longer than 40 metres.

The proposed scheme shall be such that the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent sub-spans for oscillations of sub-span mode and to ensure bundle stability for wind speeds up to 30 kms/hr (8.33 m./sec.).

The Bidder shall furnish all the relevant technical documents in support of the staggering scheme recommended for the spacer damper.

The Bidder in the latter case shall forward documentation of proto type tests conducted and acceptance given by the user authorities as also performance report for such towers in service.

Vibration dampers

All the requirements for vibration damper suitable for line conductors, shall also be applicable for galvanised steel earthwires (7/3.66mm. for 400kV and 7/3.15mm. for 220kV/132kV lines). Minimum one damper on each side per earth wire at suspension point and two dampers on each side at tension point shall be used for ruling design span. Bidders may offer damping systems involving a greater number of dampers for ruling design span; however, suitable price compensation shall be considered for evaluation.

The vibration analysis of the system, with and without dampers, dynamic characteristic of the damper as detailed shall be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows :

For 400kV Lines

Sl. No.	Description	Technical Particulars

1.	Configuration	Two galvanised steel earthwires in horizontal configuration
2.	Span length in meters	
	Ruling design span	400 meters
	Maximum span	1100 meters
	Minimum span	1 00 meters
3.	Tensile load in each earthwire for ruling span	Wind Zone : 5 (50m/s)
	a) At temperature of 5^{o} C and still air	1368 Kgf
	b) At temperature of 5^{o} C and 36% full wind	2056 Kgf
	c) At temperature of 32^{o} C and full wind	3593 Kgf
4.	Maximum permissible dynamic strain	+/- 150 micro strains

For 132kV and 220kV Lines

Sl. No.	Description	Technical Particulars	
1 .	Configuration	One galvanised steel earthwire in horizontal configuration .	
2.	Span length in meters	220 kV Line	132 kV Line
	Ruling design span	350 meters	300 meters
	Maximum span	1100 meters	1000 meters
	Minimum span	100 meters	100 meters
3.	Tensile load in each earthwire for ruling span	Wind Zone:5 (50m/s)	Wind Zone:5 (50m/s)
	a) At temperature of 5 deg.C and still air	1120 Kgf.	1120 Kgf.
	b) At temperature of 5 deg.C and	1667 Kgf.	1606 Kgf.

36% full wind		
c) At temperature of 32 deg.C and full wind	2815 Kgf.	2625 Kgf.
4 . Maximum permissible dynamic strain	+/- 150 micro strains	+/- 150 micro strains

Flexible copper bond

At suspension and tension towers the earth wire suspension and tension clamps shall be securely bonded to the tower steelwork by means of a multi-strand flexible copper bond wire. The copper bond shall be sufficiently flexible to allow movement of the suspension clamp under all operating conditions and terminated with compression lugs.

The flexible copper bond shall be of nominal 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as seven stranded ropes, each of 37 bunched wires. The tinning shall be as per IS 9567. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia. bolt. The complete assembly shall also include one 16 mm dia., 40 mm long mild steel bolt hot dip galvanised with nut and lock washers

Arcing horn

The arcing horn shall be either ball ended rod type or tubular type and shall be formed from galvanised mild steel and of approved types. The arcing horns shall be attached in an approved manner to all suspension and tension insulator sets. The horns shall be attached to the insulator fittings, but not directly to conductor clamps or to the caps of insulator units. The design of the arcing horns shall be such as to reduce, as far as reasonably possible, damage to the line conductors, clamps, insulator strings and arcing horns themselves under all flashover conditions. The general shape and method of attachment of the live end arcing horn shall also not restrict the replacement of insulators under live line conditions.

The total effective arcing distance shall be 1530mm., 2130mm. and 3050 mm. for 132kV, 220kV and 400kV respectively under nominal dimensions of insulator.

Arcing horns shall be provided on tower and/or line side as indicated on the enclosed string sketches, however, same has been tabulated below for ready reference :

SL.No.	Voltage Level	Types of Strings	Arcing horns to be provided on	Min. Arcing dist. to be maintained(mm)
1.	2.	3.	4.	5.
1.	132kV and 220kV	Single or suspension strings	Line side only	1530(for132kV)& 2130(for 220kV)
2.	-do-	Double suspension strings	Both on line side and tower side	1530(for132kV)& 2130(for 220kV)

3.	-do-	Single tension strings	Line side only	-do-
4.	-do-	Double tension strings	Both on line side and tower side	-do-
5.	400kV	Single suspension and pilot strings	Tower side (corona/grading rings on line side)	3050
6.	-do-	Double suspension strings	-do-	-do-
7.	-do-	Single tension strings	-do-	-do-
8.	-do-	Double tension strings	-do-	-do-

4.1.1 Transmission Towers

4.1.2 General Description

The towers shall be of the following types:

(b) Double Circuit (A, B, C & D)
(c) Special Towers (River Crossing, Railway Track Crossing, Power Line Crossing etc.)

Types Of Towers

The towers shall normally be of the following standard types, and as stated in Schedule C.

Type of Tower (1)	Deviation Limit (2)	Typical Use (3)
DA/OA/PA	0deg- 2deg	a) To be used as tangent tower with suspension strings. b) Also to be designed for specified broken wire conditions.
DB /0B/PB	0 deg- 15deg	a) Angle towers with tension insulator string b) Also to be designed for unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m

		(for 220kV) and of 300m and 200m (for 132kV)on each side of the tower. c) Also to be designed for uplift forces resulting from an up-lift span of 200m under broken wire conditions. d) Also to be designed for specified broken wire conditions. e) Also to be designed for anti-cascading condition.
DB/OB/PB tower.	0 deg.	f) To be used as section
DC/OC/PC	15 deg-30 deg.	a) Angle tower with tension insulator strings. b) Also to be designed for unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m and 200m (for 132kV)on each side of the tower. c) Also to be designed for uplift forces resulting from an up-lift wire span of 200m under broken conditions. d) Also to be designed for specified broken wire conditions. e) Also to be designed for anti-cascading condition.
DC/OC/PC	0 deg.	f) To be used as transposition tower with modifications (only where specified)
DD	30 deg-60 deg	a) Angle tower with tension insulator string

b) Also to be designed for the unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m and 200m (for 132kV) on each side of the tower.

c) Also to be designed for uplift forces resulting from an uplift span of 300m(for 400kV) and 200m (for 132kV and20kV) under broken wire conditions.

d) Also to be designed for specified broken wire conditions.

e) Dead end with 0 deg to 15 deg deviation on line and 0 deg to 30 deg for sub-station side (slack span side).

DD 0 deg f) Complete dead end.

g) For river crossing anchoring with longer wind span with 0 deg deviation on crossing span side and 0 deg to 30 deg deviation on other sides .

Note: The above towers can also be used for longer span with smaller angle of deviations. (To be decided as per the tower spotting data to be submitted by the Contractor and approved by Project Manager.)

4.1.3 The towers shall be of the self-supporting type, built up of lattice steel sections or members and designed to carry the power conductors with necessary insulators. Ground wires and all fittings under all loading conditions. Outline diagrams of the towers required are to be furnished by the Bidder.

4.1.4 The towers shall be fully galvanized structures built up of structural mild steel sections. All members shall be connected with bolts, nuts and spring washers.

For design of structure weight span limits given in Table 5.1 shall prevail.

TABLE 5.1 (a)
For 132 kV Line

Tower Type	Normal Condition		Broken Wire Cond	
	Max. (m)	Min. (m)	Max. (m)	Min. (m)
DA	450	150	270	100

DB, DC & DD	450	0	270	-200

TABLE 5.1 (b)
For 220 kV Line

Tower Type	Normal Condition Max. (m)	Min. (m)	Broken Wire Cond Max. (m)	Min. (m)
DA	525	200	315	100
DB, DC & DD	525	0	315	-200

TABLE 5.1 (c)
For 400 kV Line

Tower Type	Normal Condition Max. (m)	Min. (m)	Broken Wire Con Max. (m)	Min. (m)
DA	600	200	360	100
DB, DC	600	0	360	-200
DD	600	0	360	-300

However, for calculating the tower height, an allowance of 150mm shall be provided, over and above the specified ground clearances, at still air and maximum conductor temperature, to account for any stringing error.

