General and Technical

Terms & Conditions

HT AND ALLIED WORK

AT

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HT Technical Specifications

GENERAL SPECIFICATIONS

1.0 HT SWITCH BOARD (11kV)

1.1 SCOPE

This specification generally describes the HT Switchboard for use on the electrical power distribution system. The scope covers the design, manufacture, testing, supply and commissioning of the sheet steel enclosed, floor mounted, free standing, extensible, indoor type, 11 kV circuit breaker type switch board as per the specifications.

The switch board shall be suitable for the following system : -

Rated voltage	:	3 Ph, 11/12 kV + 10% earthed system
Maximum system voltage	:	11/12 kV
Rated frequency	:	50 Hz

1.2 STANDARDS APPLICABLE

1.2.1 The equipment and accessories covered by this specification shall be designed and manufactured and tested in accordance with the latest relevant Indian Standards.

1.2.2 The equipment shall also conform to the latest Indian Electricity rules, as regards the safety, earthing and other essential provisions specified therein for installation and operation of the Electrical plants.

The salient standards are listed below :

IS 2516	Circuit Breakers
IS 2705	Current Transformers
IS 3705	Voltage Transformers
IS 1248 - 83 (all parts)	Direct acting indicating analogue electrical measuring instruments and their accessories.
IS 4201 – 83	Application guide for voltage transformers.
IS 8197 – 76	Terminal markings for electrical measuring instruments and their accessories.

1.3 GENERAL DESIGN FEATURES

The switch boards shall be of the indoor, metal clad self-supported, floor mounting, drawout truck type with individual cubicles for each circuit. The cubicle shall be dust, damp and vermin-proof type and should be fully interlocked. The frame-work of the cubicle shall be of bolted/welded construction. The doors shall be provided with concealed hinges. The boards shall be suitable for extension on either side.

Each cubicle shall comprise essentially two portions :-

a) The fixed portion housing busbar, current transformers, relays and instruments and other accessories.

b) The fixed portion comprising the circuit breaker with the integral carriage.

1.3.1 The switchgear cubicle shall have structural sheet steel frame work enclosed on all the sides and top by CRCA sheet steel of minimum thickness of 2.5 mm.

1.3.2 Each cubicle shall be provided with a front access door with handle, lock and key and a removable back cover/door. The back cover/door shall be interlocked with the breaker such that the cover/door cannot be opened unless associated breaker is in 'OFF' position. Alternatively, a red colour indication lamp should be provided to glow at the back of the panel when it is in test position.

1.3.3 The circuit breakers, busbars, instrument transformers and cables shall be installed in separate compartment within the cubicle. Failure of one equipment should not affect the equipment in the adjacent compartment.

1.3.4 Each cubicle shall be separated from the adjacent one by grounded sheet-steel barrier and bus sealing arrangement. Bus connection from the bus compartment to breaker compartment or busbar compartment to cable compartment or bus compartment of adjacent panel shall be through sealed porcelain bushing with semi-conducting neoprene rubber ring.

1.3.5 Non-deteriorating synthetic rubber gaskets preferably neoprene, without any discontinuous joints shall be provided on all mating surfaces. Sufficient number of bolts, where necessary, shall be provided so that a uniform pressure is maintained on the gasket.

1.3.6 Switch and lamps shall be flush/semiflush mounted on hinged front door of the cubicle. The relays and meters shall be flush/semiflush mounted on the front portion of the cubicle.

1.3.7 The protection devices, control components and all the other parts used on the boards shall be carefully chosen to meet the system requirements and duly standardised to permit the interchangeability, minimisation of the spares and easy maintenance. The switchgear shall be designed throughout to ensure safety during operation, inspection, cleaning & maintenance. Necessary mechanical interlocks shall be provided for this purpose.

1.3.8 The degree of protection to be provided by the enclosure shall be IP-4x. In case louvers are provided, they shall have brass wire mesh and filters. Pressure relief flaps shall be covered with perforated sheet having 1mm dia holes.

1.3.9 Each panel shall be provided with thermostat controlled space heater of adequate rating and single phase plug point with switch operated at 230 VAC, 50 Hz. Heaters shall have individual 'ON/OFF' switches, wired together & brought to

easily accessible terminals in a common panel for the connection to the external supply.

1.3.10 All the external bolts and nuts shall be made of steel and shall be cadmium plated or zinc passivated. Zinc plated high tensile bolts shall be used for busbar joint.

1.4 **BUS BARS & CONNECTIONS** :

1.4.1 The bus bar and connection shall be made of hard drawn electrolytic copper or equivalent aluminium of rectangular cross section, liberally sized for specified current ratings.

1.4.2 The horizontal bus-bars shall run the entire length of the board & shall be of the same cross section. Stepped bus-bars are not acceptable.

1.4.3 The bus bars shall be sized to carry the rated continuous current under site ambient without exceeding the temperature rise specified in B.S. 159 or equivalent International Standards.

1.4.4 The bus bars shall be suitably supported and adequately secured to withstand the stresses developed during the system short circuit conditions.

1.4.5 The bus bars shall have the marking, colour coding and arrangement according to the relevant IS or International Standard and shall run in a separate bus bar chamber.

1.4.6 Connection between the vertical bus bars and circuit breaker terminals shall preferably be fully insulated and so enclosed as not to leave any exposed live parts. It shall be possible to work on the circuit breaker outgoing connections without any danger of accidental contacts with the live connections between the vertical bus bars and the circuit breaker.

1.4.7 Three phase bus bar shall be adequately insulated for unearthed system with 10% tolerance. For air-insulated switchgear, the buses & jumpers shall be provided with heat shrinkable insulating sleeves of fluidised red epoxy powder coating. All joints shall be provided with detachable cast resin fiber glass shrouds.

1.4.8 Fixed disconnects shall be shrouded with cast resin fibre glass mould. Bus insulation at joints shall be easily removable during periodic inspection at joints. In case of copper bus, all bus connections, joints and laps shall be silver plated. For aluminimum-bus, Beleville washers shall be provided at the joints. All the connections shall be as straight as possible.

1.5 **INSULATION:**

1.5.1 The insulation used shall be non-hygroscopic and shall be of adequate electrical and mechanical strength to give trouble free service during the normal operation and short circuit conditions. The insulation shall be treated suitably to withstand the tropical conditions.

1.6 **CIRCUIT BREAKERS** :

1.6.1 The circuit breakers shall be of the 3 phase single/double break, horizontal drawout, vertical/horizontal isolation. as mentioned in spec. sheet suitable for LOCAL/REMOTE operation with rupturing capacity and continuous current carrying capacity as given in the specification. The breaker shall be mounted on withdrawable truck in the single tier formation.

1.6.2 Circuit breakers controlling motors, if any, shall have provision to limit over voltage to the value safe for motor insulation. Over-voltage factor should be limited to 2.5, preferably by suitable breaker design. Alternatively, suitable surge diverter shall be used.

1.6.3 All breakers of like rating shall be physically and electrically interchangeable.

1.6.4 The closing coils and other auxiliary devices shall operate satisfactorily at all the voltages between 85% to 110% of the rated control voltage.

1.6.5 When the breaker is in closed position, a closing operation of an initiating control device shall neither result in further operation of the breaker closing mechanism nor endanger the operator.

1.6.6 An emergency handle shall be supplied for manual operation of the breaker in case of failure of closing power. The 'CLOSE' push button provided for this purpose shall be accessible after opening the door.

1.6.7 Provision shall be made for the manual closing. A suitable operating handle shall be supplied, one for each board, for this purpose.

1.6.8 Each breaker shall have three positions - SERVICE, TEST & DISCONNECTED with mechanical indications. The design of breaker should be such that without opening the front access door it should be possible to pull out the breaker in disconnected position. Panel door shall remain closed even when the breaker is drawn to test position.

1.6.9 The breakers shall be provided with motor-operated power closing mechanism and shall include trip free (electrically and mechanically) and anti-pumping features. Motor operating mechanism shall be complete with universal motor, opening spring, closing spring and all necessary accessories to make the mechanism complete operating unit.

1.6.10 The motor shall be suitable for operation with voltage variation from 80% to 110% for rated voltage. Spring charging time shall be indicated in the offer. As long as the power is available to the motor, a continuous sequence of closing and opening shall be possible. After the failure of power supply to motor, atleast one 'OPEN-CLOSE-OPEN' operation of the circuit breaker shall be possible. Motor shall be solely used for compressing the closing spring.

1.6.11 Closing action of the circuit breaker shall compress the opening spring ready for tripping.

1.6.12 Soon after closing spring is discharged after closing a breaker, the closing spring shall automatically be charged for the next operation.

1.6.13 The breaker shall be provided with shunt trip coil. Provision shall be made for mechanically tripping the breaker in case of emergency. The trip coil and other

associated auxiliary devices shall be operated reliably and satisfactorily at all voltages between 70% to 110% of its rated voltage.

1.6.14 Mechanical 'Test', 'Services' position and spring 'CHARGED-DISCHARGED' indicators appropriately marked shall be provided on the front of the breakers. The breaker shall also be provided with an operation counter.

1.6.15 The local breaker switch with sequence interlocking device shall be mounted on the switchgear. This switch shall be a three positions spring returned to 'Normal' position switch with pistol-grip handle and with the positions marked 'OPEN-NORMAL-CLOSE'. Wherever the breaker is to be controlled from remote 'LOCAL/REMOTE', selector switch with locking device shall be provided on the switchgear.

1.6.16 For switchgear which will have to close or trip automatically when another breaker or interlocking switch, etc., operates, lockable type 'AUTO/MANUAL' control switch selector shall be provided.

1.6.17 Mechanical interlocks shall be provided to prevent :

a) A closed C.B. from being isolated from inserted position into the service position.

b) Closing and opening of the C.B. in an intermediate position between 'SERVICE AND TEST'.

c) The C.B. can be racked into the service position only with the front door closed.

d) Any other interlocking feature required for safe operation.

1.6.18 Automatic safety shutters shall be provided to completely cover the primary disconnects when the breaker is withdrawn. The safety shutter shall be arc resistant polyester type. It is preferable to have this transparent and of stronger design than the pressure relief flap.

1.6.19 Positive earthing of the circuit breaker frame shall be maintained when it is in connected position and in all the other positions in which the safety shutter is in the open position.

1.6.20 Cable earthing facility should be provided in the circuit breaker for discharging the power cable through the circuit breaker contacts in the circuit breaker drawn-out position. An integral earthing arrangement shall be preferred with necessary safety interlock both for cable side and bus side. Earthing carriage shall have the necessary P.T. and alarm device to detect the live condition before the insertion in case the integral earthing switch is not provided.

1.6.21 A maintenance truck/device for raising, lowering and withdrawal of the circuit breakers, when necessary shall be provided for each board.

1.7 **Circuit breaker Auxiliary switch contacts and racking switch contacts**

1.7.1 The circuit breaker shall be provided with six numbers of the normally open and six nos. Of normally closed contacts, with the spare contacts wired to the terminal board.

1.7.2 The auxiliary contacts shall be suitable for inductive breaking (not less than 5 amp) at the control voltage specified. Necessary number of racking switch contacts shall also be included.

1.8 ARC INTERRUPTING DEVICES :

1.8.1 The arc-interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits.

The main contacts shall be of the self aligning type.

1.9 Circuit Breaker Controlling Motor :

1.9.1 The circuit breaker shall be suitable for starting and stopping induction motor a number of times without any intentional time interval.

1.10 Circuit breaker controlling capacitors :

1.10.1 The circuit breaker shall be suitable for making and breaking capacitor banks of rated current. In case there is any limitation on the size of the capacitor bank which can be safely connected to the circuit breaker, this shall be indicated.

1.11 Current Transformers

1.11.1 The current transformers may be of the bar-primary or wound primary cast resin type, depending upon the ratio involved and the dynamic considerations, output and accuracy requirements. The current transformer ratios as given in the tender details and respective drawings are tentative and are subject to confirmation.

1.11.2 The current transformers offered shall be as per the relevant IS/IEC standard and shall have the accuracies and outputs adequate for the protection, instrument and metering duties involved. The output shall preferably be 36VA per phase and in any case it shall not be less than that required for relaying, instruments and metering involved with sufficient margin for future additions. Tenderer shall clearly specify the output of the current transformers offered, after thorough checking and shall confirm these requirements.

The current transformers have the following accuracies for the various applications :-

Application :	Class of Accuracy of CT as per IS:
a) For metering services	1
b) For ammeter service	1
c) For use with protective relays (time delayed)	5P

d) For use with the protective relays and ammeter service 5P
e) For use with differential relays PS

1.11.3 The secondaries of the C.Ts shall be rated for 5 amps or 1 amp full load as called for in the feeder details.

1.11.4 The CTs for earth fault relay shall be so designed that when residually connected for earth fault protection, they are closely matched so that the spill current under full load/overload and through fault current conditions, shall be small though enough so as not to operate the earth fault relay.

1.11.5 The current transformers shall have a short time thermal current rating adequate for the short circuit level of the system in which they are to be used and their short time withstand time shall match the short time rating of the associated switchgear. The short time dynamic current rating must not be less than 2.5 times the short time thermal current.

1.11.6 The C.T. shall be capable of withstanding a momentary open circuit on the secondary side without injurious effects.

1.11.7 The temperature rise of the winding of the CTs when carrying rated continuous current shall not exceed the values given in the relevant standard and shall be limited by the lowest class of the insulation of either the windings itself or the surrounding medium in which it is embedded.

1.11.8 The C.T. shall also be secured in the position that no undue strain comes on the windings/terminals. All C.Ts shall be provided with shorting terminals and links. The test terminals with eye lugs and links shall be provided. All C.T. secondaries shall be earthed through a separate earth link on the terminal block.

1.12 **VOLTAGE TRANSFORMER** :

1.12.1 The voltage transformers (VT) shall preferably be of cast resin design (Hot casting will be preferred) and shall comply with the relevant standards. The V.T. shall be of the plug-in type, and withdrawable for isolation or maintenance. The primary and secondary disconnects shall have the pressure type contacts. It shall be mounted preferably in the breaker panel.

1.12.2 The secondary voltage of the V.T. shall be 110 volts. The accuracy class of the V.T. shall be 1.0. The V.T. shall preferably be of 200VA output per phase and in any case, the output shall not be less than that required for the relaying, instruments and metering duties involved with sufficient margins for future additions. The tenderer shall clearly specify the output of the V.T. offered and confirm after thorough checking.

1.12.3 The 110 volt bus in the switchboard shall be sectionalised, each section obtaining its 110 volts supply from the V.T. on its incoming circuit breaker through an auxiliary switch of the breaker. It shall be possible, in the event of any of the incoming circuits being put to use, to extend 110 volt supply to the affected V.T. bus section by closing the bus section breakers through auxiliary switch contacts of the bus section breaker.

1.12.4 Shutter shall be provided in the V.T. chamber so arranged that the V.T. orifices are automatically closed when the V.T. is withdrawn.

1.12.5 The V.T. shall be provided with fuses both on the H.V. and L.V. sides. H.V. winding shall be protected by current limiting fuses & low voltage fuses, sized to prevent the harmful effect of overload, shall be installed in all ungrounded secondary leads of the V.T.

1.12.6 Mechanical interlocking arrangements shall be provided so that access to the high voltage fuses is gained only when the V.T. is fully isolated.

1.12.7 The point of connection of the V.T. in the circuit shall be as specified elsewhere.

1.13 **RELAYS** :

1.13.1 The tenderer shall furnish, install and co-ordinate all the relays to suit the requirements of the protection, operation and inter-lock of the equipment connected to the switchgear. All relays shall be provided in draw out and dust proof cases and shall be flush mounted type. They shall be fully tropicalised. IDMTL current relays shall generally have adjustable plug settings ranging from 50% to 200% in steps of 25% and time multiplier ranging from 0 to 1 (settings) in steps of .05.

1.13.2 Earth fault relays shall have a setting range of 10% to 40%.

1.13.3 All IDMTL relays shall have a characteristic with DMT of 2.2 sec. and an operating time of 3 seconds at 10 times the plug setting with multiplier of 1.

1.13.4 The thermal relays specified for the protection of the H.T motors shall have overcurrent element with the high set instantaneous device on the two outer phases, instantaneous earth fault element connected in the residual circuit of the phase C.Ts and a negative phase sequence current element for tripping the motor on unbalanced supply voltage condition. The thermal element shall preferably be of the electronic type. If the tolerance on 'Operating time due to change in ambient temperature' over the 'standard' is appreciable, the thermal overcurrent element shall be calibrated for the ambient specified. The high set instantaneous element shall have a setting range, preferably 600% to 1200%.

1.13.5 The differential relays shall be of the high speed type and shall be stable under through faults and magnetic inrush currents.

1.13.6 The restricted earth fault relays shall be high impedance and high speed type and shall be complete with the required stabilising resistor. The relays shall be stable under through faults and magnetic inrush currents.

1.13.7 The relay contacts shall be of silver, platinum or other approved material and shall be capable of repeated operation without any deterioration. The contact ratings shall be as per relevant standards.

1.13.8 The operating coils of the D.C. relays shall be so placed in the circuit that they are not connected to the positive pole of the battery except through the contact which are normally open.

