Annexure- B

**TECHNICAL SPECIFICATION FOR 33/11 KV, 10 MVA, CU WOUND, CRGO CORE, POWER TRANSFORMER.**

1. **SCOPE**:

This specification covers the design, manufacture, shop testing, supply and delivery of oil immersed naturally cooled, three phase 50 Hz conventional power transformers required for power Sub-station in Jharkhand State. The transformers will be copper wound.

2. **STANDARDS**:

The transformers shall conform in all respect to IS:2026/1977 & RE. Specification (wherever applicable) as amended from time to time except where specified otherwise. Equipment meeting any other authoritative standard which ensures an equal or better quality than the standard mentioned above will also be acceptable, In such case, a copy of the relevant standard (English version) should be enclosed with the tender.

3. **CLIMATIC CONDITIONS**:

1. Maximum ambient temperature in shade : 50 deg C

2. Maximum average ambient temperature : 45 deg C

3. Maximum temperature attainable by an object

exposed to sum : 60 deg C

4. Minimum ambient temperature : 4 deg C

5. Maximum relative humidity : 95 %

6. Average number of thunderstorm days per annum­ : 50

7. Average number of rainy days per annum : 80

8. Average annual rainfall ­ : 1270 mm

9. Number of months of tropical monsoon conditions : 4 months

10. Maximum wind pressure : 100 Kg/square m

11. Altitude not exceeding : 1000 Mtrs

4. **TYPE AND RATING**:

The transformers shall be of core type construction and oil immersed, naturally cooled as mentioned below and shall be suitable for outdoor service as step down transformers. The rating and electrical characteristics of the transformers shall be as below­ :

Continuous capacity (KVA) : 10 MVA

Rated HT voltage : 33 KV

Rated L T voltage : 11 KV

Frequency : 50 Hz

No of Phases : 3

Connection (HT) : Delta

Connection (L T) : Star

Vector group : Vector Group Dy-11

Type of cooling : ONAN

The neutral point of the secondary (LV) winding shall be brought out to a separate insulated terminal enabling it being earthed solidity or enabling a. current transformer for on earth leakage relay to be connected wherever required.

All transformers should be oil immersed, weather proof and suitable for outdoor installations (in lighting areas).

The transformers shall be designed and constructed to withstand without damage, thermal and dynamic effects of external short circuits. The manufacturer *I* supplier shall furnish all relevant design data and calculation in support of having fulfilled this requirement as stipulated under relevant clause of IS:2026-1977 (Part-I).

5. **1NSULATION**:

5.1 The dielectric strength of the winding insulation and of bushing shall conform to the values given IS:2026.

5.2 For rated system voltage of 33 KV and 11, KV following impulse test voltage will be offered

**System Impulse test voltage**

33 KV 170 KV

11 KV 75 KV

5.3 All windings of the transformer shall have uniform insulation.

1. **TEMPERATURE RISE**:

The temperature rise of hottest layer of oil shall not exceed. 45° C as measured by thermometer and temperature rise of winding shall not exceed 55° C as measured by resistance method on continuous full load over a maximum ambient temperature of 50° C when tested as per 155:2026/1977 (part-II).

7. **FREQUENCY**:

The transformer shall be suitable for continuous operation with a frequency variation of +/- 2 ½% from normal 50 Hz without exceeding the specified temperature rise.

7.**0 PARALLEL OPERATIONS** :

8. The transformers shall operate satisfactorily in parallel with similar unit already in service.

9. **IMPEDANCE**:

The percentage impedance at 75 deg C should be 8.35 % for 10 MVA Power Transformers. The impedance value refers to the principal tapping are subject to tolerance of +/- 10%. The impedance value measured on any other tapping shall not exceed the value measured on the principal tapping by more than +/- 10%.

Impedance shall include positive and zero sequence and shall be expressed in terms of the branches of the star connected equivalent diagrams all on the same MVA basis. and the range shall be given for each branch of the equivalent circuit in turn.

10. (A**) LOSSES WITHOUT POSITIVE TOLERANCE**:

The losses shall not exceed the value given below :-

|  |  |  |
| --- | --- | --- |
| **KVA Rating** | **No Load Loss (In KW)** | **Load Losses (in KW) at 75° C** |
| 10000 | 07 KW | 50 KW |
| ----- | ----- | ----- |
| ----- | ----- | ----- |

Transformers of lower losses will be preferred. The Guaranteed losses should be certified by CPRI /ERDA/NTH, Govt of India only.

10. (B) The maximum flux density shall not exceed 16000 lines per sq.m. under worst condition of loading. Detailed confirmatory calculations must be submitted with the tender.