TABLE

Situation	Minimum clearance (metres)		
System voltage (kV):	**132**	**220**	**400**
Normal ground (open country)	6.10	7.015	8.84
* Road crossings, road level	7.00	7.90	9.7
Rail crossings, rail level:	17.9	17.9	19.3
River crossings, bank level River crossings, navigable rivers, above highest as specified by the Authority flood level;(data to be obtained from Navigation Authority)			
Above trees	4.0	4.6	5.5
Buildings, poles, structures and walls, etc. upon which a man may stand : horizontal clearance	4.6	5.5	7.3
Same above : vertical clearance	2.9	3.8	5.6
Power lines	3.1	4.6	6.1

*Any road which is normally maintained by Government and/or other recognised public authority.

4.1.5 Stubs and Superstructures:

(i) The stub shall mean a set of four stub angles fully galvanized from the and shall include cleats, gussets, bolts and nuts, etc. the black portion of the stub being cast in foundation footings. Stub length shall correspond to foundation depth of 3-0 metres from ground level.

(ii) Superstructure shall mean the galvanized tower assembly above the stubs which includes structural members like angle sections, cross arms, ground wire peaks, accessories and fittings such as gusset plates, pack washers, spring, washers, ladders, step bolts, anti climbing devices and such other items which are required for completing the towers in all respect. Steel and zinc required for manufacturing these items will be arranged by the supplier.

(iii) Supply of bolts and nuts and spring washers, hangers/D-shackles for attaching suspension strings and ôUô bolts for attaching ground wire suspension assemblies are included in the supply of tower.

(iv) The following provisions shall apply in connection with the procurement of steel and zinc by the supplier.

(a) The steel used for fabrication of tower parts extensions, templates etc. shall be of mild steel of tested quality as per IS:2062 GRA.

(b) The Bidder shall take into account the fabrication wastage while quoting the rates. The employer will not accept any liability in connection with the wastage of steel during fabrication or otherwise.

(c) The Bidder shall indicate in his offer the sizes of steel sections which are proposed to be used by him in the design of towers.

(d) Substitutions, if any, of steel sections of the tower parts by higher sizes, due to non-availability or otherwise shall be to the supplierôs account. The employer will not accept any liability on this account.

(e) The steel shall be procured exclusively from the main steel producers. However, sections not rolled by main producers, can be procured from re-rollers provided.

Re-rolling of structural steel sections is done from billets/ingots of tested quality.

Re-rolled sections are duly tested as per relevant standard.

(f) The zinc used for galvanizing fabricated material shall be of High Grade Electrolytic zinc.

4.1.6 Extensions:

a) The towers shall be designed so as to be suitable for adding 3 metres, 6 metres, 9 metres extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner.

b) The Buidder shall have to design leg extensions for all types of towers ranging from minus 3 metres to plus 9 metres at intervals of 1.5 metres and such leg extensions shall be suitable for being fitted to a normal tower as well as a tower with extensions. This is to enable tower spotting in hilly terrain.

4.1.7 Stub setting Templates:

Stub templates shall be designed and supplied by the supplier as per requirement for all types of towers with or without extensions. Stub templates for standard towers and towers with extension shall be fined type. The stub templates shall be painted with anti-corrosive paints.

4.1.8 Fasteners: Bolts, Nuts & Washers

4.1.9 All bolts shall be of property class 5.6 and nuts of property class 5.0 IS: 1367 (Part ï 3) 1991 and IS: 6639-1972 shall conform to IS: 12427, they shall be galvanized and shall have hexagonal heads and nuts, the heads being forged out of solid steel rods and shall be truly concentric and square with the shank. The shank shall be perfectly straight.

4.1.10 ully threaded bolts shall not be used, the length of bolts should be such that the threaded portion shall not extend into the place of contact of the members.

4.1.11 ll bolts shall be threaded to take the full depth of the nut and threaded far enough to permit firm gripping of the members, but not any further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit hand tight to the point where the shank of the bolt connects to the head.

4.1.12 lat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of electro-galvanized steel and of the positive lock type. Their thickness shall be 2.5 mm for 12 mm dia bolts, 3.5 mm for 16 mm dia bolts and 4.5 mm for 20 mm dia bolts.

4.1.13 he Bidder shall furnish bolt schedules giving thickness of members connected, size of bolts and nuts, the length of the shank, the length of the threaded portion of bolts, sizes of bolt holes, thickness of washers and any other special details of this nature.

4.1.14 To obviate bending stress in bolts or to reduce it to a minimum, no bolt shall connect aggregate thickness of more than three (3) times its dia.

4.1.15 he bolt positions in assembled towers shall be as per IS: 5613 (Part-I/Section-I) (Part-II/Section-2)-1985.

4.1.16 olts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

5.0 Tower Accessories

5.1 Step Bolt Ladders: These bolts shall be of property class 4.6 conform to IS: 6639-1972.

5.1.1 Each tower shall be provided with step bolts on one of the main legs, of not less than 16 mm diameter and 175 mm long, spaced not more than 400 mm apart and extending from about 2.5 metres above the ground level to the top of the tower. Each step bolt shall be provided with two nuts on one end to fasten the bolt security to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN and shall be used as a ladder for climbing.

5.1.2 Anti-climbing devices: This shall conform to IS: 5613 (Part-I/Sec ï I), 19085.

Fully galvanized barbed wire type anti-climbing device shall be provided at a height of approximately 3 metres as an anti-climbing measure. Four layers of barbed wires will be provided each inside and outside the tower in horizontal plane, spacing between the layers being 140 to 150 mm. The towers to be designed by the supplier shall have provision to fixed the barbed wire as indicated above. Thus the angle pieces with notches for accommodating barbed wire shall be designed and supplied with the towers along with provision for suitable bolt holes on leg members for fitting bolt holes on leg member for fitting the angles. The scheme of the anti-climbing device shall be submitted along with the tower drawing. Barbed wire shall be included in the scope of bidder.

5.1.3 Insulator strings and ground wire clamp attachments

(a) For the attachment of suspension insulator strings a suitable swinging hanger on the tower shall be provided so as to obtain requisite clearance under extreme swinging conditions and free swinging of the string.

The hanger shall be designed to withstand an ultimate tensile strength of 11.500 kg.

5.1.4 (a)For ground wires at suspension towers suitable ôUô Bolts strong enough to withstand the full designed loads shall be provided to accommodate the hook of the ground wire suspension clamps.

(b) At tension towers, horizontal strain plates of suitable dimensions on the underside of each power cross-arm tip and at the top ground wire peak shall be provided for taking the ôDô Shackles of the tension insulator strings or ground wire tension clamps, as the case may be. Full details of the attachments shall be submitted by the supplier for the employerôs approval before commencing with mass fabrication.

5.1.5 Phase Plate

Phase plate shall be of mild steel of 16 gauge vitreous enameled at back and front, circular in shape and diameter 75 mm. One set of phase plate shall be consisting of 3 plates red, yellow and blue coloured accordingly to indicate the phase of the conductor. There shall be one fixing bolt on the plate. This shall conform to IS: 5613 (Part-II/Section01) of latest edition.

5.1.6 Number Plate

The number plate shall be mild steel vitreous enameled at back and front, 200 mmx 150 mm, rectangular shape and inscribed thereon shall be the number of the tower location preceded by letter corresponding to the short name of the line and the type of towers. There shall be two fixing bolts on both end of the plates. The dimension and details of the number plate shall be as per IS: 5613 (Part-II/Section1 & Section-2), 1985.

5.1.7 Danger Plate

These shall be of mild steel vitreous enameled at back and front 250 x 200 mm rectangular shape and inscribed thereon shall be in signal red the work ôDANGERô with its Oriya and Hindi translation and also with the inscription of Bone and Scull and voltage of the line. There shall be two holes on the plates for fixing. This shall conform to IS: 2551 (latest edition).

5.1.8 Details to Tower Fabrication Workmanship

5.1.9 Except where hereinafter modified details of fabrications shall confirm to IS: 802 (Part-II)-1978.

5.1.10 But splices shall generally be used such that the inside cleat angle and outside plates are designed to transmit load. The inside cleat angle shall not be less than half the thickness of the connected heaviest member plus 2 mm. Lap splices may also be used for connecting members of unequal size in such a manner that the inside angle of the lap splice shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the members connected through bolts. But as well as lap splices shall be made as above and as close to and above the main panel point as far as possible.