1.13.9 All protective relays shall be provided with flag indicators and all relays directly tripping the breakers shall be provided with hand reset contacts in addition to the flag indicator. The flag indicators shall be suitable for external hand resetting and be mechanically interlocked to prevent from falling when the relay is subject to vibration. Hand reset relays shall be arranged for external hand resetting.

1.13.10 Test blocks of other suitable arrangements shall be provided for testing of relays, meters and instruments. The test blocks shall provide complete isolation of meters, relays and instruments and the arrangement shall be such that the testing power could be connected at the test block from an external source. Provision shall be made for short circuiting the current transformers where the test blocks are inserted. The terminals of the test block shall be numbered.

1.13.11 All the relays shall be suitably marked as per relevant standards.

1.13.12 Where the relays are required to operate with a time delay, delaying attachment shall be electronic type only.

1.13.13 All relays and other protective devices shall be properly graded, set and co-ordination chart showing the exact relay time and current settings etc., shall be supplied. All the calculations involved in the selection, protection and relay co-ordination shall be furnished to the purchaser for approval. Any data required in this respect will be furnished by the purchaser.

1.13.14 Necessary auxiliary relays and timers shall be provided where required. The tender shall clearly indicate in the offer the different auxiliary / timing relays furnished for each breaker cubicle.

1.13.15 The VA burden on the various taps of all relays and instruments shall be clearly indicated by the tenderers.

1.13.16 All the contacts of the relays, whether utilised or not, shall be wired upto the terminal board of the relays.

1.13.17 The relays shall be visibly marked to indicate the purpose for which it is used.

1.14 **INSTRUMENT AND METERS** :

1.14.1 The instruments shall be of Digital type and suitable for flush mounting of 96 sq.mm. They shall be fully tropicalized and dust-tight and shall conform to the relevant standards.

1.14.2 The instruments shall be capable of indicating accurately when operating continuously under the ambient conditions specified.

1.14.3 The instruments shall be mounted on the panel at a suitable height so as to facilitate reading and ease of access for testing and maintenance without any danger of accidental contact with live parts of the switchgears.

1.15 **INTERNAL WIRING** :

1.15.1 Internal wiring shall be securely fixed in position and shall be so arranged as to the connection to be easily traced. Wiring, subject to movement in service, shall have stranded conductors and the installation shall be adequately protected against abrasion.

1.15.2 All the wiring shall be marked in accordance with the relevant standard. The insulation on the conductors shall be fire-resisting numbered ferrules, reading from the terminals outwards shall be provided at both ends of all the wiring for easy identification. Interlocking type plastic ferrules shall be used.

1.15.3 Terminals and terminal boards for internal wiring shall be so arranged as to minimize the number of connections.

1.15.4 Internal wiring circuits, fed from a supply common to a number of panels, shall be so protected that a failure of a circuit in one panel does not affect the operation of other panels.

1.15.5 The internal wiring shall be of PVC insulated cable of 1100V/650V grade of minimum size 2.5 sq. mm copper.

1.16 **Terminal block** :

1.16.1 Terminal block shall be provided with means for terminating the outgoing ends of cubicle wiring and corresponding incoming tail ends of the control cables. They shall be shrouded, preferably by a transparent acrylic sheet.

1.16.2 The provision shall be made for accommodating 20% extra connections after wiring all the contacts, whether used or not at the terminal block.

1.16.3 The terminal block shall be suitably numbered.

1.16.4 The terminal block of different voltage classes shall be segregated.

1.17 **Control Cable Terminations** :

1.17.1 Provision for termination arrangement for the control cables shall include a suitable clamp-type terminal block, removable gland plates, cable supporting arrangements, cable glands and crimping-type lugs.

1.18 **Power Cable termination** :

1.18.1 The vendor shall include in his offer, terminal arrangements, suitable for receiving PVC/XLPE aluminum cable of sizes mentioned in the feeder details.

1.18.2 Suitable tinned copper crimping type lug sockets in accordance with table 28 of B.S. 81 (or equivalent) shall be provided.

1.18.3 Cable gland plates and supporting structure for single core cable shall be such as to prevent the flow of eddy current and heating due to such eddy current.

1.19 **ANNUNCIATOR WINDOWS ON EACH PANEL :**

These shall be provided to indicate the various circuit conditions and these shall be placed at a suitable height. The various functions shall be as follows :

- Circuit breaker closed.
- Circuit breaker open.
- Trip circuit healthy.
- Alarm and auto trip.
- Transformer non-trip.
- Circuit breaker in test.

All windows and switches shall be provided with necessary identification labels.

1.20 **ALARM ANNUNCIATOR SCHEMES** :

1.20.1 There shall be three types of alarm annunciation for each switchboard as described in the following paragraphs and detailed in the drawings enclosed.

- Auto-trip alarm scheme, which shall operate whenever any of the breakers trips on fault.

- Trip circuit supervision schemes, which shall operate whenever (i) there is a discontinuity in the trip coil circuit or (ii) complete disappearance of the trip supply in any of the breaker panels.

- Non-trip alarm scheme which will operate whenever there is a non-trip fault (e.g. Buchholz, oil temp, alarm etc.) in any of the panels.

1.21 **INTERLOCKS** :

1.21.1 The tenderer shall include all the electrical and mechanical interlocks as may be specified necessary for the safe and satisfactory operation of the switchgear. Interlocks shall incorporate fail-safe features. Interlock defeat feature shall be provided where specifically called for. Electrical interlocks shall be provided so that the incoming breakers cannot be paralleled normally.

1.22 **EARTH BUS** :

1.22.1 Every switchboard shall be provided with a continuous earth bus of copper/aluminum with two end terminals to provide a high conductive path to the earth. The earth bus shall be rated to carry the 3 phase fault current for a period of 10 sec.

1.22.2 Each stationary unit shall be earthed directly to this earth bus of copper / aluminum with two end terminals to provide a high conductive path to earth. The earth bus shall be rated to carry the 3 phase fault current for a period of 10 sec.

1.22.3 The earthing terminal connectors including the hardware shall be provided at either end for the connection to external earth conductor.

1.22.4 The frame of each circuit breaker shall be earthed through heavy multiple finger contacts at all the times except when the breaker primary disconnecting devices are separated by a safe distance.

1.23 **OTHER ACCESSORIES** :

1.23.1 The supply shall include all accessories, whether indicated in the aforesaid and the following description or not, to make the switch board complete in all respects and to ensure its safe proper operation and maintenance.

a) Secondary plug and socket assembly for testing breaker outside the housing.

b) Handle for manual spring charging.

c) Breaker transport trolley

d) Earthing truck

e) Vacuum cleaner.

1.24 **LABEL INSCRIPTION** :

1.24.1 Suitable label inscriptions like the names of panels, functions of switches, lamps, etc, made of trifoliate or similar material shall be provided on the switch boards. Two separate labels shall be provided on each panel, one bearing the panel number and the other, panel designation. Labels bearing the panel numbers and designation shall also be provided on the back side of each panel. The letter shall be in white on black background.

1.24.2 All the equipment in the various panels shall bear name plate markings giving particulars as required by the relevant standard specifications.

1.25 **AUXILIARY SUPPLY** :

1.25.1 The bus coupler panel should be provided with one DC supply for closing and indication, one AC supply for tripping and one AC supply for space heater, indication and alarm.

1.26 **OTHER POINT** :

- Necessary starting / tripping shall be provided in the schematics for motor feeders, if any.

- Flags and indications shall remain in operation till the particular fault is removed.

- The front side of the control terminal blocks shall be covered preferably by a transparent acrylic sheet.

- The panel space heaters shall be controlled by thermostat and {'ON'} indication shall be provided in the front of the panel.

- The breaker shall not have any de rating at the site ambient specified.
- The offer should clearly include the list of imported components to be used in the breaker.
- Five (5) no. auxiliary relays shall be included for Buchholz alarm and trip, winding temperature alarm and trip and oil temperature alarm.
- Units shall be constructed to provide interchangeability of corresponding parts

The HT Panel should be Type Tested with Report from CPRI i.e. Internal Arc & Impulse.

DATA SHEET FOR DISTRIBUTION TRANSFORMER

OUTDOOR/INDOOR TYPE, OIL IMMERSED DISTRIBUTION TRANSFORMERS UPTO AND INCLUDING 2500 kVA, 33 kV – SPECIFICATION (Part 2: ESTER LIQUID IMMERSED)

1. **SCOPE**

This standard specifies the requirements and tests including standard loss levels of ester liquid-immersed, natural air-cooled, outdoor/indoor type, double-wound distribution transformers for use in Power distribution systems with nominal system voltages up to and including 33 kV and of following types and ratings:

a. Three phase ratings up to and including both 200 kVA, non-sealed and sealed type.
b. Three phase ratings higher than 200 kVA up to and including 2500 kVA both non-sealed type and sealed type.
c. Single phase ratings up to and including 25 kVA sealed type.

NOTES:

1 The following types of transformers are not covered under the scope of this standard:

a. Inverter duty transformers
b. Traction transformers
c. Instrument transformers
d. Transformers for static converters
e. Starting transformers
f. Testing transformers
g. Welding transformers
h. Earthing transformers
i. Mining transformers
j. Transformers for solar, wind power application
k. Transformers for Railways (Locomotive and other applications)
l. Furnace transformers
m. Rectifier transformers
n. Dual Ratio in Primary / Secondary windings Transformers

2 For Indoor type Distribution Transformers, relevant provisions of Central Electricity Authority (CEA) regulations, if any, shall be applicable.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed in Annex A.
Annex A1 gives list of IEC, IEEE Standards, Cigre brochures etc. on Ester liquids.

3 TERMINOLOGY

For the purpose of this standard, the following terms and definitions shall apply in addition to those given in IS 1885 (Part 38).

3.1 Distribution Transformer

A Distribution Transformer is a transformer that provides the final voltage transformation by stepping voltages down within a distribution circuit or from a distribution circuit to an end user or application.

NOTE

The distribution circuit voltages are 3.3 kV, 6.6 kV, 11 kV, 22 kV and 33 kV in the country. The power supply for the end users is 415 volt, 3 Phase (240 volt, 1 phase), 50 Hz. Transformers with primary voltages of 3.3, 6.6, 11, 22 or 33 kV and secondary voltage of 433 volt, 3 Phase (and 250 volt single phase) are called Distribution Transformers. The maximum rating of these transformers for the purpose of this standard is considered up to 2500 kVA, 3 Phase.

3.2 Non Sealed type Transformer

A transformer which has a breather for breathing out and breathing in and/or a conservator with expansion and contraction of liquid with temperature. The transformer tank body and cover are bolted / clamped / welded type. The tank can also be of corrugated construction.

3.3 Sealed type Transformer

A transformer which is non-breathing that is so sealed that normally there is no significant interchange between its contents and the external atmosphere. No conservator is provided. Such a transformer may or may not have a cushion of inert gas (for example; Nitrogen, IS 1747).

Sealed transformers fall in to two categories:

a) Transformers in which the total volume of oil together with inert gas / N2 or any combination thereof, remains constant over the temperature range.

b) Transformers in which the total volume of liquid, inert gas / N2 or any combination thereof, varies over the temperature range and this variation is accommodated by a sealed flexible container (corrugated tank) or a flexible membrane.

Sealed type transformers usually have a bolted / clamped / welded cover construction.

3.4 “K” class Insulating Liquids

According to IS 13503 “Classification of Insulating Liquids”, Liquids with fire point above 300 °C are classified as K class liquids. Synthetic Organic Ester, Natural Ester and Silicon liquids come under this category. Percentage of biodegradability of silicone liquid is low (around 5 %).For the purpose of this standard, only Synthetic esters and Natural Esters which are 80 to 100% biodegradable are considered.

3.4 (a) *Natural Esters*

Vegetable oils obtained from seed (such as soya, rapeseed, and sunflower) and liquids from other suitable biological materials and comprised of triglycerides are called Natural esters. Suitable chemical substances called “additives” are deliberately added to natural ester insulating liquids in order to improve certain characteristics, e.g. pour point, viscosity, foaming and oxidation stability. Natural esters are suitable for sealed transformer and transformers equipped with airbags or suitable liquid preservation system which prevents direct contact of oxygen with the liquid in the conservator. Natural Esters are not recommended for free breathing type since oxygen from air accelerates oxidation of natural esters and which increases the viscosity of the liquid

3.4 (b) Synthetic organic Esters
By definition an ester is a reaction product from the combination of an acid and an alcohol. Synthetic organic esters are manufactured from carefully selected raw materials to give a product that is tailored to specific application of transformers blended with additives to improve certain characteristics, e.g. pour point, viscosity, foaming excellent oxidation stability making it suitable for the breathing system where the liquid has free access to oxygen from air. Synthetic organic Esters are suitable for non-sealedand sealed transformers without any preservation system.

3.5 Pad Mounted Transformer
An outdoor transformer utilized as part of underground distribution system with enclosed compartment (s) for high voltage and low voltage cables entering from below and mounted on a foundation pad.
The pad mounted transformer generally covers two bushing and terminal arrangements for radial feed systems. It consists of a tank with high voltage and low voltage cable terminating compartments separated by a barrier of metal or other rigid material. These compartments are located side by side on one side of the transformer tank. The transformer shall be of sealed construction.

4 SERVICE CONDITIONS

The provisions of IS 2026 (Part 1) shall apply.
NOTE: In case of Indoor transformers and transformers installed in an enclosure, suitable ventilation, if required, shall be provided to maintain service conditions as per IS 2026 (Part 1).

5 GENERAL

Technical parameters including standard loss levels of three categories of Distribution transformers are given in **6**, **7**&**8.**

Other requirements as described in **9** to **22** are applicable for all types and ratings of distribution transformers.

6 TECHNICAL PARAMETERS OF THREE PHASE DISTRIBUTION TRANSFORMERS UP TO AND INCLUDING 200 kVA (NonSealed and SealedType)

6.1 Ratings

The standard ratings shall be as per Table 1.

Table 1 Standard ratings
(Clause **6.1**)

Sl No.	Nominal System Voltage	Standard Ratings (kVA)
(1)	(2)	(3)
i)	Up to and including 11 kV	*6.3,*10,16, *20,25, *40,63, 100, 160 and 200
ii)	Above 11 kV up to and including 22 kV	63, 100, 160 and 200
iii)	Above 22 kV up to and including 33 kV	100, 160 and 200

NOTE -* ratings are non-preferred

6.2 Rated Frequency

The rated frequency shall be 50 Hz.

6.3 Nominal System Voltage

Nominal system voltage shall be chosen from the following:

High Voltage (HV) - 3.3, 6.6, 11, 22 & 33 kV

Low Voltage (LV) - 415V

6.4 Basic Insulation Level (BIL).

Minimum basic Insulation Levels shall be as given in Table 2.

TABLE 2 Minimum Basic Insulation Level
(Clause **6.4**)

Sl No.	Nominal System Voltage (kV)	Rated BIL (kVp)
(1)	(2)	(3)
i)	3.3	40
ii)	6.6	60
iii)	11	75
iv)	22	125
v)	33	170

NOTE: Insulation coordination of all relevant fittings and accessories corresponding to higher BIL values shall be ensured.

6.5 No-Load Voltage ratios

The no-load voltage ratios shall be as follows:

3 300/433-250, 6 600/433-250, 11 000/433-250, 22 000/433-250 and 33 000/433-250 V

NOTE— Secondary voltage may be selected as 415-240 V, subject to agreement between User and Supplier

6.6 Winding Connections and Phase Displacement

The primary winding shall be connected in delta and the secondary winding in star [vector symbol, Dyn 11 (see IS 2026 Part 1)], so as to produce, a positive phase displacement of 30^{o} from the primary to the secondary vectors of the same phase. The neutral of the secondary winding shall be brought out to a separate insulated terminal.

6.7 Tapping Range and Tapping Methods

6.7.1 No taps are normally required to be provided upto 100 kVA rating, unless specifically specified by the user.

6.7.2 The standard tapping range, when taps are provided above 100 kVA rating shall be as follows:

Winding tapped	HV
Number of tap positions	4
Voltage variation	+2 1/2 percent to -5 per cent of HV in steps of 2 1/2 percent

6.7.3 Off circuit Tap-changing arrangement shall be either by means of links or by means of an externally-operated switch with mechanical locking device and a position indicator. Arrangement for pad-locking shall be provided.

6.7.4 Provision of any other tapping range and tapping step is subject to agreement between the user and the supplier.

6.8 Losses and Impedance Values

6.8.1 *Losses*

6.8.1.1 For transformers of HV voltage up to 11 kV, the total losses (no-load + load losses at 75^{0}C) at 50 percent of rated load and total losses at 100 percent of rated load shall not exceed the maximum total loss values given in Table 3:

Table 3 Maximum total losses up to 11kV class Transformers
(Clause **6.8.1.1, 6.8.1.2 and 6.8.1.3**)

S.No	Rating (kVA)	Impedance (percent)	Max. Total Loss (W)					
			Energy Efficiency Level 1		Energy Efficiency Level 2		Energy Efficiency Level 3	
			50 % Load	**100 % Load**	**50 % Load**	**100 % Load**	**50 % Load**	**100 % Load**
(1)	(2)	(3)	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
i)	6.3	4.0	53	245	48	225	42	205
ii)	10	4.5	72	270	65	240	58	215
iii)	16	4.5	150	480	135	440	120	400
iv)	20	4.5	175	575	160	525	145	485
v)	25	4.5	210	695	190	635	175	595
vi)	40	4.5	277	914	249	834	224	774
vii)	63	4.5	380	1250	340	1140	300	1050
Viii)	100	4.5	520	1800	475	1650	435	1500
ix)	160	4.5	770	2200	670	1950	570	1700
x)	200	4.5	890	2700	780	2300	670	2100

NOTE - For non – preferred ratings of Table 1, max losses are subject to agreement between User and Supplier.