11. **GUARANTEE**:

The manufacture shall among other things guarantee the following:

i. Quality and strength of materials used.

ii. Satisfactory operation for a period of 24 months from the date of commissioning or 30 months from the date of acceptance of delivery in stores/sites of the equipment, whichever is earlier.

iii. Performance figures are to be supplied by the tenderer in the schedule of guaranteed technical particulars enclosed.

1. **TOLERANCE**:

The tolerance in the guaranteed performance figures shall be as specified in the latest issue of IS : 2026 , if not mentioned in the specification.

13. **COOLING**

13.1 All Radiators shall preferably be attached to and mounted on the transformer tank. The

arrangements of Radiators shall be such that accessories may be mounted as specified herein.

13.2 Radiator units shall be connected to the tank by machined steel flanges welded to the Radiator unit and to the tank and provided with gaskets. At each cooler unit connections, there shall be provided on the tank indicating shut off valve which can be fastened in either open or closed position. Separate oil light blank flag shall be provided for each tank connection for use when the Radiator unit is detached. Each Radiator unit shall have a lifting eye, an oil drain valve at bottom and vent at the top.

13.3 Radiators shall be designed to withstand the vacuum and pressure condition specified for the tank.

14. **CORE**-

The core shall be built up with high grade cold rolled (CRGO) non-ageing low loss, and high permeability drain oriented silicon steel lamination specially conforming to HIB grade with lamination thickness not more than 0.23 mm to 0.27 mm or better suitable for transformer cores with main flux density of 1.6 Tesla.

After being sheared, the lamination shall be treated to remove all burns and shall be re-annealed to remove all residual stresses. At least one side of each lamination shall be coated with a durable baked enamel insulations coating which shall be inert to the action of hot transformer oil. Paper and varnish insulation will not be accepted. The nature of insulation should be specified in the tender.

The core shall be rigidly clamped and bolted to ensure adequate mechanical strength and to prevent vibration during transportation operation. The bolts used in the assembly of the core shall be suitably insulated and clamping structure shall be so constructed that eddy current will be minimum.

The core assembly shall be provided with lugs suitable for lifting the complete core and coil assembly of the transformer.

The core and the coil shall be so fixed in the tank that shifting will not occur when the transformer is moved or during a short circuit.

15. **WINDING**-

The winding shall be so designed that all coil assemblies of identical voltage /rating shall be interchangeable and field repairs to the winding can be made ready, without special equipment. The coils shall be supported between adjacent sections by insulating spacers and the barriers, bracings and other

Insulations used in the assemble of the winding shall be arranged to ensure a free circulation of the oil and to reduce hot spots in the windings.

The insulation of the coils shall be treated with suitable insulating varnish or equivalent compound to develop the full electrical strength of the windings, All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic chemically inactive in the hot transformer oil and shall not soften or otherwise be adversely affected under the operating conditions. This shall generally conform to class insulating material as per IS: 1271 :1958.

All threaded connections shall be provided with locking facilities. All leads from the windings to the terminal board and bushing shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

The winding shall be clamped securely in place so that they will not be displaced or deformed during short circuit. The assembly core and windings shall be vacuum dried and suitably impregnated before removal from the treating tank. The copper conductors used in the coil structure shall be best suited to the requirements and all permanent current carrying joints in the windings and tie leads shall be welded or brazed.

The current density adopted in all windings shall not exceed 2.4 A/ sq mm . The total net cross sectional area of strip conductors for calculating current density for each winding shall be obtained after deducting the copper area lost due to rounding up of the sharp edges of the rectangular conductors.

The completed core and coil assembly shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over or in the transformer tank.

16.0 **INSULATING OIL**:

Oil for first filling shall be supplied with each transformer. The oil shall comply in all respects with the provisions of IS 335 (latest assessment) with ageing characteristics. Particular attention shall be paid to deliver the oil free from moisture having uniform quality through out in non returnable steel drums.

The quality of oil for first filling of each transformer shall be stated in the tender. B.D.V of the transformer oil (at 2.5 mm gap) should not be less than 40 KV in assembled condition at the time of commissioning.'