5.1.11 Points shall be so designed so as to avoid eccentricity. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where connections are such that the elimination of the gusset plates would result in eccentric joints then gussets plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plate, required to transmit stress, shall not be less than that of the thinnest of connected member but not less than 5 mm in any case.

The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary so as to avoid the use of filler and it shall be connected at the point of inter-section by one or more bolts.

5.1.12 The tower structures shall be accurately fabricated to bolt together easily at site without any strain on the bolts.

5.1.13 No angle member shall have the two leg flanges brought together by closing the angle.

5.1.14 The diameter of the hole shall be equal to the diameter of bolt plus 1.5 mm.

5.1.15 The structure shall be designed such that all parts are accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depressions are likely to hold water.

5.1.16 All similar parts shall be made strictly interchangeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which shall not injure the materials so that when assembled, the different matching surfaces are in close contact throughout. No rough edges shall be permitted any where in the structure.

5.1.17 Drilling and Punching

(a) Before any cutting work is started, all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

(b) Holes for bolts shall be drilled of punched with a jig but drilled holes are preferred. The following maximum tolerance of accuracy of punched holes is permissible.

(i) Holes must be perfectly circular and no tolerance in this respect is permissible.

(ii) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8 mm i.e. the allowable taper in punched holes should not exceed 0.8 mm on diameter.

(iii) Holes must be square with the plates or angles and have their walls parallel.

© All burrs left by drills or punches shall be removed completely. When the tower members be truly opposite to each other. Drilling or reaming to enlarge defective holes is not permitted.

5.1.18 Erection Mark:

Each individual member shall have an erection mark conforming to the component number given to it in the fabrication drawings. This mark shall be done with marking dies of 16 mm size before galvanizing and shall be legible after galvanising.

The erection mark shall be A-BB-CC-DDD where

A Employer code assigned to the supplier (Alphabet).

BB Supplierôs Mark (Numerical)

CC Tower type (Alphabet)

DDD Number mark to be assigned by Supplier (numerical).

5.1.19.1 Galvanizing

The super structure of all towers and stubs upto 150 mm below plinth level (Top of concrete pedestal) shall be galvanized. Galvanizing of tower members and stub shall be in conformity with IS: 4759-1984 and shall be done after all fabrication work has been completed except that the nuts may be tapped or return after galvanizing. Threads of bolts and nuts after galvanizing shall have a neat fit and shall be such that they can be turned with fingers throughout the length of the threads of bolts and they shall be capable of developing the full strength of the bolts. Spring washers shall be electro-galvanized as per Grade ï 4 of IS: 1573 ï 1986. Galvanizing for fasteners shall conform to IS: 1367 (Part-XIII) ï 1978.

5.1.19.2 Quantities and Weights

5.1.20 The quantities stated in Annexure ï I are only provisional. Final quantities will be informed by the employer to the supplier on completion of detailed survey. However, bids will be evaluated based on quantities indicated in the Annexure ï I.

5.1.21 The employer reserves the right to order for the final quantities at the rates quoted in the bid, which shall be valid throughout the pendency of the contract.

5.1.21.1 The unit weight of each type of tower stubs, super structure and extension be furnished by the Bidder. The weight of tower shall mean the weight of tower calculated by using the black section(ungalvanized) weight of steel members including stubs, of the sizes indicated in the approved fabrication drawings and bills of materials, without taking into consideration the reduction in weights due to holes, notches, cuts, etc. but taking into consideration the weight of special fittings.

5.1.21.2 Tower designs Superstructure

5.1.21.3 Wind Pressure

The wind pressure on towers, power conductors and earth wire shall be as per IS: 802 (Part-I/Sec-I) ï 1995.

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5.1.21.4 Design Temperatures

The following temperature range for the power conductor and ground wires shall be adopted for the line design confirming to IS: 802 (Part ï I/Sec ï I) ï 1995.

i) Minimum temperature 50ęC.

ii) Every day temperature 32ęC

iii) Maximum temperature of:

a)	Conductor	75ęC for ACSR Moose/Zebra/Panther 90ęC for AAAC (Moose equivalent)
b)	Ground wire exposed to Sun.	53ęC

5.1.21.5 Factors of Safety & Span details

a) Factory of safety.

The factor of safety based on crippling strength of struts and elastic limit of tension members shall not be less than 2(two) under normal condition and 1.5 (one and a half) under broken wire conditions for all the members of the towers and their cross arms.

b) Normal Span

The normal span of the line shall be 300 metres for 400 KV and 220 kV and 250 meters for 132 kV.

c) Wind and weight spans

The wind and weight spans to be adopted in the design of the structures shall be as follows:

i) Wind Span

The wind span is the sum of the two half spans adjacent to the support under consideration. In case of towers located on an perfectly horizontal terrain, this shall be the normal span. For design purposes the wind on conductor shall be calculated on at least 1.1 times the normal.

ii) Weight Span

The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower.

All C and D type towers shall be designed for uplift spans (minimum) weight spans in the following table also. These are applicable both for pointed and square cross arms.

For details of cross arms and towers, the span limits given below shall prevail.

WEIGHT SPANS

Tower Type	400/220 KV				132KV			
	Normal Condition		Broken wire condition		Normal Condition		Broken wire condition	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A & B	525	100	300	100	320	100	250	100
C & D	600	100	300	100	320	100	250	100

5.1.21.6 Conductor and Ground wire Configuration

For single circuit towers the three phases shall be Delta formation. One number of ACSR conductor shall be used for each phase. One galvanized steel wire shall be used as ground wire. The ground wire shall be continuous and shall be provided above the conductors at suitable elevation to offer effective shielding and safe clearances. For double circuit towers the phases shall be in vertical formation with phase to phase horizontal spacing of not less than 8.4 meters and vertical 4.9 meters for 220 kV.

5.1.21.7Loads on Towers

i) Transverse Loads:

Transverse load due to wind on towers conductors and under broken wire earthwire shall be calculated in accordance with IS: 802(Part-I/Sec-I)-1995.

ii) Longitudinal Loads due to wind on towers conductors and shield shall be calculated as per IS: 802 (Part-I/Sec-I)-1995.

iii) Vertical Loads:

The vertical load due to conductors and ground wire shall also include 150 kg. As weight of a Lineman with tools. These loads are in addition to the vertical loads due to insulator fittings and the dead weight of the structure. The weight of a Lineman with tool should not be considered in minimum vertical load calculation. An additional erection load of 3.5 KN shall also be considered for the design of the tower. The stringing procedure shall ensure that the above vertical loads are not exceeded. For calculating vertical loads the following insulator weights may be considered.

400/220/132 KV

Each single suspension insulator string	160 kg
Each double suspension insulator string	320 kg
Each double tension insulator string	420 kg
Pilot string for 60ę tower	160 kg

iv) Broken Wire condition

a) Suspension Tower Type A/DA

Breaking of any one power conductor in one phase only, resulting in instanceous unbalance tension of 50% of conductor tension at 32ęC without wind or breaking of one earthwire resulting in an unbalance tension equal to the maximum tension of the ground wire whichever is more stringent is to be considered for design along with appropriate impact factor.

b) Tower Type B & C

Breakage of two phases on the same side and on the same span or breakage of any one phase and any one ground wire on the same span whichever combination is more stringent along with appropriate impact factor for a particular member.

c) Tower Type D/DD

Breakage of all the three phases on the same side and on the same span or breakage of two phases and any one ground wire on the same span, whichever combination is more stringent along with appropriate impact factor for a particular member. Cross arms for angle tower shall be of equal length for both sides.

v) Design Load

Employerôs requirement for design longitudinal and transverse loads shall confirm to IS: 802(Part-I/Sec-I)-1995.

The Bidder shall furnish the details of design loads proposed to be adopted in the tower design in accordance with this specification.

The design criteria and other special requirements as stipulated for special towers shall be applicable for river crossing/special towers.

5.1.21.8Tower Steel Sections:

i) Steel sections of tested quality in conformity with IS: 2062 GRA are to be used in towers, extensions and stub setting templates. No individual members shall be longer than 6000 mm.