6.8.1.2 For transformers having voltage class above 11kV and up to and including 22 kV, the permissible total loss values shall not exceed by 5 percent of the maximumtotal loss values mentioned in table 3.

6.8.1.3 For transformers having voltage class above 22 kV and up to and including 33 kV, the permissible total loss values shall not exceed by 7 ½ percent of the maximum total loss values mentioned in table 3.

6.8.2 *Impedance*

The recommended impedance at 75ºC for different ratings is as per Table 3.

6.9 Permissible Flux Density and over fluxing

6.9.1 The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with + 12.5 percent combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla.

NOTE The design calculations in support of flux density shall be furnished by manufacturer.

6.9.2 No load current up to 200 kVA shall not exceed 3 percent of full load current and will be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5 percent of rated voltage shall not increase the no load current by 6 percent maximum of full load current.

6.10 Limits of Temperature-Rise

6.10.1 The type of cooling shall be type KNAN as per IS 2026 (Part 2).

6.10.2 The permissible temperature-rise shall not exceed the limits of 40^{o}C (when measured by resistance method) for transformer winding and 35^{o}C (measured by thermometer) for top liquid when tested in accordance with IS 2026 (Part 2) when conventional insulation system is used (as for retro filling).The marginal increase in temperature rises by use of Ester liquids is ignored (since this is compensated by slow ageing).

6.10.3 The permissible temperature rise will not exceed the limit of 55^{o}C (when measured by resistance method) for transformer winding and 50^{o}C (measured by thermometer by oil when tested in accordance with IS 2026 (Part 2) when semi hybrid high temperature insulation in accordance with IEC 60076-14 (2013)

Note— Semi hybrid insulation system consists of mainly high temperature solid insulation materials thermally upgraded paper (TUP) used for windings alone.

During temperature rise test, total losses at 75 ^{o}C shall be fed.

7 TECHNICAL PARAMETERS OF THREE PHASE DISTRIBUTION TRANSFORMERS HIGHER THAN 200 kVA UP TO AND INCLUDING 2500 kVA (NON SEALED AND SEALED TYPE)

7.1 Ratings

The standard ratings shall be as per Table 4.

Table 4 Standard ratings
(*Clause***7.1**)

Sl No.	Nominal System Voltage	Standard Ratings(kVA)
(1)	(2)	(3)
I)	Up to and including 11 kV	250, 315, 400, 500, 630, 800,1000, 1250, 1600, 2000 and 2500
Ii)	Above 11 kV up to and including 22 kV	250, 315, 400, 500, 630, 800,1000, 1250, 1600, 2000 and 2500
Iii)	Above 22 kV up to and including 33 kV	250, 315, 400, 500, 630, 800,1000, 1250, 1600, 2000 and 2500

7.2Rated Frequency

The rated frequency shall be 50 Hz.

7.3Nominal System Voltage

Nominal system voltage shall be chosen from the following :

HV - 3.3, 6.6, 11, 22 & 33 kV

LV - 415V

7.4 Basic Insulation Level (BIL)

The minimum Basic Insulation Level (BIL) shall be as given in Table 5.

Table 5 Minimum Basic Insulation Level
(Clause **7.4**)

Sl No.	Nominal System Voltage (kV)	Minimum BIL (kVp)
(1)	(2)	(3)
i)	3.3	40
ii)	6.6	60
iii)	11	75
iv)	22	125
v)	33	170

NOTE: Insulation coordination of all relevant fittings and accessories corresponding to higher BIL values shall be ensured.

7.5 No-Load Voltage Ratios

The no-load voltage ratios shall be as follows:

3 300/433-250, 6 600/433-250, 11 000/433-250, 22 000/433-250 and
33 000/433-250 V

NOTE-Secondary voltage may be selected as 415-240 V, subject to agreement between User and Supplier

7.6 Winding connections and Phase Displacement

The primary winding shall be connected in delta and the secondary winding in star [vector symbol, Dyn 11 (see IS 2026 Part 1)], so as to produce, a positive phase displacement of 30^{o} from the primary to the secondary vectors of the same phase. The neutral of the secondary winding shall be brought out to a separate insulated terminal.

Alternatively, [Dyn1 (see IS 2026 Part 1)] can also be specified. If system and application requirements demand different vector groups, the same can also be adopted.

7.7 Tapping ranges and Tapping methods

7.7.1 The standard tapping ranges, when taps are provided, shall be as follows:

Winding tapped	HV
Number of tap positions	7
Voltage Variations	+ 5 percent to -10 percent in steps of 2.5 % for variation of HV

7.7.2 Off circuit Tap-changing arrangement shall be either by means of links or by means of an externally-operated switch with mechanical locking device and a position indicator. Arrangement for pad-locking shall be provided.

7.7.3 For ratings 500 kVA and above, on load tap changers may be provided for variation of HV voltage from + 5 percent to – 15 percent in steps of 2.5 percent.

7.7.4 Provision of any other tapping range and tapping step is subject to agreement between user and the supplier.

7.8 Losses and Impedance Values

7.8.1 *Losses*

7.8.1.1 For transformers of HV voltage upto 11kV, the total losses (no-load + load losses at 75ºC) at 50 percent of rated load and total losses at 100 percent of rated load shall not exceed the maximum totalloss values given in the following Table 6.

Table 6 Maximum total losses up to 11 kV class transformer
(*Clauses* **7.8.1.1, 7.8.1.2, 7.8.1.3 and 7.8.2**)

S. No.	Rating (KVA)	Impedance (%)	Max. Total loss (W)					
			Energy Efficiency Level 1		Energy Efficiency Level 2		Energy Efficiency Level 3	
			50% Load	100% Load	50% Load	100% Load	50% Load	100% Load
i)	250	4.50	1050	3150	980	2930	920	2700
ii)	315	4.50	1100	3275	1025	3100	955	2750
iii)	400	4.50	1300	3875	1225	3450	1150	3330
iv)	500	4.50	1600	4750	1510	4300	1430	4100
v)	630	4.50	2000	5855	1860	5300	1745	4850
Vi)	800	5.0	2459	7300	2287	6402	2147	5837
vii)	1000	5.00	3000	9000	2790	7700	2620	7000
viii)	1250	5.00	3600	10750	3300	9200	3220	8400
ix)	1600	6.25	4500	13500	4200	11800	3970	11300
x)	2000	6.25	5400	17000	5050	15000	4790	14100
xi)	2500	6.25	6500	20000	6150	18500	5900	17500

7.8.1.2 For transformers having voltage class above 11 kV and up to and including 22kV, the permissible total loss values shall not exceed by 5 percent of the maximum total loss values mentioned in Table 6.

7.8.1.3 For transformers having voltage class above 22 kV and up to and including 33kV, the permissible total loss values shall not exceed by 7 ½ percent of the maximum total loss values mentioned in Table 6.

7.8.2 ***Impedance***

The recommended percent impedance at 75^{o}C for different ratings shall be as perTable 6.

7.9Permissible Flux Density and Overfluxing

7.9.1 The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with + 12.5 percent combined voltage and frequency variation from rated voltage and frequency does not exceed 1.9 Tesla.

NOTE - The design calculations in support of flux density shall be furnished by the manufacturer.

7.9.2 No load current shall not exceed two percent of the full load current and shall be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5 percent of rated voltage shall not increase the no load current by 5 percent of full load current.

7.10 Limits of Temperature Rise

7.10.1 The type of cooling shall be KNAN as per IS 2026 (Part 2).

7.10.2 The permissible temperature-rise shall not exceed the limits of 45°C (when measured by resistance method) for transformer winding and 40°C (measured by thermometer) for top

oil when tested in accordance with IS 2026 (Part 2) when conventional insulation system is used(as for retro filling). The marginal increase in temperature rises by use of Ester liquids is ignored (since this is compensated by slow ageing).

7.10.3 The permissible temperature rise will not exceed the limit of 60^{o}C (when measured by resistance method) for transformer winding and 55^{o}C (measured by thermometer) for top oil when tested in accordance with IS 2026 (Part 2) when semihybrid high temperature insulation (thermally upgraded paper TUP) is used in windings in accordance with IEC 60076-14: (2013).

During heat run test losses computed at 75^{o}C shall be fed.

8 TECHNICAL PARAMETERS OF SINGLE PHASE DISTRIBUTION TRANSFORMERS UP TO AND INCLUDING 25 kVA (SEALED TYPE)

8.1 Ratings

The standard ratings shall be as per Table 7:

Table 7: Standard ratings
(*Clause* **8.1**)

Sl. No. (1)	Nominal system voltage (2)	Standard ratings(kVA) (3)
i)	11 kV	5,10,16,25, 50*,75* & 100*
ii)	22 kV	10,16,25, 50*,75* & 100*
iii)	33 kV	16,25, 50*,75* & 100*

NOTE: * ratings are non-preferred.

8.2Rated Frequency

The rated frequency shall be 50 Hz.

8.3Nominal System Voltage

Nominal system voltage shall be chosen from the following :

HV 11, 22 and 33 kV
LV 415V (240 V, 1 Phase)

8.4Basic Insulation Level (BIL)

Minimum Basic Insulation level shall be as given in Table 8.

Table 8: Minimum Basic Insulation Level
(Clause **8.4**)

Sl. No. (1)	Nominal System Voltage (kV) (2)	Minimum BIL (kVp) (3)
i)	11	75
ii)	22	125
iii)	33	170

NOTE: Insulation coordination of all relevant fittings and accessories corresponding to higher BIL values shall be ensured.

8.5No Load Voltage Ratio

The No load voltage ratios shall be as follows:

11000/ √3 / 250 V ,	11000 / 250 V
22000/ √3 / 250 V ,	22000 / 250 V
33000/ √3 / 250 V ,	33000 / 250 V

NOTE- Secondary voltage may be selected as 415-240 V, subject to agreement between User and Supplier

8.6No of Phases and Polarity:

No of phases shall be one (Single Phase).
Polarity: Additive or Subtractive

8.7Tap changing arrangement

Taps are not required.

8.8Losses and Impedance values

8.8.1 *Losses*

8.8.1.1 For transformer of HV voltage 11 kV, the total losses (no load + load losses at 75 C)̊ at the 50 percent of rated load and total losses at 100 percent of rated load shall not exceed the maximum total loss values given in Table 9.

Table 9 Maximum total losses of single phase transformers upto 11 kV
(*Clause* **8.8.1.1,8.8.1.2, 8.8.1.3 and 8.8.2**)

S. No.	Rating (KVA)	Impedance (%)	Max. Total loss (W)					
			Energy Efficiency Level 1		Energy Efficiency Level 2		Energy Efficiency Level 3	
			50% Load	100% Load	50% Load	100% Load	50% Load	100% Load
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I)	5	2.5	40	115	35	95	30	75
Ii)	10	4.00	70	190	60	170	55	150
Iii)	16	4.00	95	265	82	224	63	190
Iv)	25	4.00	125	340	110	300	95	260
v)	50	4.0	230	665	210	590	190	520
Vi)	75	4.0	340	995	310	880	285	780
vii)	100	4.0	445	1250	410	1140	375	1030

8.8.1.2 For transformers having voltage class above 11 kV and up to and including 22 kV, the permissible total loss values shall not exceed by 7 ½ percent of the maximum totalloss values mentioned in table 9.

8.8.1.3 For transformers having voltage class above 22 kV and up to and including 33 kV, the permissible total loss values shall not exceed by 10 percent of the maximum total lossvalues mentioned in table 9.

8.8.2 Impedance

The recommended percent impedance at 75°C for different ratings shall be as per Table 9.

8.9 Permissible Flux Density and Over fluxing

8.9.1 The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with + 12.5 percent combined voltage and frequency variation from rated voltage and frequency does not exceed 1.9 Tesla.

NOTE - The design calculations in support of flux density shall be furnished by the manufacturer.

8.9.2 No load current shall not exceed 3 percent of full load current and will be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5% of rated voltage shall not increase the no-load current by 6 percent maximum of full load current.

8.10 Limits of Temperature Rise

8.10.1 The type of cooling shall be KNAN as per IS 2026 (Part 2).

8.10.2 The permissible temperature-rise shall not exceed the limits of 40 $^{\circ}$C when measured by resistance method for transformer winding and 35 $^{\circ}$C measured by thermometer for top oil when tested in accordance with IS 2026 (Part 2). The marginal increase in temperature rises by use of Ester liquids is ignored (since this is compensated by slow ageing).

8.10.3 The permissible temperature rise will not exceed the limit of 55^{O}C (when measured by resistance method) for transformer winding and 50^{O}C (measured by thermometer) by oil when tested in accordance with IS: 2026 (Part 2) when semi hybrid high temperature insulation, thermally upgraded paper (TUP) is used for windingsalone in accordance with IEC 60076-14 (2013).

During heat run test load losses at 75^{O}C shall be fed.

9 STANDARD MATERIALS

9.1 Major material used in the transformer shall conform to the following Indian Standards:

i) Cold Rolled Grain Oriented electrical steel – IS 3024
ii) Amorphous core material – (IS under preparation)
iii) Copper/Aluminum conductor – IS 191, IS 1897, IS 7404,IS 12444,IS 13730/IS 6162 series as given in Annex A.
iv) Kraft paper –IS 9335 series as given in Annex A.
v) Press Board – IS 1576
vi) Synthetic organic Ester – IS 16081
vii) Natural Ester – (IS under preparation)

10. TERMINAL ARRANGEMENT

10.1For Three Phase transformers:

10.1.1 The transformers shall be fitted on high voltage and low voltage sides with outdoor type bushings of appropriate voltage and current ratings. The high voltage bushings (3 Nos.) shall conform to IS 2099. The low voltage bushings (4 Nos.)shall conform to IS 7421. Alternatively, the low voltage side may be made suitable for adoption of PVC / XLPE cables of suitable size.

10.1.2 If required by the user, a suitable cable-end box may be provided on the high voltage and or low voltage side. Alternatively bus duct arrangement may be provided on low voltage side by agreement between user and supplier".

Note: Porcelain / Epoxy / Silicon Rubber Bushing may also be used in the cable box subject to agreement between user and supplier.

10.1.3 In case of sealed type transformer, the terminal arrangements shall be such that it shall be possible to replace the bushings (external) without opening the cover and also without affecting the sealing of the transformer. The arrangement shall meet the following requirements:

HV & LV Bushings:

The bushing shall be made in two parts. The outer bushing shall be of porcelain. The dimensions of the outer bushing shall conform to relevant part /Section No. of IS 3347 depending on the voltage class. The internal bushing shall be of either porcelain or tough insulating material, like epoxy and shall have embedded stem. Metal portion of the internal HV and LV bushing inside the tank shall remain dipped in oil in all operating conditions.

NOTE - Any other suitable arrangement can be used subject to agreement between User and Supplier.

10.1.4 The dimensions of bushings of the following voltage classes shall conform to the following Indian Standards mentioned against them:

Voltage Class	For Porcelain Parts	For Metal Parts
Up to 1.0 kV bushings	IS 3347 (Part1/Sec 1)	IS 3347 (Part1/Sec2)
3.6 kV bushings	IS 3347 (Part 2/Sec 1)	IS 347 (Part 2/Sec 2)
12 kV bushings	IS 3347 (Part 3/Sec 1)	IS 3347 (Part 3/Sec 2)
24 kV bushings	IS 3347 (Part4/Sec 1)	IS 3347 (Part 4/sec 2)
36 kV bushings	IS 3347 (Part 5/Sec.1)	IS 3347 (Part 5/Sec.2)

NOTE: For heavily polluted atmosphere, dimensions of bushings shall conform to IS 8603.

10.2 For Single Phase Transformers

For 11/√3, 22/√3, and 33/√3 transformers, neutral end of the HV winding shall be brought out to Neutral through 1.0kV bushing. Neutral terminal shall be connected to tank by a tinned copper strip of adequate size.

For 11, 22, 33 kV transformers, two HV bushings shall be used for termination of both ends of HV winding.

The HV bushings shall be fixed to the top cover and the LV bushings of 1.0kV class shall be fixed to the transformer tank on sides.

10.3 Marking and relative positions of terminals

Appropriate characters in accordance with IS 2026 (Part 1) shall be indelibly marked upon or adjacent to terminals.

11. MINIMUM CLEARANCES IN AIR

The minimum phase-to-phase and phase-to-earth external clearances for LV & HV bushings shall be as per Table 10.

Table 10: External (Air) Clearances between bushings mounted on transformers *(Clause* **11)**

Nominal System Voltage	Phase to Phase clearance in mm	Phase to earth clearance in mm
Up to 1.1kV	75	40
11 kV	255	140
22 kV	330	230
33 kV	350	320

11.1 For transformers with air filled cable-end box/connection chamber, the phase-to-phase and phase-to-earth clearance shall be as per Table 11.