For designing of towers only rationalized steel sections shall be used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost. However, design approval for such substitution shall be obtained from the employer.

ii) Thickness of Members

The minimum thickness of angle sections used ion the design of towers, shall be kept not less than the following values:

a) Main corner leg members excluding the ground wire peak and main cross arm 6 mm.

b) For all other main members 5 mm.

c) Redundant members 4 mm.

iii) Bolt Arrangement

The minimum bolt spacing and rolled edge distance and sheared edge distances of sections from the centers of the bolt holes shall be provided as furnished in Table-1.

Dia of Bolts (mm)	Hole Dia (mm)	Min. bolt Spacing (mm)	Min. rolled Distance (mm)	Min. Sheared Edge distance (mm)
12	13.5	30	16	19
16	17.5	40	20	23
20	21.5	50	25	27

Bolts sizes mentioned above shall only be used. The minimum width of flanges without bolt holes shall be 30 mm.

For the purpose of calculating stress and bearing stress for bolts refer clause 14.4 and 14.5 of IS: 802 (Part-I/Sec-2)-1992.

iv) Allowable Stress:

Structural steel angle section manufactured according to the latest ISL: 808(Part-V & VI) and tested according to the latest edition of IS:2062 and having its yield strength not less than 255 N/mm. sq. shall be used in the fabrication of tower members.

v) Axial Stress in tension:

The estimated tensile stress in various members multiplied by the appropriate factors of safety shall not exceed the value given by the formula specified in Clause 9.2.1 of IS:802(Part-I/Sec-2)-1992.

vi) Axial Stress in Compression

The estimated compressive stress in various members multiplied by the appropriate factors of safety shall not exceed the value given by the formula specified in Clause 9.2.1 of IS:802(Part-I/Sec-2)-1992.

vii) Slenderness ratio:

Slenderness ratio for members shall be computed in accordance with IS:802(Part-I/Sec-2)-1992. Slenderness ratio for compression and tension members shall not exceed the values specified therein. The following maximum limits of the slenderness ratio shall be adopted i.e. the ratio of unsupported length of the section in any place to the appropriate radius of gyration.

a)	For main corner leg member including the corner members of earth wire peak and the lower corner members of the armsé	150
b)	For other members having calculated stressesé .	200
c)	For redundant membersé .	250
d)	For members having tensile stress onlyé .	375

viii) Erection Stress

Where erection stresses combined with other permissible co-existent stresses could produce a working stress in any member appreciably above the specified working stress, then additional materials shall be added to the member or such other provision made so as to bring the working stress within the specified limit. For the purpose of this clause the specified working stress shall be the ultimate stress divided by the factor of safety of 2.0.

ix) Design calculation and Drawings

The following design calculations and drawings are required to be furnished to the employer.

a) Along with the Bid:

Detailed design calculations and drawing for each type of tower.

b) On award of Contract

The supplier shall submit design of tower extension, stub templates and loading/rigging arrangement of tower testing to enable the employer to make preliminary check regarding structural stability of tower tests.

Upon successful testing of tower and subsequent approval of designs, drawings and bill of materials, the supplier shall furnish Photostat copies of the following in 6(six) copies to the employer for necessary distribution along with one copy of reproducible print.

a) Detailed design calculations along with drawings of towers and foundations.

b) Detailed structural drawings indicating section size, length of member. Sizes of plate along with hole to hole distances, joint details etc.

c) Bill of materials indicating cutting and bending details against each member.

d) Shop drawings showing all details relevant to fabrication.

e) All drawings for the tower accessories.

The supplier is required to submit four copies of the drawings with Photostat copies mentioned above for approval by the employer while submitting the designs, structural drawings. Bill of materials and any other drawings pertaining to the subject transmission line. The supplier shall clearly indicate in each drawing the project code number, if any, specification no.;, name of transmission line, letter reference no. and date on which the submissions are made. The said procedure is to be followed while submitting the distribution copies.

5.1.21.9 Statutory Electrical Clearances:

i) Ground Clearances:

The minimum ground clearance from the bottom conductor shall not be less than 7.00 metres for 220 kV at the maximum sag conditions i.e. at maximum temperature and in still air. However, to achieve the above clearance the height of the tower shall be increased in the following manner:

a) An allowance of 4% of the maximum sag shall be provided to account for errors in stringing.

b) Conductor creep shall be compensated by over tensioning the conductor for a temperature of 26ęC lower than the stringing temperature.

In case of rail track crossings the minimum height above rail level of the lowest portion of any conductor under conditions of maximum sag, in accordance with the regulations for Electrical Crossing of Railway Tracks are given in Table ï 5.

TABLE – 5

Type of work	Inside stn. Limits(mm)	Outside stn. Limits(mm)

a)	For unelectrified track and tracks electrified on 1500 V.DC		
	i) For metre/narrow gauge	10,00017,600	
	ii) For broad gauge	11,200	8,800
b)	Tracks electrified on 25 kV AC for metre, narrow and broad gauge	15,300	13,300

Minimum clearance between the subject power line and any other power line crossing shall not be less than 7000 mm.

ii) Live Metal Clearance:

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as given in IS:5613 (Part-2/Sec-I).

The Bidder may adopt separate cross arm design and length for ôDô type towers under dead end conditions provided adequate live metal clearance is available with at least 15ę angle and also provided that all the other specified conditions of this specifications are fulfilled. In case pilot insulator strings are proposed to be used, the angle of swing to be considered shall be minimum of 15ę.

In computing live metal clearances, the dimensions of suspension and tension string shall be taken as given in drawings attached herewith. The design of the towers shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the insulator strings.

iii) Angle Shielding

The angle shielding, defined as the angle formed by the line joining the center lines of the ground wire and outer conductor in still air, at tower supports, to the vertical line through the center line of the ground wire shall not be more than 30ę. The drop of the ground wire clamp which is employer supplied item should be considered while calculating the minimum angle of protection. For estimating the minimum angle of protection the drop of ground wire suspension clamp along with U-bolt may be taken as 150 mm.

iv) Mid Span Clearance

The minimum vertical span clearance between any of the earthwire and the nearest power conductor under all temperatures and in still air condition in the normal ruling span shall be 8.10 metres for 220 kV. Further the tensions of the earthwires and power conductors, shall be so co-ordinated that the sag of earthwires shall be at least 10% less than that of the power conductors under all temperatures and loading conditions.

5.1.21.10 Packing

Angle sections shall be wire bundled, cleat angles, gusset plates, blackets, filler plates, hanger and similar other loose items shall be netted and bolted together in multiples or securely wired together through holes.
Bolts, nuts, washers and other attachments shall be packed in double gunny bags, accurately tagged, in accordance with the contents.

The packings shall be properly done to avoid losses/damages during transit. Each bundle or package shall be appropriately marked.

5.1.21.11 Special Towers:

i) Special towers are to be used for major river crossing requiring very long spans. These towers shall form part of the Bidderôs scope.

Unit rates for design, fabrication, galvanizing, testing and supply for such towers shall be quoted in the appropriate schedule of Volume IB.

Anchoring of major river crossing towers, shall be with óDôor DD type towers.

All the requirements as meant for standard towers shall apply for such special towers except those noted in the following clauses.

ii) Shielding Angle:

The shielding angle shall not be greater than 30ę.

iii) Clearances:

The minimum clearance of lowest point of power conductor from the highest flood level in navigable rivers for crossing towers shall be obtained from the navigation authority.

The minimum electrical clearances between live parts and tower body and cross arm member shall be the same as for normal towers.

iv) Stub Location:

The approximate height of foundation on which stub for river cross towers are to be set, over the highest flood level of the river shall be fixed only after employerôs approval.

v) Angle of Deviation

The minimum angle of deviation to be considered for special towers is 2ę and all live material clearances are to be computed considering double suspension insulator strings as per drawing enclosed.

vi) Factors of Safety:

Towers:

The minimum factors of safety for towers shall be:

a) Under normal conditions 2.0
b) Under broken wire conditions 1.;5

vii) Conductor and Earth wire:

The minimum factor of safety for conductors and ground wire shall be 2.5 maximum tension corresponding to 2/3rd full wind pressure at minimum temperature or full wind pressure at the mean annual temperature such that the initial unloaded tension at the mean annual temperature do not exceed 30% of the ultimate strength of conductor and ground wire respectively.

viii) Wind Loads:

a) The procedure for wind load calculation on conductor and ground wire shall be the same as for normal structures.

b) The wind pressure values on tower shall be based on IS:802(Part-I/Sec-I)-1995.

ix) Longitudinal Loads:

a) The longitudinal loads due to power conductors and earth wires for suspension towers shall be nil under normal conditions and 100% of the maximum tension of bundled conductors or earth wire under broken wire conditions.

b) Under normal conditions, unbalanced longitudinal pull due to difference in tension in ruling span for river crossing towers on one side and span of the line on the other wise shall also be considered for the design of anchor towers.