Table 11: Air Clearances in Cable Box
(*Clause* **11.1**)

Nominal System Voltage	Phase to Phase clearance in mm	Phase to earth clearance in mm
Up to 1.1kV	25	20
11 kV	130	80
22 kV	240	140
33 kV	350	220

12. CONNECTORS(APPLICABLE FOR BARE BUSHING TERMINATIONSONLY)

Wherever specified, suitable bimetallic connectors (clamp type) shall be provided on both HV and LV side in order to ensure sound and robust connection.

13. MARKING

13.1 Rating Plate

Each transformer shall be provided with rating plate made of Anodized Aluminium / Stainless Steel material securely fixed on the outer body, easily accessible, showing the information given in Fig. 1 for 3 phase transformers and Fig. 2 for single phase transformers. The entries on the rating plate shall be indelibly marked for example, by etching, engraving or stamping.

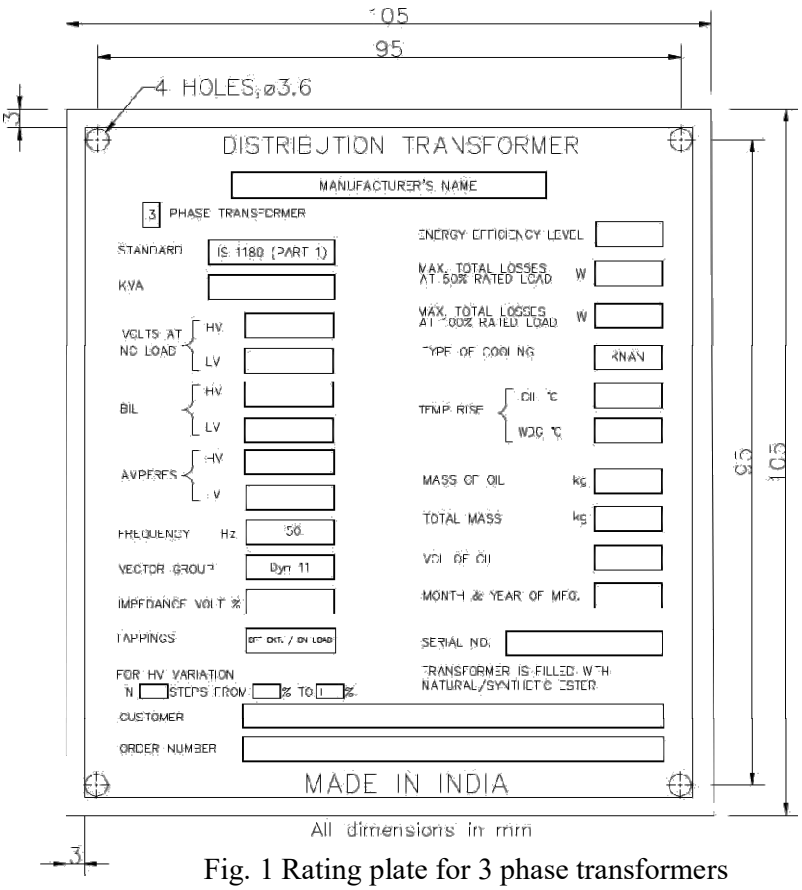
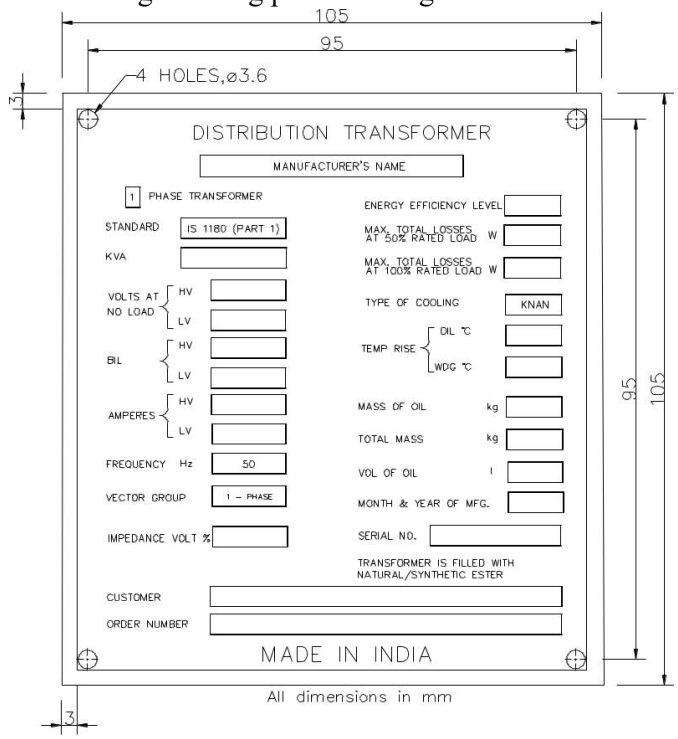


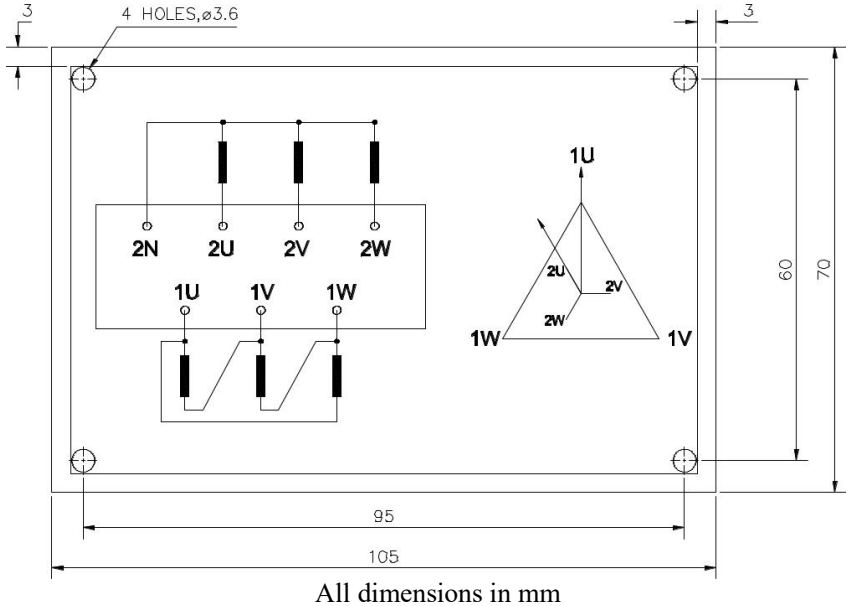
Fig. 1 Rating plate for 3 phase transformers

Fig.2 Rating plate for Single Phase Transformers



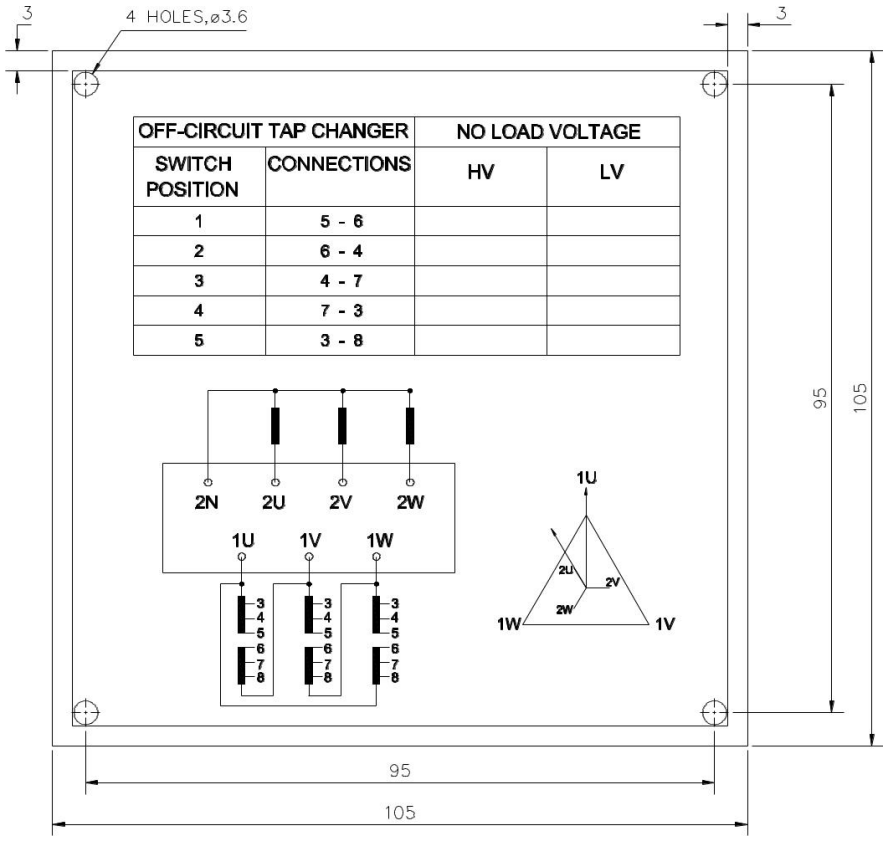
13.2 Terminal Marking Plate

Each transformer shall be provided with a terminal marking plate in accordance with Fig. 3 to 5 whichever is applicable.



All dimensions in mm

Fig. 3 Terminal Marking Plate for 3 Phase Transformers without Taps



All dimensions in mm

Fig. 4 Terminal Marking Plate for 3 Phase Transformers with Taps

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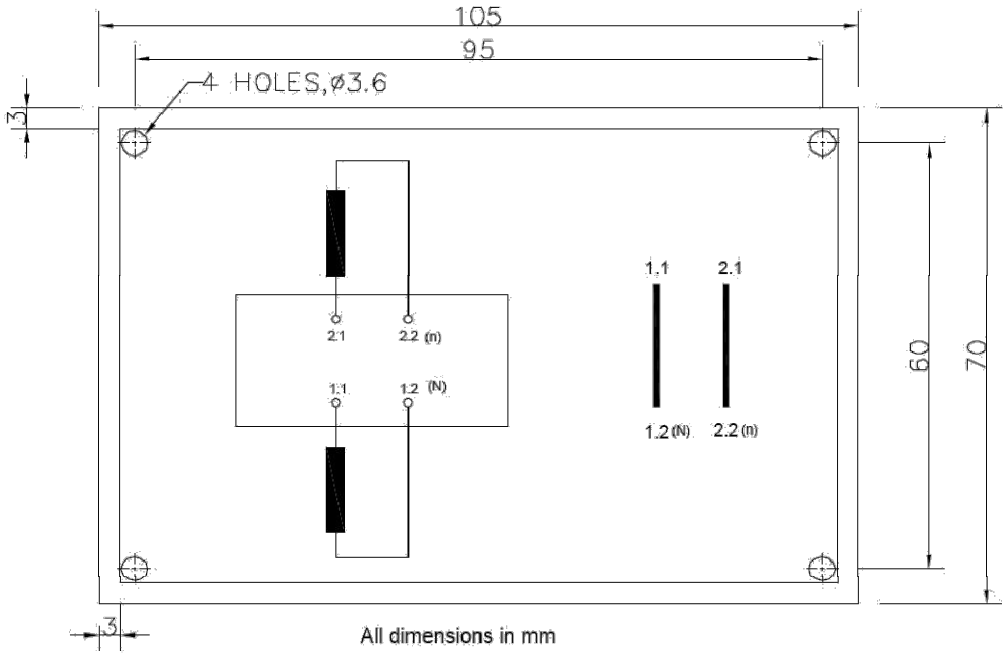


Fig. 5 Terminal Marking Plate for Single Phase Transformers

13.3 The rating and terminal marking plates may be combined into one plate at the option of the manufacturer.

NOTE:

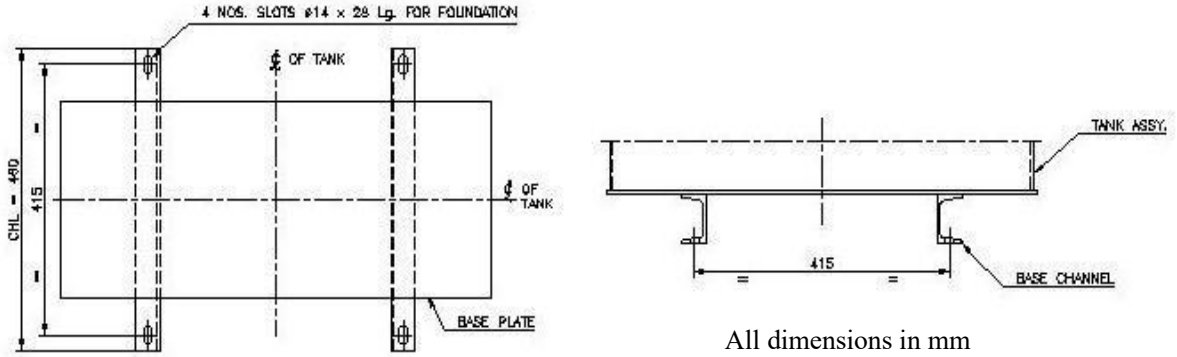
Dimensions of Rating Plate, Terminal Marking Plate and Combined Rating and Terminal Plate can be changed subject to agreement between the user and the supplier.

13.4 The Distribution Transformer may also be marked with the Standard Mark.

13.4.1 The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

14 MOUNTING ARRANGEMENT

14.1 The under-base of all three phase transformers upto 200kVA ratings shall be provided with two channels of minimum size 75 x 40 mm as shown in Fig. 6 to make them suitable for fixing to a platform or plinth.

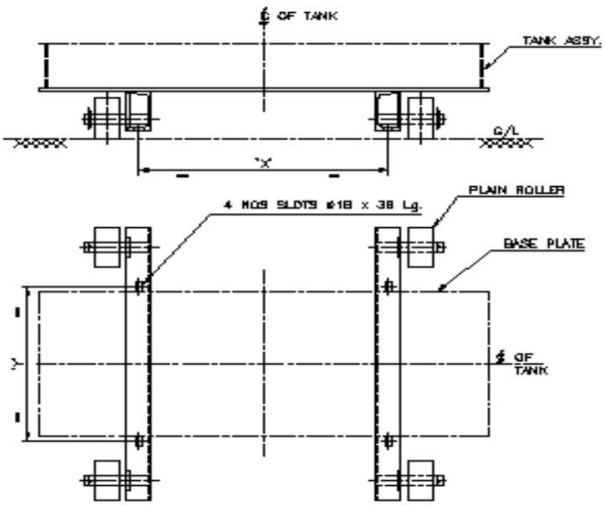


All dimensions in mm

NOTE: Any other mounting dimensions are subject to agreement between the user and the supplier.

Fig. 6: Mounting Dimension of Transformers up to 200 kVA

14.2 The under base of all transformers beyond 200 kVA may be as per Fig. 7 to make them suitable for mounting on flat rollers



Rating (kVA)	X	Y
2500	1200	800
2000	900	800
1600	900	800
1250	800	800
1000	800	800
800	800	800
630	800	800
500	700	450
400	700	450
315	600	450
250	500	415

All dimensions in mm

NOTE:
1.0 Bidirectional rollers can also be used as per mutual agreement between the user and the supplier.

2.0 Any other mounting dimensions are subjected to agreement between the user and the supplier.

Fig. 7 Mounting Dimensions of Transformers beyond 200kVA

14.3 Suitable Pole mounting arrangement may be alternatively provided for 3 phase transformers upto 500 kVA, subject to agreement between User and Supplier.

14.4 Single phase transformers are pole mounted type and shall be provided with two mounting lugs suitable for fixing the transformer to a single pole by means of two bolts of 20 mm diameter.

Both mounting lugs are made with steel of minimum 5 mm thickness.

14.5 For pad mounted transformers other constructional features and fixing details shall be subject to agreement between user and supplier.

15 TRANSFORMER TANK

15.1 Construction

15.1.1 For non-sealed or sealed type transformer, Transformer tank can be of plain tank configuration with/without radiator fins or cooling tubes. The tank can also be made of corrugated panels of adequate thickness, also used for cooling. The transformer tank covers shall be bolted/clamped alternatively welded with tank rim so as to make a leak proof joint. The curb design in case of welded construction shall be such that it is possible to remove the weld and reweld the tank at least two times.

NOTE: Minimum thickness of corrugations shall be 1.0 mm

15.1.2 The transformer tank shall be of adequate mechanical strength to withstand positive and negative pressures built up inside the tank while the transformer is in operation.

15.1.3 The tank design shall be such that the core and windings can be lifted freely.

15.1.4 For single phase sealed type transformers, the circular base plate edges of the tank shall be folded upward for at least 25 mm, to have sufficient overlap with vertical sidewall of the transformer.

15.2 Pressure and Vacuum Requirements

15.2.1 In case of transformers up to 200 kVA, plain tank shall be capable of withstanding a pressure of 80 kPa and a vacuum of 250 mm of mercury. Limiting values of the deflections are specified in Cl. 21.5.1.

For transformers above 200 kVA plain tank shall be capable of withstanding a pressure of 80 kPa and a vacuum of 500 mm of mercury. Limiting values of the deflections are specified in Cl. 21.5.2.

For single phase transformers up to 25 kVA, the transformer tank shall be of robust construction round in shape and shall be capable of withstanding a pressure of 100kPa and a vacuum of 760 mm of mercury.

15.2.2 For three phase transformers up to 2500 kVA, transformer tanks with corrugations shall be designed for a pressure of 15 kPa measured at the top of the tank with no leakage.

15.2.3 For three phase sealed type transformers with cover welded to the curb of the tank shall be of sound and robust construction so as to withstand pressure of 80 kPa without any deformation.

15.2.4 For single phase transformers of sealed type construction, when the space on the top oil is filled with inert gas, the inert gas plus oil volume inside the tank shall be such that even under extreme operating conditions, the pressure generated inside the tank does not exceed 0.4 kg/cm^2 positive or negative.

15.3 All bolts/nuts/washers exposed to atmosphere shall be as follows.

a) Size 12 mm or below – stainless steel.

b) Above 12 mm – steel with suitable finish like electro galvanized with passivation or hot dip galvanized.

15.4 Gaskets wherever used shall conform to Type III as per IS 11149 / Type C as per IS 4253 (Part 2).

S.No	Paint Type	Area to be Painted	No. of coats	Total dry film thickness (min.) (microns)
1.	Thermo setting powder paint	Inside	01	30
		Outside	01	60
2.	Liquid Paint			
	22) Epoxy (primer)	outside	01	30
	b) Polyurethane (Finish coat)	outside	02	25 each
	c) Hot oil resistant paint / Varnish	inside	01	35 / 10

Table 12 Paint scheme for Distribution Transformers
(Clause **15.5**)

Note: It is recommended to choose paint shade of the transformer as green 218 following IS 5.

15.5 Inside of tank shall be painted with varnish or oil resistant paint. For external surfaces onecoat of thermo setting powder paint or one coat of epoxy primer followed by two coats of polyurethane base paint shall be used. Table 12 shall be referred to for paint thickness for normal to medium corrosive atmosphere. For highly polluted atmosphere and special application external paint work shall be subject to agreement between the user and the transformer manufacturer.

16 CONSERVATOR FOR NON SEALED TYPE TRANSFORMERS

16.1 Transformers of ratings 63 kVA and above with plain tank construction, the provision of conservator is mandatory .For sealed type transformers with or withoutN2 cushion, conservator is not required.

16.2 When a conservator is provided, oil gauge and the plain or dehydrating breathing device shall be fixed to the conservator which shall also be provided with a drain plug and a filling hole (1¼" normal size thread) with cover. The capacity of a conservator tank shall be designed keeping in view the total quantity of oil and its contraction and expansion due to temperature variations. In addition, the cover of main tank shall be provided with an air release plug to enable air trapped within to be released, unless the conservator is so located as to eliminate the possibility of air being trapped within the main tank.

16.3 The inside diameter of the pipe connecting the conservator to the main tank should be 25 to 50 mm and it should be projected into the conservator so that its end is at least 20 mm above the bottom of the conservator so as to create a sump for collection of impurities.

The minimum oil level corresponding to -5°C should be above the sump level.

17 ABILITY OF TRANSFORMERS TO WITHSTAND EXTERNAL SHORT CIRCUIT

The performance of transformer under external short-circuit conditions shall be in accordance with IS 2026 (Part 5).

18 EFFICIENCY AND REGULATION

When statements of efficiency and regulations are required they shall be based on specified loading at the rated kVA and unity power factor and computed in accordance with Annex B and C respectively.

NOTE Efficiency and regulations at other power factors as agreed between the user and supplier shall also be computed.

19 TOLERANCES

The tolerance on electrical performance excluding losses shall be as given in IS 2026 (Part 1).

20 FITTINGS

20.1 Standard Fittings

The following standard fittings shall be provided:

a)Two earthing terminals with the earthing symbol ⏚;

b) Oil level gauge indicating oil level at minimum, 30°C and maximum operating Temperature;

NOTES

1) Minimum and maximum positions correspond to the operating temperature of -5°C and 90°C respectively (for Non-sealed type Transformer).

2) Only minimum position corresponding to the operating temperature of 30°C (for sealed type transformers)

c) Air release device (for Non-sealed type Transformers)

d) Rating and terminal marking plates;

e) Dehydrating breather shall be provided non-sealed transformers.

f) Drain-*cum*-sampling valve preferably steel with plug for three phase transformers (for transformers above 500 kVA).

NOTE: Valve size shall be as per agreement between the user and the supplier.

g) Thermometer pocket with cap

h) Oil/Nitrogen/Air filling hole having (1 1/4" nominal size thread) with cover (for sealed type transformers without conservator)

i) Lifting lugs for the complete transformer as well as for core and winding assembly.

j) Pressure relief device or explosion vent {for sealed type transformers (for all ratings) and non-sealed type transformers (for ratings above 200 kVA)}

k) One filter valve on the upper side of the tank (for transformers above 200 kVA).

l) HV side neutral grounding strip (where one of the HV bushing terminal is connected to earth).
m) LV earthing arrangement for single phase transformers.
n) Buchholz relay for transformers above 1000 kVA
o) Arcing horns for HT side (one number per phase)

20.2 Optional Fittings

The following shall be available as additional fittings at the option of the user wherever specified:

a) Dehydrating breather in lieu of plain breathing device for transformers up to 200 kVA.
b) Filter valve for transformers up to 200 kVA.
NOTE: Valve size shall be as per agreement between the user and the supplier.
c) Suitable rating lightning arrestors for HT side (one number per phase).
d) Bird Guard
e) Terminal connectors
f) Oil temperature indicator and winding temperature indicators for transformers above 200 kVA.
g) Jacking pads (for transformer above 1600 kVA)

h) Buchholz relay (for transformers above 200 kVA)
i) Magnetic oil level gauge (for transformer above 1600 kVA) with low oil level alarm contact.
j) Non return valve (for conducting pressure test).
k) Pressure relief device or explosion vent (up to 200 kVA for non-sealed type transformers).
l) Protection relay for sealed type transformers for internal parameters that is pressure, temperature, oil level and gas detection
m) 4 No‟s Anti-Theft stainless steel Fasteners with breakaway nut shall be provided at top cover (up to 200 kVA)
n) Unidirectional flat rollers (for transformers above 200 kVA)
o) Drain-cum-sampling valve preferably steel with plug for three phase transformers (for transformers up to 500 kVA)
NOTE: Valve size shall be as per agreement between the user and the supplier.

NOTE IS 3639 describes some of the fittings and accessories

21. TESTS

21.1 General

All routine, type and special tests as described in Cl 21.2 to 21.4 shall be performed as per relevant parts of IS 2026. Pressure and oil leakage test shall be conducted as per Cl 21.5.

21.2 Routine Tests (to be conducted on all units)

The following shall constitute the routine tests:

a) Measurement of winding resistance (IS 2026 Part 1)

b) Measurement of voltage ratio and check of phase displacement (IS 2026 Part 1)

c) Measurement of short-circuit impedance (principal tapping, when applicable) and load loss at 50% and 100% load (IS 2026 Part 1)

d) Measurement of no-load loss and current (IS 2026 Part 1)

e) Measurement of insulation resistance (IS 2026 Part 1)

f) Induced over-voltage withstand test (IS 2026 Part 3)

g) Separate-source voltage withstand test (IS 2026 Part 3)

Note: For single phase transformer with 11/√3 or 22/√3 or 33/√3 kV and with 1.0 kV neutral bushing, this test shall be conducted at test voltage of neutral (3 kVrms for one minute).

h) Pressure test (see 21.5)

i) Oil leakage test (see 21.5)

21.3 Type Tests (to be conducted on one unit)

The following shall constitute the type tests:

a) Lightning impulse test (IS 2026: Part 3)

b) Temperature-rise test (IS 2026: Part 2)

c) No load current at 112.5 percent voltage (see 6.9.2, 7.9.2, 8.9.2)

d) Pressure test (see 21.5)

21.4 Special Tests (to be conducted on one unit)

The following shall constitute the special tests which shall be carried out by mutual agreement between the User and Supplier.

a) Determination of sound levels (IS 2026: Part 10)

b) Short-circuit withstand test (IS 2026: Part 5) (above 200 kVA)

NOTE– Routine tests before and after short circuit test shall be conducted as per IS 2026 (Part 1)

c) No load current at 112.5% voltage (see 5.9.3)

d) Paint adhesion test

The test is performed as per ASTM D3359 (Standard Test Methods for measuring adhesion by Tape test).

e) BDV and Moisture content of liquid in the transformer IS 16081, IS 16099 and IEEE C57.147

NOTE Tests at d) and e) may be carried out on more than one unit subject to agreement between user and supplier

21.5 Pressure and Oil leakage Test

21.5.1 *For Transformers up to 200 kVA*.

21.5.1.1 *Pressure test (type test)*

For non-sealed and sealed type transformers, the transformer tank shall be subjected to air pressure of 80 kPa for 30 min (25 kPa for 30 minutes for corrugated tanks) and vacuum of 250 mm of mercury for 30 min. There should not be air leakage at any point.

The permanent deflection of flat plates, after pressure / vacuum has been released, shall not exceed the values given below.

Length of Plate	Deflection
Up to 750 mm	5.0 mm
751 to 1250 mm	6.5 mm
1251 to 1750 mm	8.0 mm

NOTE: Permanent deflection is not applicable for corrugations.

21.5.1.2 *Pressure (routine test)*

a) Corrugated tanks

The corrugated transformer tank shall be tested for air pressure of 15 kPa above atmosphere pressure maintained inside the tank for 10 minutes. There should be no leakage at any point.

b) Sealed type transformers

The transformer with welded cover shall be tested at an air pressure of 80 kPa above atmosphere pressure maintained inside the tank for 10 minutes. There should be no leakage at any point.

21.5.1.3 *Oil leakage test (routine test)*

The assembled transformer with all fittings including bushings in position, shall be tested at a pressure equivalent to twice the normal head measured at the base of the tank for 8 Hrs. There should be no leakage at any point. Tank with corrugations shall be tested for oil leakage test a pressure of 15 kPa measured at the top of the tank for 6 Hrs. There should be no leakage at any point.

21.5.2 *For Transformers above 200 kVA and up to including 2500 kVA.*

21.5.2.1 *Pressure test (Type test)*

For non-sealed and sealed type transformers, the transformer tank shall be subjected to air pressure of 80 kPa for 30 min (25 kPa for 30 minutes for corrugated tanks) and vacuum of 500 mm of mercury for 30 min. There should not be air leakage at any point. The permanent deflection of flat plate, after pressure / vacuum has been released, shall not exceed the values given below.

Length of Plate	Deflection
Up to 750 mm	5.0 mm
751 mm to 1250 mm	6.5 mm
1251 mm to 1750 mm	8.0 mm
Above 1751 mm	9.0 mm

NOTE: Permanent deflection is not applicable for corrugations.

21.5.2.2*Pressure test (routine test)*

a)Plain tanks

The transformer tank with welded / bolted cover shall be tested at a pressure of 35 kPa above atmosphere pressure maintained inside the tank for 10 minutes. There should be no leakage at any point.

b)Corrugated tanks

The corrugated transformer tank shall be tested for air pressure of 15 kPa above atmosphere pressure maintained inside the tank for 10 minutes. There should be no leakage at any point.

21.5.2.3 *Oil leakage test (routine test)*

The assembled transformer for non-sealed and sealed type with all fittings including bushing in position shall be tested at a pressure equivalent to twice the normal head measured at the base of the tank for 8 Hrs. There should be no leakage at any point. Tank with corrugations shall be tested for oil leakage test a pressure of 15 kPa measured at the top of the tank for 6 Hrs. There should be no leakage at any point.

21.5.3 *For Single Phase Distribution Transformers up to including 25 kVA.*

21.5.3.1 *Pressure test (type test)*

The tank shall be subjected to air pressure of 100 kPa above atmospheric pressure for 30 minutes. There should be no leakage at any point and there is no deformation of tank.

21.5.3.2 *Pressure (routine test)*

The transformer tank shall be tested at a pressure of 35 kPa above atmosphere pressure maintained inside the tank for 10 minutes. There should be no leakage at any point.

21.5.3.3 *Oil leakage test (routine test)*

The assembled transformer for non-sealed and sealed type with all fittings including bushings in position, shall be tested at a pressure equivalent to twice the normal head measured at the base of the tank for 6 Hrs. There should be no leakage at any point. Tank with corrugations shall be tested for oil leakage test a pressure of 15 kPa measured at the top of the tank for 6 Hrs. There should be no leakage at any point.

22. INFORMATION REQUIRED WITH ENQUIRY AND ORDER

22.1 The information to be supplied by the manufacturer with enquiry and order to the purchaser shall be in accordance with Annex D.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	**Title**
IS 191: 2007	Copper
IS 554 : 1999	Dimensions for pipe threads where pressure tight joints are required on the threads
IS 1576 : 1992	Solid pressboard for electrical purpose
IS 1608 : 2005	Mechanical testing of metals – Tensile Testing
IS 1747 : 1972	Nitrogen
IS 1885 (Part 38) : 1993	Electrotechnical vocabulary- Part 38: Power Transformers and Reactors
IS 1897 : 2008	Copper strip for electrical purpose
IS 2026	Power transformers
(Part 1) : 2011	General
(Part 2) : 2010	Temperature rise
(Part 3) : 1962	Insulation levels, Dielectric tests and External Clearances in Air
(Part 5) : 2011	Ability to Withstand Short Circuit
(Part 8) : 2009	Application Guide
(Part 10) : 2009	Determination of sound levels
IS 2099 : 1986	Bushings for alternative voltages above 1 000 volts
IS 3024 : 2006	Grain oriented electrical steel sheets and strips
IS 3347	Dimensions for porcelain transformer bushings for use in lightly Polluted Atmospheres
(Part 1/Sec 1) : 1979	Part 1: Up to and including 1 kV – Section 1 : Porcelain Parts
(Part 1/Sec 2) : 1979	Part 1: Up to and including 1 kV – Section 2 : Metal Parts
(Part 2/Sec 1) : 1979	Part 2: 3.6 kV Bushings – Section 1 : Porcelain Parts
(Part 2/Sec 2) : 1979	Part 2 : 3.6 kV Bushings- Section 2 : Metal Parts
(Part 3/Sec 1) : 1988	Part 3 : 17.5 kV Bushings- Section 1 : Porcelain Parts
(Part 3/Sec 2) : 1988	Part 3 : 17.5 kV Bushings- Section 2 : Metal Parts
(Part 4/Sec 1) : 1988	Part 4 : 24 kV Bushings- Section1 : Porcelain parts

(Part 4/Sec 2) : 1982	Part 4 : 24 kV Bushings- Section 2 : Metal parts
(Part 5/Sec 1) : 1979	Part 5 : 36 kV Bushings- Section 1 : Porcelain parts
(Part 5/Sec 2) : 1979	Part 5 : 36 kV Bushings- Section 2 : Metal Parts
IS 3639 : 1966	Fittings and accessories for Power Transformers (under revision)
IS 4253 (Part 2) : 2008	Cork Composition Sheet-Part 2-Cork & Rubber
IS 6162 (Part 1) : 1971	Paper-Covered Aluminum Conductors – Part 1: Round Conductors
IS 6162 (Part 2) : 1971	Paper-covered Aluminum Conductors – Part 2: Rectangular Conductors
IS 7404(Part1) : 1991	Paper Covered Copper Conductors – Part 1 Round Conductors
IS 7421 : 1988	Porcelain bushings for alternating voltages up to and including 1000 V
IS 8999 : 2003	Gauging practice for pipe threads where pressure tight joints are required on the threads
IS 9335 (Part1) : 1979	Cellulosic papers for electrical purposes: Part 1 Definitions and general requirements
(Part 2) : 1998	Cellulosic Papers for Electrical Purposes : Part 2 : Methods of test
(Part 3/Sec 1) : 1984	Cellulosic papers for electrical purposes: Part 3 Specifications for individual materials, Section 1 General purposes electrical paper
(Part 3/ Sec 3) : 1984	Cellulosic papers for electrical purposes: Part 3 Specifications for individual materials, Section 3 Crepe paper
(Part 3/ Sec 5) :1985	Cellulosic papers for electrical purposes: Part 3 Specifications for individual materials, Section 5 Special papers
IS 11149 : 1984	Specification for Rubber Gaskets
IS 12444 : 1988	Continuously cast and rolled electrolytic copper wire rods for electrical Conductors
IS 13730(Part 0/Sec 1) : 2012	General requirements, Section 1 Enamelled round copper wire (First Revision)
IS 13730(Part 0/Sec 2) : 2011	General requirements, Section 2 Enamelled rectangular copper wire (First Revision)
IS 13730(Part 0/Sec 3) : 2012	General Requirements Section 3: Enameled round Aluminum wire
(Part 17) : 1996	Particular Types of Winding Wires : Part 17 Polyvinyl acetal enameled rectangular copper wire, Class 105
(Part 27) : 1996	Specification for Particular Type of Winding Wires – Part 27 : Paper Covered Rectangular Copper Wire
IS	Thermally Upgraded Paper (TUP)
IS 16081 : 2013	Insulating Liquids - Specification for Unused Synthetic organic Organic Esters for Electrical Purposes
IS	Insulating Liquids – Specification for unused synthetic organic Natural Esters for Electrical purposes
IS 13503	Classification of Insulating liquids
IS 16099	Synthetic organic esters for electrical purposes – Guide for maintenance of transformer

ANNEXURE A 1
(*Clause* 2)

LIST OF INTERNATIONAL STANDARDS

1. IEC 61039 Edition 2.0 2008, Classification of insulating liquids.

2. IEC 62770 Edition 1.0, 2013, Liquids for electro technical applications – Unused natural esters and similar electrical equipment

3. IEC 61099 (2010), Insulating liquids – Specifications for unused synthetic organic esters for electrical purpose

4. IEC 61203 (1992), Synthetic organic esters for electrical purposes – Guide for maintenance of transformer esters in equipment

5. IEEE Std. C57.147 – 2008, IEEE Guide for acceptance and maintenance of Natural Ester liquids in Transformers

6. Cigre Brochure 443(Working Group D1.32), DGA in Non-Mineral oil and Load Tap changers and improved DGA diagnosis criteria

7. Cigre Brochure 436, WG A2.35, October 2010, Experiences in service with new insulating liquids.

8. IEC 60074-14 (2013), Power Transformers – Part 14: Liquid immersed power transformers using high-temperature insulation materials.