5.1.22 TESTS

5.1.23 General

a) All standard tests including quality control tests in accordance with IS:802(Part-III)-1978 shall be carried out.

b) A galvanized tower of each type complete with 6 metres extension shall be subjected to design and destruction test. The tower shall be tested with nuts and bolts of the same make and type which are proposed to be used on the line. The supplier shall submit to the employer for approval, a detailed programme and proposal for testing the towers showing the method of carrying out the tests and the manner of applying the loads. The supplier on receipt of such approval shall intimate the employer about carrying out of the tests at least 30 days in advance of the scheduled date of tests during which time the employer will arrange to depute his representatives

to witness the tests. Six copies of the test reports thereof shall be submitted to the employer for approval.

c) In case of premature failure, the tower shall be retested and steel already used in the earlier test shall not be used again. The supplier shall provide facilities to the employer for inspection of materials during manufacturing stage and also during testing of the same.

d) No part of any tower subject to test shall be allowed to be used in the work. The prices to be quoted for such type tests shall be after allowing rebate for the scrap value of the tested tower which is to be retained by the supplier

e) The supplier shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully undergone the tests. In case any deviation is detected the supplier shall replace such defective towers free of cost of the employer. All expenditure incurred in erection, to and fro transportation, any other expenditure or losses incurred on this account shall be fully borne by the supplier.; No extension in delivery time shall be allowed on this account. The employer, however, reserves the right to waive off the testing of the towers, provided the supplier had earlier successfully tested, erected and commissioned similar towers and certificates for such tests carried out earlier are furnished duly certified by the employer and are found acceptable.

f) Each type of tower to be tested shall be a full scale prototype galvanized tower and shall be erected vertically on rigid foundation with the stub protruding above ground level as provided in the design/drawing between ground level and concrete level.

g) The suspension tower to be tested shall be with hanger and ôUô Bolt as per approved design/drawings. The tension tower to be tested shall similarly be with the strain plate as per approved design/drawings.

h) In case of any premature failure even during waiting period, the tower shall be retested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected then in such cases all the tests which have been carried out earlier are to be reconducted to the entire satisfaction of the employer.

i) The sequence of testing shall be at the discretion of the employer.

5.1.23.1Test for Galvanization

Galvanization of the members of the tower shall withstand tests as per IS:2633.

5.1.24 INSPECTION

5.1.24.9 The supplier shall keep the employer informed well in advance of the commencement of manufacture, progress of manufacture thereof and fabrication of

various tower parts at various stages. So that arrangements could be made for inspection by the employer.

5.1.24.10 The acceptance of any batch of items shall in no way relieve the supplier of any his responsibilities for meeting all the requirements and intent of this specification and shall not prevent subsequent rejection if any item of that batch is later found defective.

5.1.24.11 The employer or his authorized representatives shall have free access at all reasonable time to all parts of the supplierôs works connected with the fabrication of the material covered under the contract for satisfying themselves that the fabrication is being done in accordance with the provisions of this specification.

5.1.24.12 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

5.1.24.13 Should any member of the structure be found not to comply with the approved design, it shall be liable for rejection. No member once rejected shall be resubmitted for inspection except in cases where the employer or his authorized representative considers that the defects can be rectified.

5.1.24.14 Defects which occur during fabrication shall be made good with the consent of and according to the procedure to be laid down by the employer.

5.1.24.15 All gauges and templates necessary to satisfy the employer for conducting tests shall be made available at the test site by the supplier.

5.1.24.16 The correct grade and quality of steel shall be used by the supplier. To ascertain the quality of steel the employer may at his discretion get the material tested at an approved laboratory.

5.1.25 SCHEDULE OF REQUIREMENTS

5.1.25.1 The schedule of requirements of different types of towers is indicated in Volume-III. The quantities indicated therein are tentative and based on preliminary survey conducted by the employer. The exact quantity will be informed to the supplier on completion of detailed survey.

5.1.25.2 The time frame for executing the work is also indicated in this schedule. The supplier has to match the supply and delivery of stubs, tower-parts etc. to complete the work within the time schedule desired by the employer.

5.1.25.3 The supplier shall, as far as possible, dispatch the tower material as completed towers in order to enable erection of complete tower structures at site. Payment for the initial dispatches, to the extent of 30% of the total ordered quantity will be released on the basis of weight (i.e. Metric tones of steel supplied). Beyond this limit, however, payment will be released only for material supplied to complete towers.

5.1.26 SCUEDUALE OF PRICES

5.1.26.1 The prices for supply of materials shall be furnished in the relevant schedule in the manner specified in Volume-III.

5.1.27 GENERAL TECHNICAL REQUIREMENTS

Particulars	Design details	- foundation
Line voltage	-	400/220132 kV
No. of circuits	-	Double/Double/Double

a) Properties of soil for bidding purpose only

Sl. No.	Details	Soft Loose	Mud	Hard Soil	Soft Rock	Hard Rock
1.	Angle of repose of soil(in degree)	30	15	0	0	0
2.	Ultimate bearing strength of earth (T/M^2)	10	5	20.0	50.0	125.0

b) Properties of concrete

All concrete shall be RCC with ratio(1:1.5:3).

c) Factor of safety for foundation against over turning due to up-lift and thrust.

i) Normal condition 2.2

ii) Broken wire condition 1.65

d) Concrete Mixture

i) pad 1:3:6

ii) Pyramid or stepped part of foundation 1:1:5:3

iii) Chimney 1:1:5:3

e) Minimum thickness of chimney 300 m

f) Minimum thickness of concrete over stub
Dry soil 100 mm
Wet & WBC 150 mm

g) Minimum length of stub 2000 mm
in concrete.

h) Distance above ground level of 450 mm
Tower stub and super structure

5.1.28 .Foundation General Description

5.1.29 Design, construction and other relevant drawings shall be furnished by the tower designer for all types of towers (including special towers) for different kinds of soil as detailed below. According to the locations foundations for towers shall be normally of the following types:

a) Soft/Loose Soil
b) Mud
c) Hard/Dense soil
d) Hard/Disintegrated rock

5.1.30 For rock foundations the holes in rocks shall be made in an approved manner so as to eliminate the possibility of serious cracking of the rock. The concrete block shall be properly secured to rock base by adequate no. of anchor bolts and further secured by concrete lodge section by the sides.

TECHNICAL SPECIFICATION

ERECTION OF

400/220/132 KV D.C. TRANSMISSION LINES

CONSTRUCTION OF TOWER FOUNDATION AND ERECTION OF TOWER

1.0 ERECTION OF TOWER AND TOWER FOUNDATION

1.1 SCHEDULE OF ERECTION PROGRAMME

After due approval of the detailed and check survey, the contractor shall submit to the employer a complete detailed schedule of erection programme with a Bar-Chart for construction of the lines indicating therein the target date of completion.

1.1.1 DRAWINGS FOR TOWER AND FOUNDATIONS

The same shall be supplied by the contractor.

1.1.2 TAKING OVER

Tower and tower accessories received at site stores are to be stored item-wise and mark-wise to facilitate joint inspection of the materials (with reference to packing list and detailed order).

If the materials/equipment or any part thereof is damaged or lost during the transit, the replacement of such materials shall be effected by the contractor timely so as to maintain programme of work. However, the line under erection shall be taken over by the purchaser only when the entire line is completed in all respect and made ready for commissioning at rated voltage. Partly erected line will not be taken over.

Taking over of the line shall be in no way relieve the contractor from his responsibility for satisfactory operation of the erected line in terms of the guarantee clause of the specification.

1.1.3 MATERIALS HANDLING AND INSURANCE

The contractor shall deliver all equi9pment/materials against this contract to his site stores under cover of Transit Insurance to be taken in his name. Cost of such insurance is to be borne by the contractor.