9. ASTM D 6871-03, Standard specification for natural (vegetable oil) ester liquids in electrical apparatus

10. ANSI C57.12.22 – 1989, Pad-mounted, Compartmental type self-cooled Three-phase Distribution Transformers with High-Voltage Bushings, 2500 kVA and smaller

11. IEEE Std. C57.12.28, IEEE standard for Pad-mounted Equipment – Enclosure integrity

12. IEEE Std. C57.12.29: 2005, IEEE standard for Pad – Mounted Equipment – Enclosure integrity for Coastal Environment.

13. IEEE Std. C57.155:2014, IEEE guide for interpretation of gases generated in Natural Esters and Synthetic organic Esters immersed transformers.

ANNEX B
(Clause 18)

METHOD OF DECLARING EFFICIENCY

B-1 EFFICIENCY

B-1.1 The efficiency to be declared is the ratio of the output in kW to the input in kW and calculated as under.

$$Efficiency\ (\eta) = \frac{Output}{Input} = \frac{Input - Total\ Losses}{Input}$$

Total losses comprise:

a) No-load loss, which is considered to be constant at all loads : and
b) Load loss, which varies with load.

The total loss, on load is the sum of (a) and (b).

ANNEX C
(Clause 18)

CALCULATION OF INHERENT VOLTAGE REGULATION

C-1INHERENT VOLTAGE REGULATION

C-1.1 The inherent voltage regulation from no-load to a load of any assumed value and power factor may be computed from the impedance voltage and corresponding load loss measured with rated current in the winding (see also IS 2026 : Part 8)

Let

I = rated current in winding excited;
E = rated voltage of winding excited;
I_{SC} = current measured in winding excited
E_{ZSC} = voltage measured across winding excited (impedance voltage);
P_{SC} = watts measured across winding excited
E_{XSC} = reactance voltage = $\sqrt{E^2_{ZSC} - \left(\frac{P_{SC}}{I_{SC}}\right)^2}$

P = Psc corrected to 75^{o}C, and from current Isc to I;
Ex = $E_{XSC} \times \frac{I}{I_{SC}}$
Er = $\frac{P}{I}$

C-1.2 For rated load at unity power factor, the percentage regulation is approximately equal to

$$Er\% + (Ex\%)^2$$

$$\frac{}{200}$$

Ex% = 100 Ex/E;
Er% = 100 Er/E
n = Ia/I; and
Ia = current in the winding excited during the short circuit tests corressponding to that obtained when laoding at the assumed load on the output side and with rated voltage on the input side.

C-1.3 For rated load any power factor cosϕ, the percentage regulation is approximately equal to:

$$Er\% \cos\phi + Ex\ \% \sin\phi + \frac{(Ex\% \cos\phi - Er\% \sin\phi)^2}{200}$$

C-1.4 For any assumed load other than rated load and unity power factor, the percentage regulation is approximately equal to;

$$n.Er\% + \frac{(n.\ Ex\%)^2}{200}$$

C-1.5 For any assumed load other than rated load and at any power factor cosϕ, the percentage regulation is approximately equal to:

$$n.Er\% \cos\phi + n.\ Ex\% \sin\phi + \frac{(n.\ Ex\% \cos\phi - n.\ Er\% \sin\phi)^2}{200}$$

C-1.6 The above formulae are sufficiently accurate for transformers covered by this specification.

ANNEX D
(*clause* 22.1)

INFORMATION REQUIRED WITH ENQUIRY AND ORDER

A) Normal Information

The following information should be given in all cases:

a) Particulars of the specification to be complied with;
b) Application of Transformer e.g. normal Distribution Transformer, Solar duty, wind application, Motor starting etc.
c) Single or three phase unit;
d) Number of phases in system;
e) Frequency;
f) Indoor or outdoor type;
g) Type of cooling (KNAN);
h) Rated power (in kVA)
j)Rated voltages (for each winding);
k)State if tappings are required and if on-load or off-circuit tap-changers, or links are required.
l)Highest voltage for equipment (for each winding);
m)Method of system earthing (for each winding);
n)Insulation level (for each winding), power frequency test level/impulse level;
o)Connection symbol;

p)Neutral terminals, if required (for each winding) and their insulation level to earth;
q)Special requirements of installation, assembly, transport and handling;
r)Fittings required and an indication of the side from which meters, rating plates, oil-level indicator, etc. may be readable.
s) Natural ester liquid or Synthetic organic ester liquid

B) Special Information

The following additional information may be required to be given:

a) If a lightning impulse voltage test is required, whether or not the test is to include chopped waves [see IS 2026 (Part 3)].
b) Impedance voltage at rated current, if specific value is required;
c) Altitude above mean sea-level, if in excess of 1 000 m;
d) Whether transformers will be subjected to frequent overcurrent, for example, furnace transformers and traction feeding transformers;
e) Any other exceptional service conditions;
f) Whether noise level measurement is to be carried out;
g) Vacuum withstand of the transformer tank, if a specific value is required;
h) Type of Tap-changer controls required (if OLTC is provided);
j) Type of mounting for example pole mounted, ground mounted etc.
k) Any other appropriate information, including reference to any special tests not referred to above which may berequired.

ANNEX E

ADDITIONAL INFORMATION ON LEAKAGE TEST
(Cl. 21.2 j, 21.5.1.3, 21.5.2.3 and 21.5.3.3)

E-1 Calculation of Gauge pressure during oil leakage test from Normal static head
Hydrostatic pressure in oil is given by:

$$P=\rho gh$$

Where,
p = Pressure at a point (Pa)
ρ=Density of liquid (kg/m3) (Ref. relevant standard or supplier‟s test certificate).
g = acceleration due to gravity (9.81 m/s2)
h = height of oil column at a particular point (m) (measured from top)

E-2 As per 21.5.1.3, 21.5.2.3 and 21.5.3.3, the amount of pressure application during the leakage test on assembled transformer for non-sealed and sealed type transformers with all fittings including bushing in position is summarized below:

a) Tank without corrugations:

Pressure equivalent to twice the normal head measured at base of tank for 8 h (for 3 phase transformer) and 6 h (for 1 phase transformers)

b) Tank withcorrugations

15 kPa measured at top of the tank for 6 h for both 3 phase and 1 phase transformer

E-3 Position of Pressure gauge is not specified. Based on facility available,the pressure gauge can be mounted near the base of the tank or near the top cover(or on the cover)

The depth of static head at bottom gauge position shall be the height from highest oil level to base of tank

The depth of static head at top of the tank shall be the height from highest oil level in conservator up to tank top gauge location.

In case the conservator is not provided, (eg. Single phase transformers and small 3 phase transformer below 63 kVA) and pressure gauge is mounted on cover of tank, a pressure equivalent to one static head (tank height in this case) shall be applied since as per requirement test pressure is equivalent to twice the static head.

E-4 Sample calculation of pressure for a transformer having ester liquid level of 1000 mm:

Density of ester liquid, ρ = 1.0 g/cc = 1000 kg/m3
Ester liquid level in the T/F, h = 1000 mm = 1 m
Hence, normal head pressure = (1000 x 9.81 x 1) Pa = 9810 Pa $\approx$ 9.81 kPa
Twice the normal head pressure = 2 * 9.81 kPa = 19.62 kPa
Hence, Pressure to be measured in the gauge is,
19.62 kPa, if gauge is fixed at base of tank and
9.81 kPa, if gauge is fixed at top

LT Technical Specifications

GENERAL SPECIFICATIONS

INSTRUCTIONS FOR FILING IN TENDER

1. Please study the documents carefully

2. Please put in your signature on every page of the Bid alongwith Company's rubber stamp.

3. Please do not fill in the Articles of Agreement while submitting the tender. This Will have to be done at the time the contract is awarded to successful Tendered, After affixing stamps, or appropriate value.

4.. Item description is binding and it supersedes the drawing, unless otherwise specified. Any discrepancy amongst Tender – documents and Drawings should be brought to Architect's notice immediately, for further necessary instruction. Technical
Specifications 1

LT TECHNICAL SPECIFICATIONS

1. MV SWITCHGEAR - POWER PANELS

Scope

The scope of work shall cover the supply, installation, testing and commissioning of all power panels, incorporating circuit breakers, switch fuse units,busbars,interconnections, earthing etc., meeting the requirements shown in equipment schedule and the drawings.
All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the relevant British Standard Codes of Practice in the absence of corresponding standards.

Circuit breaker

Circuit breakers shall be air break horizontal draw out type fully interlocked and meeting the requirements of IS: 2516 or BS: 3659. Breakers shall be rated for a medium voltage of 600V and rated full load amperes as indicated on drawings.
Breaker shall be capable of making and breaking system short circuits specified.Breakers shall be unless specified otherwise manually operated complete with front - of the panel operating handle, isolating plug with safety shutters, mechanical ON/OFF indicator, silver plated arching and main contacts, are chutes, trip –free operation. Breakers shall be capable of being racked out into testing 'Isolated' and Maintenance' positions and kept locked in any position. Breakers for remote operation shall be motor operated spring charged.

Switch fuse units & disconnects

Switch fuse units shall have quick - make, quick - breaker silver plated preferably double break contracts with operating mechanism suitable for rotary operation in the case of cubical mounting. All switches shall be rated according to the equipment schedule or drawings and shall withstand the system prospective fault current let through. Cam operated rotary switches with higher rating switch fuse units shall be heavy duty type conforming to IS" 4047.
Fuses shall be HRC cartridge type conforming to IS: 2208 with a breaking capacity corresponding to system fault level. Fuses shall be link type with visible indication.

screw type diazed fuses are not acceptable for any ratings.

All disconnects shall consist of switch units quick-make, quick-break type with silver plated contacts. The switches shall preferably have double breaks. All switches shall be mounted in sheet steel enclosure, which in turn is mounted on suitable angle from frame Work. In wet locations switches shall have cast iron enclosure. Disconnects shall have minimum breaking capacity.

Instrument Transformers & Meter & Relays

Ammeters and Voltmeters shall have moving iron spring controlled dead-beat elements in square/bezel flush type cases 144 mm in size and suitable for switch board mounting Meter shall conform to BS: 89 and have grade 'A; accuracy. Scale ranges shall meet with the requirements or as indicated on the drawing or in the Schedule of quantities. Energy meters shall be two element switch board mounting type suitable for unbalanced loads. Meters should incorporate a KVA demand meter with an integration time of 30 minutes. In case of two incoming feeders, a summating C.T. shall be provided with the meter, Meters shall conform to BS: 37.

All tripping may be through combination thermal and magnetic releases or IDMT release as specified.

Cubical boards

All boards shall be combination of 14 & 16 SWG sheet steel, free standing, extensible, totally enclosed, dust tight, vermin-proof cubical, 4 wire 50 Hertz system. All Board shall be accessible from the front for the maintenance of switch fuses, bus bars, cable terminations meters etc. Cable shall be capable of entering the board both from top as well as bottom. All panel shall be machine pressed with punched openings for meter etc.

All sheet steel shall be rust inhibited through a process of degreasing, acid Pickling, Phosphating etc. The panels shall be finished with two coats of sythestic enamel of approved colour applied over one coat of red oxide primer. Engraved plastic labels shall be provided indicating the feeder details, and capacity and danger signs.

The boards shall accommodate air insulated bus bars, air circuits breakers, switch fuse units with HRC fuses, starters, necessary meters, relays contactor etc. as required and arranged in suitable tiers.

The switch board shall by fully compartmentalised in vertical tiers housing the feeder switches in different totally enclosed independent compartment. Each compartment shall be self sufficient with switch unit, fuses, contactors, relays indicating lamps and an inner locked door with facility for padlocking. Each feeder must terminate in independent labelled terminal block. Strip type terminal block accomodating several feeders together is not acceptable. Pressure clamp type terminals suitable for aluminium wires may be used upto switches of 25A. And cable lugs for higher ratings.

All terminations shall be shrouded in an approved manneer. The entire enclosure shall meet with IS: 2147/1962. Feeder connection shall be out of solid insulated copper/ aluminium wires or strips with bimetallic clamps wherever required. Internal wiring busbar markings etc shall conform to IS 375/1963. Internal wiring shall have terminal ferrules Main switches should be at an easily accessible height and the highest switch operating handle should not be over 1.75M from floor level. Cable glands need not form part of the switch board as the cost of glands will form part of the cable termination.

Busbars

Bus bars shall be three phase and neutral and of copper or copper alloy rated for a temperature rise of 30 Degree C. over the ambient temperature specified, based on insulated conductor rating (IS: 8084 - 1976). Neutral bars may be or one half the size of the phase bars. The main horizontal bus bars shall be uniform cross secrtion and rated in accord with the incoming switch. The vertical bus bars for the feeder column may be rated at 75% of aggregate feeder capacity and shall be unifor in size. Bus bars and interconnections shall be taped with PVC colour coded tape to prevent bar-to-bar accidental shorts. Each bus bar shall be directly and easily accessible on removal of the front cover. Bus bars shall be totally enclosed, shrouded and supported on nonhygroscopic insulator blocks to withstand thermal and dynamic overloads during system short circuits. An earth bus of size 50% of the phase subject to the following maximum and minimum shall be provided. Individual switch components shall be connected with the earth bus through aluminium strip size of connecting wire being as above. All wire connections to bars shall be through lugs, bolts and nuts and spring washers.

Copper Aluminium Galvanised Steel

Minimum 6.5 sq.mm. 10 sq.mm. 16 sq.mm.

Maximum 6.5 sq.mm. 120 sq.mm. 200 sq.mm.

The minimum size of earth bar in a board shall however be 25 x 3AL or equivalent.

Isolators

Isolators shall be fixed on wall on self- supported angle iron frame work as required and mounted as near to the motor as possible. Where several motors are installed. Isolators if required shall be provided at a central location on a common frame work.

Painting, earthing and labels shall be provided as generally indicating for MV switchgear and shown on drawings.

Earthing

All switch panels shall be provided with an earth bar as specified.

Earthing of the switch boards shall be through the equipment. Earthing system provided in the building.

All meters shall be calibrated and tested through secondary injection tests.

All field tests shall be witnessed by Consultants and recorded. Certificates shall be furnished.

Installation

All panels shall be supported on MS channels incorporated in the panel during the fabrication. All such supports shall be prime coated with two finish coats after completion of the work all panels shall be touched up for damaged painting.

All panels shall be meggared phase and to neutral using a 1000V megger with all outgoing feeders in closed position. The meggar value should not be less than 2.5 megohms between phase 1.5 megohms between phase and neutral. Fabrication drawings of all panels shall be approved by the consulting engineers before fabrication.

Testing & Inspection

All switch boards shall be factory inspected before finishing and dispatch.

Certificate for all routine and type tests for circuit breakers in accordance with the IS: 2516 - 1963 shall be firnished. In addition, all panels shall be meggared phase to phase and phase to neutral using 1000V. Meggar with all switchgear in closed position.

The meggar value should not be less than 2.5 megohms between phase and 1.5

megohms between phase and neutral.
Earthing of the panels from the equipment earthing system will be paid for unit rates seperately as specified under earthing.
Outgoing and incoming feeded terminations will be paid for the unit rates seperately, as specified under cabling.

2. DISTRIBUTION BOARD

Scope

The scope of work shall cover the supply, installation, testing and commissioning of lighting & power distribution boards. Associated minor civil work required for the erection of the DB's are also included in the scope of this contract.

Standards

The following standards and rules shall be applicable:
1) IS: 2675 - 1983 - Enclosed distribution fuse boards and cutouts for Voltages not exceeding 1000 V.
2) IS: 375 - 1963 Marking and arrangement of Switchgear busbars main connections and auxiliary wiring.
3) IS: 8828 - 1978 Miniature circuit breakers
4) IS: 2607 - 1976 - Air break isolators for voltages not exceeding 1000V.
5) IS: 9926 - 1981 Fuse wire used in Rewirable type Elec. Fuses upto 650 Volts.
6) Indian Electricity Act 1910 and rules issued thereunder.
All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard Codes of Practice or the relevant British Standard Codes of Practice in the absence of Indian Standard.

Distribution boards

Distribution boards along with the controlling MCB's , isolator as shown shall be fixed in an M.S. box suitable for recessed mounting in all . Distribution boards shall be made of 16 SWG sheet steel duly rust inhibited through a process of degreasing, acid pickling, phosphating and spray painted to an approved colour over a coat of red oxide primer.
Three phase boards shall have phase barriers and a wire channel on three sides generally as shown on drawings. Neutral bars shall be solid tinned copper bars and tapped holes and chase headed screws. For 3 phase DN's, 3mm independent neutral bars shall be provided.
Conduit knockouts shall be provided as required/Shown on drawings and the entire boards shall be rendered dust and vermin proof and shall have conduit knowck out entry.
MCB's shall have quick and break non-welding self wiping silver alloy contacts both on the manual and automatic operation. Each pole of the breaker shall be provided with inverse time thermal over load and instantaneous over current tripping elements, with trip free mechanism. In case of multipole breakers, the tripping must be on all the poles and operating handle shall be common. Breakers must conform to BS 3871 with facility for locking in off position. Pressure clamp terminals for stranded/solid conductor insertion are acceptable upto 4 sq.mm. Aluminium or 2.5 sq.mm. Copper and for higher ratings, the terminals shall be suitable shrouded. Wherever MCB isolators are specified they are without the tripping elements.
Fuse shall be HRC link type OR DZ type with necessary fuse Carriers and with rating of not less than 25 MVA. Bottle type fuses are only acceptable. Fuse carrier terminals shall be suitable shrouded.
Distribution boards shall have HRC or DZ fuses as shown on the schedule and drawings Boards shall meet with the requirements of IS 2675 and marking arrangement of busbar shall be in accordance with IS 375. Bus bars shall be suitable for the incomer switch rating and sized for a

temperature rise of 35 degree C. over the ambient. Each board shall have two separate earthing terminals. Circuit diagram indicating the load distribution shall be pasted on the inside of the DB as instructed. One earthing terminal for single phase and two terminals for 3 phase DBs shall be provided with an earth stip connecting the studs and the outgoing ECC earth bar.
In the case of MCB distribution boards, the back up fuses wherever shown shall be not less than 63A with a delayed Characteristic and a minimum preparing time of 0.5 sec.at 5 KVA fault current.
All outgoing feeders shall terminate on a terminal strip which in turns in interconnected to the MCB. Base by means of insulated single conductor copper wires as follows.
Upto 15A. 2.5 sq.mm.
25A. 4.0 sq.mm.
63A. 6.00 sq.mm

Installation & Testing
All distribution boards shall be mounted on necessary angle iron frame work. All mounting frames shall be prime coated with two finish coats after the completion of the work. All distribution boards shall be touched up for damaged painting.

All boards shall be meggered phase and to neutral using a 1000V megger with all switchgear in closed position. The megger value should not be less than 2.5 megohms between phase and 1.5 megohms between phase and neutral.
Fabrication drawings of all boards shall approved by the consultants before fabrication and the boards inspected before dispatch.

3. MEDIUM VOLTAGE CABLING
Scope
The scope of work shall cover supply, laying, connecting testing and commissioning of medium voltage power cabling.
Standards
The following standards and rules shall be applicable:
1) IS: 1554 PVC insulated electric cable (heavy duty)
2) IS: 1753 Aluminium conductors for insulated cables
3) IS: 3961 Recommended current ratings for cables
4) Indian Electricy act and rules.
All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard Codes of practice or the British Standard Codes of practice where indian standards are not available.

Cable
All cable shall be 1100 Volts grade PVC insulated, sheathed with or without steel armouring as specified and with an outer PVC protective sheath. Cables shall have high conductivity stranded aluminium or copper conductors and cores shall be colour coded to the Indian Standards.
All cables shall be new without any kinds or visible damage. The manufacturers name, insulating material, conductor size and voltage class shall be marked on the surface of the cable at every 600mm centres.

Installation
Cables shall be laid in the routes marked in the drawings. Where the route is not marked the contractor shall mark it out on the drawings and also on the site and obtain the approval of the

Architect/Consultant before laying the cable. Procurement of cables shall be on the basis of actual site measurements and the quantities shown on the schedule of work be regarded as a guide.
Cables, rising indoors shall be laid on wall, ceiling inside shafts, or trenches. Single cable laid shall be fixed directly to wall or ceiling. All supports shall be at not more than 500 mm Where number of cables are run, necessary perforated cable trays shall be provided wherever shown. Cables laid in built - up trenches shall be on steel supports.
plastic identification tags shall be provided at every 20m.Cable shall be bent to a radius not less than 12 times the overall diameter of the cable,or in accordance with the manufacturer's recommendations whichever is higher.
In case of direct buried cables, the cables, the cable route shall be parallel or perpendicular to roadways, walls, etc., cable shall be laid in an excavated, graded trench,over a sand cushion to provide protection against abrasion. Width of excavated trenches shall be as per drawings. Backfill over buried with a minimum earth cover of 600mm.
the cables shall be provided with cable markers at every 20 meters.
The general arrangement of cable laying is shown on drawings. All cables shall be runs from panel to panel without any joints or splices. Cable shall be identified at end terminations indicating the feeder number and the Panel/Distribution Boards from where it is being laid.
All cable termination for conductors upto 4 sq.mm. May be insertion type and all higher sizes shall have tinned copper compression lugs. Cables terminations shall have necessary brass cable gland. The end terminations shall be insulated with a minimum of six half - lapped layer or PVC tape cable The end armouring shall be earthed at both ends.

Testing
MV cables shall be tested upon installation with a 500V . Megger and the following reading established.
1) Continuity on all phases
2) Insulation Resistance (a) between conductors
(b) all conductors and ground

All test readings shall be recorded

Mode of Measurement
Cable will be measured on the basis of unit length and shall include the following:
I) Cables and clamps
ii) Installation, commissioning and testing
iii) Cable marking
Each cable termination will be measured as one unit for payment. Certain cable sizes are grouped together and rates shall be furnished against each group. The item shall included the following.
I) Cable glands, lugs, bolts, nuts,
ii) All jointing materials
iii) Installation, testing and commissioning.
iv) Earthing the glands.

Cables buried under ground will be measured on the basis of unit length and paid for at unit rates and shall include :
I) Excavation and back filling
ii) 6" Sand cushioning below and above cable

iii) Protective bricks / tiles
iv) Cable markers.

5. EARTHING

Scope

The scope of work shall cover earthing station, laying aluminium / copper earth strips and connecting the power panels, DBs and switch boards. All motor civil work involved shall be covered in the scope of their contract.

1.0 Standards

The following standards and rules shall be applicable:
1) IS: 3043 - 1966 Code of Practice for earthing.
2) Indian Electricity Act and rules
All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard code of Practice or the British Standard Codes of Practice in the absence of Indian Standards.

2.0 REFERENCES

This specification requires the reference to the following documents:

IS 3043-1987	Indian standard code of practice for earthing
IEEE 80	IEEE guide for safety in AC sub-station grounding
IEEE 837	Standard for qualifying permanent connections used in substation grounding.
Indian Electricity Rules 1956 with latest amendments	

Wherever, reference to any specification appears in this document, it shall be taken as a reference to the latest version of that specification unless the year of issue of the specification is specifically stated.

3.0 APPLICATIONS

Earthing systems covered in this document shall be for providing effective grounds for

1. Sub-Stations
2. RTUs, supply control posts
3. Transformer and Generator neutral earths
4. Lightning arrester earths
5. Equipment earths including panels
6. In applications for PRS, UTS, FOIS, COIS, ATMs and data processing centre etc.
   Note: -These specifications do not cover earthing requirements for Indian Railway's telecom & signalling installations.

4.0 SELECTION OF EARTH SYSTEM

S.N.	Installations/ Current Capacity	IR Value Required	Soil Type/ Resistivity	Earth System
1.	House hold earthing/ 3kA	8 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ between 50 to 2000 ohm-mtr	Single Electrode
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
2.	Commercial premises Office buildings/ 5kA	2 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
3	Transformers, substation earthing, LT line equipment/ 15kA	1 - 2 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
4	Transformers, substation earthing, HT line equipment/ 40kA	less than 1 Ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
5	Lightning arresters, extra high current applications etc./ 50kA	less than 1 Ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes

6	PRS, UTS, RTUs,FOIS, COIS, ATMs and data processing centre etc./5KA	less than 0.5 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes

7. Note :- Single/multiple electrode in above earth system shall be either rod earth electrode or concentric pipe earth electrode as per clause 8.1.

5.0 TYPE OF SOILS

Soil can be classified in to various types, though based on the size of the particles it contains:

5.1 Normal soil

Black cotton soil, vegetable soil, garden soil, loamy garden, soil shallow black , soil medium black soil ,deep black soil and marshy soil etc having low soil resistivity value (up to 50 ohm meter)

5.2 Sandy soil

This type has the big particles and the size of the particles does determine the degree of aeration and drainage that the soil allows. It is granular and consists of rock and mineral particles that are very small. Therefore the texture is gritty and sandy soil is formed by the disintegration and weathering of rocks such as limestone, granite, quartz and shale, thus resulting in over-drainage. It warms very fast in the spring season. Coastal area, silt soil, red sandy soil, sandy clay and coastal alluvium etc having soil resistivity up to 2000 ohm-meter are considered as sandy soil.

5.3 Rocky soil

The area containing rocks, pebbles, uneven hard surface laterite soil, lime stone, sand stone, gravel, granite and chalk etc having soil resistivity more than 2000 ohm-meter is considered as rocky soil. This type of soil does not absorb moisture and are extremely poor conductor.

6.0 LOCATION OF EARTH ELECTRODE

Where there is option, site should be chosen in one of the following types of soil in the order of preference given:-

2. Wet marshy ground;
3. Clay, loamy soil, arable land.
4. Clay and loam mixed with varying proportions of sand, gravel and stones;
5. Damp and wet sand, peat.

Dry sand, gravel chalk, limestone, granite, very stony ground and all locations where virgin rock is very close to the surface should be avoided,

7.0 MEASUREMENT OF EARTH ELECTRODE RESISTANCE

The earth resistance shall be measured using fall of potential method as per para 37 of IS:3043.

8.0 EARTHING SYSTEM

The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

8.1 Earth electrode

The earth electrode is the main component of the earthing system which is in direct contact with the ground and thus provides a means of releasing or collecting any earth leakage currents. The material should have good electrical conductivity and should not corrode in a wide range of soil conditions. For an effective earthing system, two types of earth electrodes can be used as described here:

8.1.1 Rod earth electrode

8.1.1.1 High tensile-low carbon steel rod having diameter not less than 17mm complying with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more, Length 3000mm.(minimum). Length of the electrode may be increased in multiple of 1 meter to reduce earth resistance if required. To increase the length, pieces of similar rod shall be either exothermally welded to basic 3 meter electrode or connected using socket of suitable size. These sockets shall also be molecularly bonded by 99.99% pure high conductivity copper on inner & outer surface with copper coating thickness 250 micron or more.

8.1.1.2 Copper bus bar of size 250 mm x 50mm x 6 mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall be exothermically welded to rod with 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.

8.1.1.3 Current carrying capacity: The design of the electrode should be such as to have more than 15kA current carrying capacity for 1 second.

8.1.2 Concentric pipe earth electrode:

8.1.2.1 Primary conductor

MS pipe with 25 - 50 mm diameter, class B, ISI mark as per IS-1239, Length 2000 or 3000 mm as per table at para 8.1.2.7.

8.1.2.2 Secondary conductor

MS pipe with 40-100 mm diameter, class B, ISI mark as per IS-1239, Length 2000 or 3000 mm as per table at para 8.1.2.7.

8.1.2.3 Conductive mixture

For hermetically filling inside the cavity i.e. between secondary conductor & primary conductor, crystalline compound is to be injected in the electrode assembly. It is a combination of high conductivity metal alloys, copper & aluminium powder, conductive carbon/cement and bonding material etc. mixed in different proportion. The mixture is forced (pressurized) filled inside the earth electrode in the paste form and after solidification of the same, the end caps are welded. The metal alloys shall help in conducting the current and conductive carbon gives anti corrosive property. Bonding material should provide strength to the mixture. Resistivity of the mixture shall be less than 0.2 ohm-meter. Resistivity shall be tested by making a 20cm cube of the material and checking resistance across the opposite face of the cube.

8.1.2.4 Complete electrode shall be molecularly bonded by 99.99% pure, high conductivity copper on outer surface with copper coating thickness 300 micron or more.

8.1.2.5 Its surface shall be clean and free from any visible oxide layer or foreign material.

8.1.2.6 Copper bus bar of size 250 mm x 50mm x 6 mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall preferably be exothermically welded to earth electrode or connected with the help of two number stainless steel nut bolts of appropriate size having 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.

8.1.2.7 Current carrying capacity: The design of the electrode should be such as to have more than following current carrying capacity in kA (for 1 second):

S.N.	Current Capacity	Primary Conductor diameter	Electrode dimensions (dia. x length)
1.	3 kA	25 mm	40 mm x 2000 mm
2.	5kA	25 mm	40 mm x 3000 mm
3	15kA	25 mm	50 mm x 3000 mm
4	40kA	40 mm	80 mm x 3000 mm
5	50kA	50 mm	100 mm x 3000 mm

Note:- For more than 50KA applications, multiple electrodes of 50KA capacity shall be installed and connected.

8.2 Earth enhancement material:

Earth enhancement material is a superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It may contain conductive cement, graphite, hydrous aluminium silicate, sodium montmorillonite etc and shall not contain bentonite. It improves conductivity of the earth electrode and ground contact area. It shall have following characteristics-

1) It should have low resistivity preferably bellow 0.2 Ohm-meters. Resistivity shall be tested by making a 20cm. cube of the material and checking resistance across the opposite face of the cube.
2) It shall not depend on the continuous presence of water to maintain its conductivity.
3) It should be a little alkaline in nature with pH value >7 but <9, test certificate from NABL approved laboratory to be provided for the composition so designed.
4) It should have better hygroscopic properties to absorb moisture. It should absorb and release the moisture in dry weather condition and help in maintaining the moisture around the earth electrode.

5) It should have capacity to retain >10% moisture at 105ºC. Test certificate from NABL approved lab to be submitted for the composition so designed.
6) It should have water solubility < 5%. Test certificate from NABL approved lab be submitted for the composition so designed.
7) It should be granular with granule size 0.1 mm to 3 mm.
8) It should be non toxic, non reactive, non explosive & non corrosive.
9) It shall be thermally stable between -10 degree centigrade to +60 degree centigrade ambient temperature.
10) It shall not decompose or leach out with time.
11) It shall not pollute the soil or local water table and meets environmental friendly requirement for landfill.
12) It should expand & swell considerably and removes entrapped air to create strong connection between earth electrode and soil.
13) It should be diffuses into soil pores and creates conductive roots enlarging conductive zone of earth pit.
14) It shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.
15) It shall not require periodic charging treatment or replacement.
16) It shall be suitable for any kind of electrode and all kinds of soils of different resistivity.
17) It shall not cause burns, irritation to eye, skin etc.
18) Minimum quantity of earth enhancement material to be supplied :
    For 5' x5'x 10' earth pit – Min. 75 kgs per pit
    For 300mm bore type earth pit – Min 50 kgs per pit
19) The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity, batch no & date of manufacture.

8.2.1 Backfill material

Normally the excavated soil shall be used if it is free from sand, gravel and stones. In case the excavated soil contains sand, gravel and stones these shall be removed by appropriate methods such as hand picking, sieving etc. Small proportion of sand in the soil may be permissible. Material like sand, salt, coke breeze, cinders and ash shall not be used because of its acidic and corrosive nature. If the excavated soil contains sand, gravel and stone in large proportion and it is not feasible to remove these economically, good quality soil from other place may be used for backfilling.

While backfilling the soil shall be thoroughly compacted with at least 5 kg compactor. In case the soil is dry, small quantity of water may be sprinkled only to make it moist enough suitable for compacting. Large quantity of water may make the soil muddy which is not

suitable for compacting and after drying the soil may contain voids which may permanently increase earth resistance.

8.3 Equipotential bus & Earthing Conductor

i) A copper bus bar of size 300mm x 25mm x 6mm to be installed in the equipment room as equipotential bus and must be connected with preferably copper strip of 25mm x 3mm (suitable length) from instrument to the bus bar . The connecting terminal of the earth electrode to the bus bar must be connected by copper strip of 25mm x 3mm (suitable length) buried inside a trench of 300mm width x 600mm depth (from the earth pit to the nearest wall) .It shall be duplicated. However, it shall be ensured that only minimum required length is used and any extra length is cut away to keep the earth impedance minimum.

ii) It shall be high conductivity copper having electrical conductivity of 101% IACS i.e. minimum 99.9% copper content The maximum specific resistance of the copper strip earthing conductor shall be 17.241 x 10-7 ohm cm at 20ºC.

iii) At a temperature of 20ºC, its density shall be 8.89 gm/cm^3

iv) Its surface shall be clean and free from any visible oxide layer or foreign materials.

v) It shall preferably be connected to earth electrode and earth bus bar with the help of exothermic welding or at least two number stainless steel nut bolts of appropriate size.

vi) Normally a single length of copper strip shall be used for each duplicate copper strip earthing conductor and no joint should be used. However in situation requiring greater length one joint in each copper strip shall be permitted. The joints shall be made by exothermic welding of at least 10mm overlapping portion of the strips.