Cost of transportation of materials from contractorôs store to the site of work shall be borne by the contractor irrespective of made of transportation and site condition.

The contractor has to bear the cost of premiums for all materials, tower accessories, total erection cost of the line including cement, torsteal for foundation.

It will be the responsibility of the contractor to report to the concerned Police Station about all incidents of thefts and lodge, pursue and settle all claims with Insurance Company in case of damage/loss due to theft, pilferage, flood and fire etc. and the employer of the work shall be kept informed promptly in writing about all such incidents. The loss, if any, on this account shall be recoverable from the contractor if the claims are not lodged and properly pursued in time or

if the claims are not settled by the insurance company due to lapses on the part of the contractor. The contractor shall have to replenish promptly damaged, stolen tower members and accessories conductors, earth wire, hardwares etc. and repair/re-erect the damaged lines, free of cost to the employer so as to maintain the programme of work. The employer will not be responsible in any way for such loss of materials.

1.1.4 EXCAVATION FOR FOUNDATION PITS, DE-WATERING AND SHORING SETS

The contractor shall execute the open excavation job in the foundation pits in all type of soil including latterite and or bounder mixed soil as detailed abelow including removing, spreading and/or stacking the excess spils (as directed by the employer). The item includes the necessary trimming of the sides, leveling, dressing and ramming (as necessary) the bottom of the pits including bailing out water, dewatering by manual and/or mechanical means by emplying water pumps including removing of slushes from foundation pits and nominal open plank shoring with vertical poling boards placed at suitable intervals as directed with required runners, struts, battens for framing as required complete. While quoting the unit rate for foundation as per the activity schedule, the contractor shall include cost of design, all cost of labour, materials, tools, plants, incidentals for earth excavation, dewatering, cement, water, sand, coarse and find aggregates, steel reinforcement, steel angles, forms, mixing, finishing, protection and curing of concrete, back-filling with carried earth, if necessary, disposal of surplus, spoils, stub setting and template. The contractor shall also include in the quoted unit rate for foundation, all charges/costs for preparing the pit marking and foundation layout drawing, grounding of towers including supply of pipe/concrete pipe, earthing, measurement of ground resistance before often growing etc.

1.1.5 CEMENT CONCRETE :

A) Materials

All materials whether to be consumed in the work or used temporarily shall conform to relevant IS specification, unless stated otherwise, and shall be of the best approved quality.

B) Cement

Cement to be used in the work under the contract shall generally conform to IS:269/455-1989. Cement bags shall be stored by the contractor in a water tight well ventilated store sheds on raised wooden platform/dunnage (raised at least 150 mm above ground level) in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter. Sub-standard or partly set cement shall not be used and shall be removed from the site by the contractor at his cost on receipt of approval from the Engineer.

C) Coarse Aggregates Stone chips or stone ballast

D) Reinforcement : Different size of reinforcement(MS ROD-FE-500) as per latest IS.

Remarks: All foundation of tower shall be of RCC: M20 Grade(1:1.5:3) nominal mix

General Technical Particulars
C. 1 - Span Lengths

		132kV	220kV	400kV
Normal span	m	300	350	400
Tower design spans:				
Wind spans:				
Suspension towers	m	300	350	400
Tension towers	m	300	350	400
Maximum weight spans:				
Suspension towers	m	450	525	600
Tension towers	m	450	525	600
Minimum weight spans:				
Suspension towers	m	100	100	100
Tension towers (uplift net)	m	-200	-200	-200 (for DB&DC) -300 (forDD)

C . 2 - Line Conductor (132 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm^2	288.3
Number of conductors per phase		ONE
Horizontal distance between conductor centres of one phase	mm	-
Each single conductor:		
Equivalent to ACSR conductor of code name		ACSR PANTHER
IEC STANDARD No INDIAN STANDARD No		IEC 1089 IS 398 (Pt 4) 1994
Material of conductor		AlumIminium
Number and diameter of wires: Aluminium	No./mm	30/3.0
Total area of conductor	mm^2	261.5
Overall diameter of stranded conductor	mm	21
Mass of conductor per kilometre	kg	974
Ultimate strength of conductor	Newton	89670
Assumed equivalent modulus of elasticity of conductor	N/mm^2	81580
Assumed equivalent coefficient of linear expansion of conductor	per °C	17.8×10^{-6}
Maximum length of conductor supplied on one drum	km	2.4+/-5%

C . 3 - Line Conductor (220 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm^2	484.5
Number of conductors per phase		ONE
Horizontal distance between conductor centres of one phase	mm	-
Each single conductor:		
Equivalent to ACSR conductor of code name		ACSR ZEBRA
IEC STANDARD No INDIAN STANDARD No		IEC 1089 IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium	No./mm	54/3.18
Total area of conductor	mm^2	428.9
Overall diameter of stranded conductor	mm	28.62
Mass of conductor per kilometre	kg	1621
Ultimate strength of conductor	Newton	130320
Assumed equivalent modulus of elasticity of conductor	N/mm^2	81580
Assumed equivalent coefficient of linear expansion of conductor	per °C	19.3×10^{-6}
Maximum length of conductor supplied on one drum	km	1.8 +/- 5%

C . 4 - Line Conductor (400 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm^2	597.00
Number of conductors per phase		TWO

Horizontal distance between conductor centres of one phase	mm	450
Each single conductor: Equivalent to ACSR conductor of code name		ACSR MOOSE
IEC STANDARD No INDIAN STANDARD No		IEC 1089 IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium alloy	No./mm	54/3.53
Total area of conductor	mm^2	597
Overall diameter of stranded conductor	mm	31.77
Mass of conductor per kilometre	kg	2004
Ultimate strength of conductor	Newton	161200
Assumed equivalent modulus of elasticity of conductor	N/mm^2	68600
Assumed equivalent coefficient of linear expansion of conductor	per °C	19.3×10^{-6}
Maximum length of conductor supplied on one drum	km	1.8 +/- 5%

****ALL THE CONDUCTORS ARE ACSR CONDUCTORS HAVING 7 STRANDS OF GI STEEL WIRE.**

C . 5 - Earth Wire (132 kV And 220 kV Constructions)

		GSW
Complete earth conductor:		
Appropriate Indian Standard No		398(Part-2)
Appropriate British Standard No		183
Material of conductor		galvanised steel
Number and diameter of wires	No./mm	7/3.15
Overall diameter of conductor	mm	9.45
Mass of conductor per kilometre	kg	428
Ultimate strength of conductor	Newton	56000
Lay length	mm	160 +/- 15
Direction of the lay of the outer layer		Right hand
Chemical composition of the steel wire	%	
Carbon		not more than 0.55
Manganese		0.4 to 0.9
Phosphorous		not more than 0.04
Sulphur		not more than 0.04
Silicon		0.15 to 0.35
Purity of Zinc for galvanising	%	99.95
Galvanising after stranding		
a) Minimum weight of Zinc coating per sq. m. of the uncoated wire surface	gms	240
b) Minimum no. of one minute dips that the galvanised wire can withstand in Standard Preece Test		3 and 1/2
Maximum length of conductor on drum #	km	4 +/- 5%
D.C. resistance at 20 ^{o}C	ohms/km	3.375

C . 6 - Earth Wire (400 kV Construction)

	GSW
Complete earth conductor:	

Appropriate Indian Standard No		398(Part-2)
Appropriate British Standard No		183
Material of conductor		galvanised steel
Number and diameter of wires	No./mm	7/3.66
Overall diameter of conductor	mm	10.98
Mass of conductor per kilometre	kg	583
Ultimate strength of conductor	Newton	68400
Lay length	mm	160 +/- 15
Direction of the lay of the outer layer		Right hand
Chemical composition of the steel wire	%	
Carbon		not more than 0.55
Manganese		0.4 to 0.9
Phosphorous		not more than 0.04
Sulphur		not more than 0.04
Silicon		0.15 to 0.35
Purity of Zinc for galvanising	%	99.95
Galvanising after stranding		
a) Minimum weight of Zinc coating per sq. m. of the uncoated wire surface	gms	240
b) Minimum no. of one minute dips that the galvanised wire can withstand in Standard Preece Test		3 and 1/2
Maximum length of conductor on drum #	km	4 +/- 5%
D.C. resistance of the complete earthwire at $20^{O}C$	ohms/km	2.5

C.14 * - Disc Insulator Units (Anti-Fog Type)

		70kN	90kN	120kN	160kN
Size and designation of the ball pin shank	mm	16	16	20	20
Diameter of the disc	mm	280/305	280/305	280/305	280/305
Tolerance on the diameter	+/-mm	13/15	13/15	13/15	13/15

Ball to ball spacing between disc	mm	145	145	145	170
Tolerance on ball to ball spacing	+/-mm	4	4	4	5
Minimum creepage distance of a single disc **	mm	430	430	430	475
Steepness of the impulse voltage which the disc unit can withstand in Steep Wave Front Test	kV per micro sec.	2500	2500	2500	2500
Purity of Zinc used for galvanising	%	99.95	99.95	99.95	99.95
Purity of Zinc used for sleeve	%	99.7	99.7	99.7	99.7
No. of dips in Standard Preece Test 1) Cap socket 2) Ball pin		6 6	6 6	6 6	6 6

***The parameters specified are for disc insulator unit only. For the Bids offering composite insulator units, the parameters may be suitably selected by the Bidder so as to meet the overall requirements of the respective strings and same shall be guaranteed at Schedules 13A and 14A of the Technical Data Requirement Schedules, Section X.**

**** The minimum creepage distance of single composite insulator unit shall be such that it matches with the total creepage distance of the respective strings with disc insulator units.**

C . 15 - Insulator Strings (Suspension Sets For 132 kV Lines)

	Single "I" Suspension Strings	Double "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions kV(rms)	275	275	275
Impulse withstand voltage			

(peak) under dry conditions				
1) Positive	Kv	650	650	650
2) Negative	kV	650	650	650
Minimum corona extinction voltage under dry conditions	kV(rms)	105	105	105
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	70	2x70	70
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	20	20	20
Number of insulator units in each string **		9	2x9	9
Purity of Zinc used for galvanising	%	99.95	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 16 - Insulator Strings (Tension Sets For 132 kV Lines)

		Single Tension Strings	Double Tension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet	kV(rms)	275	275

conditions			
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	650	650
2) Negative	kV	650	650
Minimum corona extinction voltage under dry conditions	kV(rms)	105	105
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	90	2x90
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	22	22
Number of insulator units in each string **		10	2x10
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 17 - Insulator Strings (Suspension Sets For 220 kV Lines)

		Single "I" Suspension Strings	Double "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with	kV(rms)	460	460	460

arcing horns and corona control rings / grading rings under wet conditions				
Impulse withstand voltage (peak) under dry conditions				
1) Positive	kV	1050	1050	1050
2) Negative	kV	1050	1050	1050
Minimum corona extinction voltage under dry conditions	kV(rms)	154	154	154
Radio interference voltage under dry conditions at 1MHz, at 154kV	Micro Volts	not more than 1000	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	70	2x70	70
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	13	13	13
Number of insulator units in each string**		14	2x14	14
Purity of Zinc used for galvanising	%	99.95	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 18 - Insulator Strings (Tension Sets For 220 kV Lines)

	Single Tension Strings	Double Tension Strings

Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	kV(rms)	460	460
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Minimum corona extinction voltage under dry conditions	kV(rms)	154	154
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	2x120
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	14	14
Number of insulator units in each string **		15	2x15
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 19 - Insulator Strings (Suspension Sets For 400 kV Lines)

		Single "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and	kV(rms)	680	680

corona control rings / grading rings under wet conditions			
Switching surge withstand voltage (peak) under wet conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1550	1550
2) Negative	kV	1550	1550
Minimum corona extinction voltage under dry conditions	kV(rms)	320	320
Radio interference voltage under dry conditions at 1MHz, at 305kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	120
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	9	9
Number of insulator units in each string **		23	23
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 20 - Insulator Strings (Tension Sets For 400 kV Lines)

		SingleTension Strings (Low Duty)	Double Tension Strings
Power frequency withstand voltage	kV(rms)	680	680

of the string with arcing horns and corona control rings / grading rings under wet conditions Switching surge withstand voltage (peak) under wet conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1550	1550
2) Negative	kV	1550	1550
Minimum corona extinction voltage under dry conditions	kV(rms)	320	320
Radio interference voltage under dry conditions at 1MHz, at 305kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	2x160
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	10	10
Number of insulator units in each string **		24	2x23
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 21 - Tower Design Particulars (132 kV Construction)

Minimum clearance between live metal and tower steelwork:	

i.with suspension insulator set swing 0°	mm	1530
with suspension insulator set swing 15°	mm	1530
with suspension insulator set swing 30°	mm	1370
with suspension insulator set swing 45°	mm	1220
with suspension insulator set swing 60°	mm	1070
ii.with jumper loop swing 0°	mm	1530
with jumper loop swing 10°	mm	1530
with jumper loop swing 20°	mm	1070
with jumper loop swing 30°	mm	1070
with jumper loop swing 40°	mm	-
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 60
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	30

C . 22 - Tower Design Particulars (220 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i. with suspension insulator set swing 0°	mm	2130
with suspension insulator set swing 15°	mm	1980
with suspension insulator set swing 30°	mm	1830
with suspension insulator set swing 45°	mm	1675
with suspension insulator set swing 60°	mm	-
ii. with jumper loop swing 0°	mm	2130

with jumper loop swing 10°	mm	1675
with jumper loop swing 20°	mm	1675
with jumper loop swing 30°	mm	-
with jumper loop swing 40°	mm	-
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 45
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	30

C . 23 - Tower Design Particulars (400 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i. with suspension insulator set swing 0°	mm	3050
with suspension insulator set swing 15°	mm	3050
with suspension insulator set swing 30°	mm	1860
with suspension insulator set swing 45°	mm	-
with suspension insulator set swing 60°	mm	-
ii. with jumper loop swing 0°	mm	3050
with jumper loop swing 10°	mm	3050
with jumper loop swing 20°	mm	3050
with jumper loop swing 30°	mm	1860
with jumper loop swing 40°	mm	1860
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 30
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	20

C . 25 - Particulars Of Double Circuit Towers (132 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	300	300	300	300
Minimum ground clearance of line conductor at 85°C, normal ground	m	6.42	6.42	6.42	6.42
Minimum height of earth conductors above upper line conductor at mid-span	m	6.1	6.1	6.1	6.1
Vertical spacing between line conductors at tower (minimum)	m	3.9	3.9	3.9	3.9
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	4.5	4.5	4.5	4.5

C . 26 - Particulars Of Double Circuit Towers (220 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60

Normal span length	m	350	350	350	350
Minimum ground clearance of line conductor at 85 °C, normal ground	m	7.23	7.23	7.23	7.23
Minimum height of earth conductors above upper line conductor at mid-span	m	8.5	8.5	8.5	8.5
Vertical spacing between line conductors at tower (minimum)	m	4.9	4.9	4.9	4.9
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	5.5	5.5	5.5	5.5

C . 27 - Particulars Of Double Circuit Towers (400 kV Construction)

Type Of Tower		**DA**	**DB**	**DC**	**DD**
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	400	400	400	400
Minimum ground clearance of line conductor at 85 °C, normal ground	m	8.84	8.84	8.84	8.84
Minimum height of earth conductors above upper line conductor	m	9.0	9.0	9.0	9.0

at mid-span					
Vertical spacing between line conductors at tower (minimum) .	m	8.0	8.0	8.0	8.0
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	6.5	6.5	6.5	6.5

C . 28 - Foundation Design Particulars

Assumed density of Plain Cement Concrete (PCC) for foundation in dry soil	kg/m^3	2240
Assumed density of Plain Cement Concrete (PCC) for foundation in presence of sub-soil water	kg/m^3	1240
Assumed density of Re-inforced Cement Concrete (RCC) for foundation in dry soil	kg/m^3	2400
Assumed density of Re-inforced Cement Concrete (RCC) for foundation in presence of sub-soil water	kg/m^3	1400
28 day concrete cube strength (characteristic strength for M-20 concrete)	N/mm^2	20
28 day concrete cube strength (characteristic strength for M-15 concrete)	N/mm^2	15
Minimum proportion of stub load to be allowed for in the design of stub cleats	%	100
Density of all type of soils :		
1) under dry conditions	kg/m^3	1440
2) in presence of surface water	kg/m^3	1440
3) in presence of sub-soil water	kg/m^3	840
Ultimate bearing capacity of the soil :		
1) normal soil under dry condition	kN/m^2	214
2) normal soil in presence of surface as well as	kN/m^2	107

sub-soil water		
3) wet black cotton soil	kN/m^2	107
4) fissured rock (both for dry and wet)	kN/m^2	400
5) hard rock	kN/m^2	750
Angle of repose for :		
1) dry soil	Degree	30
2) wet soil due to presence of surface/ sub-soil water	Degree	15
3) wet black cotton soil	Degree	0
4) dry fissured rock	Degree	20
5) wet fissured rock	Degree	10
Ultimate bond between steel and concrete	kN/m^2	0.147

Note : All the soil parameters furnished above are subject to verification by actual soil investigations. The Contractor shall be required to carry-out field test for each type of foundation, as per the quoted rates in Price Schedules, to prove the design parameters considered.