8.4 Construction of unit earth.

i) Make 5ft x 5ft x 10ft earth pit. If it is not possible to make such a pit due to non availability of clear space at locations like ATM, High mast lighting tower, Passenger information systems, PRS etc. or in rocky soil, min. 300 mm bore up to 10 ft deep can be made using earth auger or any other method. Earth pit larger than specified size can be made, if required.

ii) Sleeve the soil digged and remove the gravels and stones. If soil quality is good (without Murum and rocks) then add some quantity of earth enhancement material in the soil for using as backfill.

iii) If the soil seems unusable (containing large quantity of gravel, stones, murum, sad etc.) then replace the soil with black cotton soil.

iv) Insert the electrode at the centre of the earth pit and arrange to keep it vertical in the pit.

v) Arrange for adequate quantity of water supply for the earth pit. (Approx. 600 litres)

vi) Fill the pit with the backfill and keep on adding the earth enhancement material surrounding the electrode and simultaneously watering the pit.

vii) With a steel bar or pipe, keep on poking the soil gel and stirring intermittently for removing the air pockets and proper settlement of the pit.

viii) The procedure to be repeated till completion of the filling of the earth pit along with the packing material and sufficient watering adequate ramming.

ix) The pit should be very compactly rammed and watering for 2-3 days and addition of soil if required be done.

x) Make trench of 600 mm (depth) x 300 mm (wide) from the earth pit to the nearest point of connection.

xi) Construct inspection chamber with cover for the installation.

xii) Measure the earth resistance as per IS 3043:1987 code of practice. Earth resistance value shall be less than 1 ohm in non-rocky/non-sandy surface by single electrode Installation and in rocky surface by multiple electrode installation (not more than three electrodes & its individual earth pits). For earthing purpose, if solid rocky layer is found within 10 feet from ground level while digging the earth pit then it is considered rocky surface. Coastal area, silt soil, red sandy soil and sandy clay are considered as sandy surface.

xiii) If required resistance is lower than the resistance of single earth electrode then multiple earths can be constructed and interconnected.

8.4.1 Construction of ring earth by providing multiple earth pits

i) Wherever it is not possible to achieve required earth resistance with one earth electrode/pit due to difficult/rocky soil conditions, provision of ring earth consisting of more than one earth pit shall be done. The number of pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one earth pit shall be repeated for other earth pits.

ii) The distance between two successive earth electrodes shall be min. 3mtrs / length of electrode which ever is higher. and max. up to twice the length of the earth electrode.

iii) These earth pits shall then be inter linked using 25X3 mm copper strip to form a loop preferably using exothermic welding or with the help of at least two number of stainless steel nut bolts of appropriate size.

iv) The interconnecting strip shall be buried no less than 600mm (0.6m) below the ground level. This interconnecting strip shall also be covered with earth enhancing compound.

8.4.2 Inspection chamber

I) A 300X300X300 mm (inside dimension) concrete box (wall thickness min. 50 mm)with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid 25 to 50 mm. thick, with pulling hooks, painted black shall be provided to cover the earth pit. PVC sleeve of appropriate size shall be provided in concrete wall to take out earthing connections.

ii) The masonry work shall be white washed inside and outside.

iii) Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it.

iv) On backside of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.

9.0 MARKING:

The marking shall be clear, distinct and visible to the naked eye from a distance of about 1 meter; the size of marking shall be of minimum 25 mm. Following information shall be legibly and indelibly marked on the packed sets**:**

a) Specification no.

b) Name of the manufacturer

c) Batch no. & Date of manufacturer

d) Current carrying capacity

10.0 TESTS-

Following tests shall be done on one sample-

10.1 Testing of copper coating shall be done as described below:-

I) The copper coating mentioned in clause 8.1 shall not be less than the prescribed thickness at any point and shall comply with the adherence requirement in para (ii) & (iii) below.

ii) Length of the electrode with one end cut to a 45 degree point shall be driven between two steel clamping plates or the jaws of a vise set 0.04 in (1.02 mm)

less than the diameter of the electrode, so as to shear off sufficient metal to expose the bond between the copper coating and electrode. Peeling of the coating by the steel plates or the jaws of the vise is acceptable, but there shall be no other evidence of separation of the coating from the metal core.

iii) At room temperature, a length of the electrode is rigidly held in a clamp or vise and the free end is bent by applying a force normal to the electrode at a distance from the clamping device equal to 40 times the diameter. The magnitude of the force and the direction of application of force shall be such that the electrode is permanently bent through a 30-degree angle. While bending of the electrode there shall be no evidence of cracking of the copper coating.

10.2 Material composition of rod shall be tested as per standards mentioned in clause no. 8.1.1.1.

10.3 MS pipes shall be tested as per IS:1239.

10.4 Copper bus bars of shall be tested for percentage of copper as per IS:14644.

10.5 Current carrying capacity test on rod electrode shall be done as per clause no. 8.1.1.3 and for concentric pipe electrode as per 8.1.2.7.

10.6 **Corrosion Test :** As per IS:2119, salt spray test for analysis of effect of corrosion for the specific electrode shall be done through NABL approved testing lab, preferably for 500 hrs. or more.

10.7 Exothermic weld material shall be tested as per provisions of IEEE 837.

10.8 Electrical properties test on conductive mixture as per clause no. 8.1.2.3.

10.9 Physical, chemical & electrical properties test on earth enhancement material as per clause no. 8.2.

10.10 Toxic content tests for cadmium, lead, mercury, hexavalent chromium, polybrominated biphenyls (PBBs) & polybrominated diphenyl ethers (PBDEs) on conductive mixture & earth enhancement material.

Certificates from NABL approved laboratories shall be submitted with test results of above tests. Test certificates shall not be more than three years old.

For dimension, weight and specific resistance average of 3 readings shall be taken. Average value shall be within specified limits and individual values shall not go beyond double of tolerances.

11.0 ACCEPTANCE TESTS

11.1 Following shall constitute acceptance tests and shall be done on 100% sample basis for all the tests mentioned below except where otherwise indicated–

a) Physical check for earth electrode as per clause no. 8.1.1.1 for rod type electrode and as per clause no. 8.1.2.7 for concentric pipe type electrode.

b) Physical check for copper bus bar as per clause no. 8.1.1.2 for rod type electrode and as per clause no. 8.1.2.6 for concentric pipe type electrode.

c) Dimensional and construction feature tests of inspection chamber (Cl. no. 8.4.2)

d) Earth enhancement material as per clause no. 8.2(xviii) & 8.2(xix).

e) Earth resistance measurements as per clause no. 7.0.

11.2 Rejection:

In case the any component tested and inspected in accordance with this specification, fail to pass the tests or comply with the requirement of the specification, another two component from the same lot shall be inspected in accordance with the specification and if one of them also fail to pass the test, the whole lot of that component shall be rejected subject to the discretion of the purchaser or his nominee.

12.0 INSPECTION:

All the gauges/ test & measuring instruments shall be under calibration control at the time of inspection and proof to this office shall be produced.

Inspection and testing shall be carried out by the inspecting authority nominated by the purchaser to ensure that all the requirements of this specification are complied with for the acceptance of the materials offered by the supplier for inspection.

The purchaser or his nominee shall have right of free access to the works of the manufacturer and to be present at all reasonable times and shall be given facilities by the manufacturer to inspect the manufacturing process at any stage of manufacture. He shall have the right to reject whole or part of any work or material that does not conform to the terms of this specification or any other specification or requirement applicable and may order the same to be removed / replaced or altered at the expense of the manufacturer. All

reasonable/complete facilities considered necessary by the inspecting authorities for the inspection shall be supplied by the manufacturer free of cost.

The manufacturer shall at his own cost prepare and furnish the necessary test pieces and appliances for such testing as may be carried out at his own premises in accordance with the specification. Failing the existence of facilities at his own premises for the prescribed tests, the manufacturer shall bear the cost of carrying out the tests in an approved laboratory, workshop or test house.

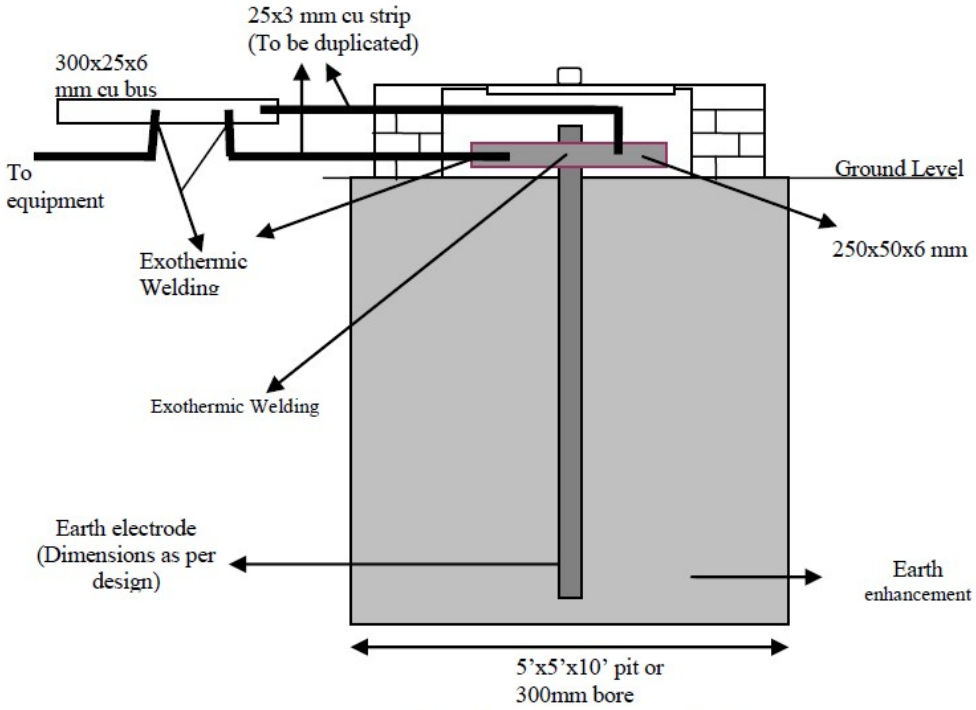
13.0 COMPLETION REPORT & CERTIFICATION:

13.1 The last documents for the completion of the procedure will be submission of the work completion report to the concern Railway authority. After testing the earth values of the pits and proper recording in presence of Railway authority, certified grounding self adhesive certificate shall be provided for all installations and the same will be displayed / pasted at the place of installation.

13.2 The complete layout with dimensions of the earthing & bonding system shall be submitted by the supplier in appropriate size (in three copies) after commissioning showing commissioning date, earth resistance, specification no. and manufacturer's name.

`14.0 GENERAL ARRANGEMENTS FOR EARTH SYSTEM

General Arrangements for Earth System



Earth electrode Installation

Plate Earthing station

The Substation earthing shall be with copper plate earthing station.

The earthing station shall be as shown on the drawing. The earth electrodes shall be 600 x 600x 3.15 copper plate. The earth resistance shall be maintained with a suitable soil treatment as shown on drawings.

The resistance of each station should not exceed 5 Ohms.

The earth lead shall be connected to the earth plate through copper/ brass bolts as shown on the drawing.

Pipe Earthing station

The earth station shall be as shown on the drawing and shall be used for equipment earth grid. The earth electrode shall be 2.5 M long 50mm dia galvanised steel pipe. The earth resistance shall be maintained with a suitable soil treatment as shown on drawings.

The resistance of earth earth station should not exceed 5 ohms.

The earth lead shall be fixed to the pipe with a clamp and safety set screws. The clamp shall be permanently accessible.

Earth leads and connections

Earth lead shall be bare copper or aluminium or galvanised steel as specified with sizes shown on drawings. Copper lead shall have a phosphor contact of not over 0.15 per cent Aluminium and galvanised steel buried in ground shall be protected with bitumen and hessian wrap or polythene faced hessian and bitumen coating. At road crossing necessary hume pipes shall be laid. Earth lead run on surface of wall or ceilings shall be fixed on saddles or wall so that the strip is atleast 8mm away from the wall surface.

The complete earthing system shall be mechanically and electrically connected to provide an independent return path to the earthing source.

Equipment earthing

All Apparatus and equipment transmitting or utilising power shall be earthed in the following manner.

Copper earth wires shall be used where copper wires are specified. Aluminium wires may be used where aluminium phase wires are specified unless otherwise indicated in the schedule of work and drawings.

Testing

The following earth resistance values shall be measured with an approved earth meggar and recorded.

1) Each earthing station
2) Earthing system as a whole
3) Earth continuity conductors

Mode of Measurement

Providing, earthing station complete with excavation, electrode, watering pipe, soil treatment, Masonry chamber etc. shall be treated as one unit of measurement.

The following items of work shall be measured and paid at unit rates covering the cost of the earth wires/ strips clamps, labour etc.

a) Main equipment earthing grid and connections to the earthing stations.
b) Connections to the switchboard, power panels, distribution boards etc.

The cost of earthing the following items shall become part of the cost of the items itself and no separate payment for earthing shall be made.
c) HT Panel & metering panel- earthing forming part of the system/cabling.
d) LT control panel – earthing forming part of the system/cabling.

Annexure – I

Contractor to submit along with Tender (It is not limited to the list below. Institute may ask additional documents to pre-qualify the vendor)**:-**

1. List of similar jobs executed in the last 3 years with value of work.
2. List of Manpower Proposed to be deployed for the job.
3. List of equipment / Machinery proposed to be deployed for the job.
4. Income tax clearance certificate for the last 3 years.
5. Partnership Deed.
6. Power - of - Attorney, in favor of person signing the Bid/contract.
7. Business Turnover Details of organization for last 3 years.
8. List of Senior- Permanent staff, in the employment of the organization.
9. Solvency certificate from your bankers.
10. Current Order- Booking and Order- backlog.

Annexure – II

Contractor to Submit the following Documents after Receipt of Letter of -Intent, within 15 days. (It is not limited to the list below. Institute may ask additional documents to ensure safety, security, quality and timely completion of work)

1. Security Deposit. (in Rupees) in form of Bank Guarantee or demand draft
2. Proposal construction Schedule for timely completion for acceptance by Architect.
3. Lay-out showing places for stacking materials, location of Stores, Site- office, Labour Hutments, Temporary water - tanks etc. so as not to foul with future permanent constructions.
4. Manpower planning, month to month, of important, skilled category.
5. Site organization chart with Bio-data of site - in - charge.
6. A phased indication of requirement by you, of Owners' materials, if and as applicable to be issued to you on free/ chargeable basis.
7. A rough Schedule, indicating the peak Months.
8. Following Insurance - Policies, to adequate cover, as advised by architect.
a) Men, Machineries, equipment of project.
b) Group Personal Accident Insurance.
c) Fire / Theft / All risk.
d) Third party.

Annexure – III

DIVISION OF WORK

BY ELECTRICAL CONTRACTOR

1. Supply & installation of Panels (Metering panel, HT & LT).
2. Making of foundations for various equipments, masonary for the transformers, HT panels, metering panel, LT control panel.
3. Supply & laying of HT cabling and cable trench with hume pipes and cable chambers.
4. Preparation of Earthing pits.
5. Making of Fencing with doors for the substation area.
6. Testing & commissioning of transformers, HT metering panel, HT panel, LT control panel.
7. Liasioning with power supply company.
8. LT cable connection with LT control panel.

Annexure – IV

DEVIATION FROM TENDER

(All deviations shall be set down here. Deviations mentioned anywhere shall be as per approval and discussions with clients, architects and consultants)

Annexure – V

COMPLETION PERIOD

Description delivery Installation after (In weeks) Delivery (In weeks)
1. Cabling with cable trenches & cable chambers.
2. HT panel supply & installation.
3. Metering panel supply & installation.
4. Transformer supply & installation.
5. LT control panel supply & installation.
6. Substation fencing and civil works.
7. Earthing.
8. Testing & commissioning after installation.
9. Liasioning with power supply company.
10. LT cable connection with LT control panel.

Description delivery to be mentioned above.

Annexure – VI

TEST REPORT

CERTIFICATE OF COMPLETION AND GUARANTEE FOR respective work / job.

1. **INSTALLATION DETAILS**
A. Transformers installation.
B. Voltage & system of supply system.
C. Neutral grounded and grounded neutral system.
D. Earthing grounded.
E. Particulars of cabling works :-
1) HT Cables laying & termination.
2) LT Cables termination.
3) Hume pipes & cable chambers installation.
F. Metering Panel installation.
G. HT Panel installation.
H. LT control panel installation.
I. Substation civil works.

2. **TEST RESULTS**

A. Transformer test certificates.
B. LT control panel test certificates.
C. Metering panel certificates.
D. HT panel certificates.
E. Earthing pit & earthing certificates.
F. HT cable certificates.

I/We certify that the installation detailed above has been installed by me/ us and tested to the best of my/our knowledge and belief, if complies with:
I) I.E. Act and rules there under.
ii) I.S. Code of Practice.
iii) Fire Insurance regulations.

4. I/We guarantee the installation for a period of twelve months against defective materials and workmanship, the gurantee commencing from the date the installation is takne over by the Employer and during the period of gurantee. I/We shall rectify or replace defects in materials or workmanship free of cost to the owner.

5. I/We submit herewith six sets of drawings showing the installation and conduit layout as actually executed.

Signature of Supervisor Signature of Contractor

Name & Address of Name & Address of Supervisor Contractor

Annexure – VII

TEST READING

Test readings shall be submitted in the proforma for acceptance tests to be furnished by the Consulting Engineers. Any other proforma will not be acceptable.