The foundation classification criteria shall be as given below, depending upon type of soil and sub-soil water level / presence of surface water :

Normal Dry : To be used for locations where normal dry cohesive or non-cohesive soils are met without encountering sub-soil water table within the depth of foundation.

Wet : To be used for locations,

a) where sub-soil water is met at 1.5 m. or more below the ground level;

b) which are in surface water for long periods with water penetration not exceeding one metre below the ground level e.g. , the paddy field.

Partially Submerged : To be used for the locations where sub-soil water table is met between 0.75 to 1.5 m. below the ground level;

Fully Submerged : To be used for locations where sub-soil water table is met at less than 0.75 m. below the ground level;

Black Cotton Type : To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing the foundation for such locations, the soil is to be considered as fully submerged.

Fissured Rock : To be used at locations where decomposed or fissured rock, hard gravel, kankar, lime-stone, laterite or any other soil of similar nature is met. Under-cut type foundation is to be used for such locations.

In case of fissured rock locations where water table is met at 1.5 m. or more below ground level, wet type fissured rock foundations shall be adopted.

Hard Rock : To be used for the locations where chiselling, drilling or blasting is required for excavation . For these locations rock anchoring is to be provided to resist the uplift forces.

PILE FOUNDATION-

a) **SCOPE-** The work involved is to take up the pile foundation work of including stub setting of special type tower. The detailed survey, soil investigation and the design has to be done bidder and the design is to be approved by OPTCL, which shall be strictly followed by the contractor. The contractor shall cast the foundation including stub setting as per the design, the schedule of quantities enclosed and direction of engineer in charge.

b) 1. The pile foundation shall be of RCC, Cast-in-situ bored piles as per IS:2911 . Pile boring shall be done using Rotary Hydraulic Rigs. Two stage flushing of pile bore shall be ensured by airlift technique duly approved by the Employer

2. Minimum diameters of piles shall be 450/500mm (for under reamed piles)/ 600 mm (for bored cast in situ piles).

3. Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.

4. The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, locations of initial test piles etc.) for Engineerôs approval.

5. The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.

6. Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical		
Lateral	:	Minimum of 2 Nos. in each mode
Uplift		

7. The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test (initial test) the method of loading shall be cyclic as per IS:2911 (relevant part).

8. Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter

9. Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :
   (i) Vertical : 0.5% of the total number of piles provided.
   (ii) Lateral : 0.5% of the total number of piles provided.

10. The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.
11. In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.
12. Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

13. The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.

14. Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM.

15. Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.
16. The following shall be adhered to **PILE FOUNDATION**:

i) The pile foundation shall be of under reamed piles as per IS: 2911 part III or bored cast in situ piles as per IS 2911 part I sec2

ii) The minimum diameter of pile shall be 500 mm in case of under reamed piles and 600 mm in case of bored cast in situ piles.

iii) Under reamed piles shall be adopted only in case of clay black cotton soil or medium dense sandy soil is encountered. Design of under reamed shall be done strictly as per IS 2911 part III.

iv) The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, locations of initial test piles etc.) for Engineerôs approval.

v) The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.

vi) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical	
Lateral	Minimum of 2 Nos. in each mode.
Uplift	

vii) The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test (initial test) the method of loading shall be cyclic as per IS:2911 (part IV).

viii) Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter.

ix) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :

i) Vertical : 0.5% of the total number of piles provided.

ii) Lateral : 0.5% of the total number of piles provided.

x) The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.

xi) In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.

xii) Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

xiii) The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.

xiv) Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.

a) MATERIALS- Contractor shall supply cement, steel rod and stubs and all other materials required. All coarse aggregates, fine aggregates are to be of very good quality and to be approved by the engineer in charge.

b) Watch and Ward- The cost of watch and ward, site store, making of Islanding/platform for the pile boring, stabilization of bore hole and all other activities incidental to successful construction of the pile foundation are to be included in the cost of the tender and no additional cost shall be paid separately on any additional component.

The cement, steel shall be supplied to the contractor at the nearest tore and the contractor shall have to receive the same at designated stores and transport to site at his own cost.

The piling shall be done in presence of the engineer in charge and due certification to be done at the spot only.

Standard followed and to be followed-

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS:1080-1990	Codes of Practice for Design and Construction of Simple Spread Foundations	
IS: 1498-1992	Classification and Identification of Soils for General Engineering Purposes.	ASTM D 2487/ ASTM D 2488
IS: 1892-1992	Code of Practice For Design and Construction of Foundation in Soils : General Requirements.	
IS: 2131-1992	Method of Standard Penetration Soils	ASTM D 1586

IS: 2132-1992	Code of Practice For Thin Walled Sampling of Soils	ASTM D 1587
IS: 2720-1992	Method of Test For Soils (Relevant Parts.	ASTM D 420
IS: 2809-1991	Glossary of Terms And symbols Relating to Soil Engineering	ASTM D 653

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS: 2911-1980	Code of Practice For Design and Construction of Pile Foundations (Relevant Parts).	
IS: 3025	Methods of Sampling And Testing (Physical And Chemical) for Water used in industry.	
IS: 3043-1991	Code or Practice for Indexing and Storage Of Drill Cores.	
IS: 4091-1987	Code of Practice for Design and Construction Of Foundations for Transmission Line Towers and Poles.	
IS: 4434-1992	Code of Practice for in-situ Vane Shear Test for Soils.	ASTM D 2573/ ASTM D 4648
IS: 4453-1992	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.	
IS: 4464-1990	Code of Practice for Presentation of Drilling Information and core Description in Foundation	

	Investigation	
IS: 4968 - (Part-II) ï 1992	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS: 5313-1989	Guide for Core Drilling Observations.	

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS:6403-1990	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.	
IS: 6935-1989	Method of Determination of water level in a Bore Hole.	
IS: 7422-1990	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant Parts).	
IS:8009 (Part-I)-1993	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS:8764-1991	Method of Determination of Point Load Strength Index of Rocks.	
IS: 9179-1991	Method of Determination of Unconfined compressive Strength of Rock Materials.	ASTM D 2938
IS: 9179-1991	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS: 9259-1992	Specification for Liquid Limit apparatus.	ASTM D 4318
IS: 9640-1992	Specification for Split	ASTM D 1586

Spoon Sampler

IS: 10050-1992	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS: 11315- (Part-II)-1991	Description of Discontinuities in Rock Mass-Core Recovery	

TESTS

Tests as indicated in this specification and as may be requested by the Owner, shall be conducted. There tests shall include but may not be limited to the following :

a) **Tests of undisturbed and disturbed samples**

- Visual and engineering classification;
- Sleeve analysis and hydrometric analysis;
- Liquid, plastic and shrinkage limits;
- Specific gravity;
- Chemical analysis
- Swell pressure and free swell index determination
- Proctor compaction test.

b) Tests of undisturbed samples:

- Bulk density and moisture content;
- Relative density (for sand),
- Unconfined compression test;
- Box shear test (for sand);
- Tri-axial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):

i) Unconsolidated untrained;

ii) Consolidated drained test;

- Consolidation.

c) **Tests on rock samples**

- Visual classification:
- Moisture content, porosity and density:
- Specific gravity;
- Hardness
- Stake durability;
- Unconfined compression test (both saturated and at in-situ water content;
- Point load strength index;
- Deformability test (both saturated and dry samples)