The Supplier shall warrant that oil furnished is in accordance with the following specifications. Supplier shall submit the test certificate accordingly.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr.** **No.** | **Characteristic** | **Requirement** | **Method** **of** **Test** |
| 1 | Appearance | The oil shall be clear & transparent & free from suspended matter or sediment | A representative sample of oil shall be examined in a 100 mm thick layer at ambient temp. |
| 2 | Density at 200C | 0.89g/cm3 Max. | IS: 1448 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr.** **No.** | **Characteristic** | **Requirement** | **Method** **of** **Test** |
| 3 | Kinematic Viscosity at 27 deg. C Max | 27 CST | IS: 1448 |
| 4 | Interfacial tension at 27 deg. C Min. | 0.03N/m | IS: 6104 |
| 5 | Flash Point | 140 deg. C | IS: 1448 |
| 6 | Pour Point Max. | -6 deg. C | IS: 1448 |
| 7 | NeutralizationValue (Total acidity) Max. | 0.04 mg KOH/gm | IS: 335 |
| 8 | Electric strength Break Down(voltage) Min. | 60 kV | IS: 6792 |
| 9 | Dielectric dissipation factor tan delta at 900 C | 0.002 Max | IS:6262 |
| 10 .a | Min.Specific resistance(resistivity) at 90 deg. C | 35 x 1012 ohm cm (min.) | IS: 6103 |
| 10 .b | Min.Specific resistance(resistivity) at 27 deg. C | 1500x1012 |  |
| 11 | Neutralization value after Oxidation | 0.40 mg KOH/g |  |
| 12 | Total sludge after Oxidation | 0.10% by weight max. |  |
| 13 | Presence of oxidation Inhibitor | The oil shall not contain anti-oxidant additives | IS:335 |
| 14 | Water content Max: | Less than 25 ppm | IS: 2362 |

17.0 ­**TANK**

The transformer tank and cover shall be fabricated from good commercial grade low carbon steel suitable for welding and of adequate thickness. The tank and the cover shall be of welded construction. All sheets shall be welded and wherever practicable they shall be double welded. The tank shall have sufficient strength to withstand permanent, distortion (i) a vacuum of *760* mm of mercury and (ii) continuous internal gas pressure of 0.7 atmospheres with oil at operating level i.e., the transformer tank should be able to withstand *100% of vacuum* and also one atmospheric pressure above atmospheric internal pressure.

The tank cover shall be bolted to the tank and the transformer design shall be such that the tank will not be split between the lower and upper Radiator connection. The minimum thickness of tank plates shall be 6.0 mm for the sides and 10 mm for the top and bottom where the longer sides have a horizontal length up to but not exceeding 1800 mm . For horizontal length in excess of 1800 mm side thickness shall be 10 mm and minimum top and bottom plate thickness shall be 12 mm.

A manhole with welded flanges and a bolted cover shall be provided on the cover. The manhole shall be sufficient size to afford easy access to the longer side of the bushing terminals etc.

All bolted connections to the tank shall be fitted with suitable oil gasket which shall give satisfactory service under operating conditions. Special attention shall be given to the method of making the not al tight joints and between the tank and the cover as also between the cover

and all other outlets to ensure that the joints can be remade with ease with, the help of semi skilled labour. Where compressible gaskets are used, steps shall be provided to prevent cover compression.

Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between core and winding and the bottom *of* tank for collection of any sediment.

Lifting eyes and lugs shall be provided on all parts *of* the transformer requiring independent handling during assembly or dismantling. In addition, the transformer shall be provided with lifting lugs and bosses properly secured in the sides of the tank forlifting the transformer either by cranes or jacks.

The design of the tank, the lifting lugs and bosses shall be such that the complete transformer assembly filled with oil can be suitable for use these lugs without any damage.

The tank shall be provided with two suitable copper alloy lugs for the purpose of grounding.

**Each tank shall be equipped with the following valves with standard screw connection for external fitting ­-**

I. One drain and lower filter valve located on the lower voltage side of the transformer and placed to completely drain the tank. At the option of the contractor, a large valve may be furnished with an concentric reduce. This valve shall be equipped with a small sampling cock.

ii. One filter valve located at the top of the tank on the high voltage side. The opening *of* this valve shall be baffled to prevent accretion of the coil.

III. One filter valve located on the high voltage side *of* the transformer above the bottom of the tank.

IV. One relief valve to operate at a pressure below the test pressure for the tank.

V. Oil filling valve.

18. **UNDER CARRIAGE**:

The transformer tank shall be supported on a structural steel base equipped with forged steel or cast steel single flanged wheels suitable moving the transformer completely filled with oil.

The transformer shall be provided with bi-directional flat rollers suitable for use on a 1000 mm gauge track.

Pulling eyes shall be provided to facilitate .pulling of transformers and they shall be suitably braced in a vertical direction so that handing does not occur when the pull has a vertical components.

**19. Valves**

(I) Valves shall be of forged carbon steel up to 50 mm size and of gun metal or of cast iron bodies with gun metal fittings for sizes above 50 mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

(II) Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.

(III) All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requirements. Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required, the supplier shall supply the same.

(IV) Each transformer shall be provided with following valves on the tank: a) Drain valve so located as to completely drain the tank.

b) Two filter valves on diagonally opposite corners, of 50 mm size.

c) Oil sampling valves not less than 8 mm at top and bottom of main tank.

d) One 15 mm air release plug.

e) Valves between radiators and tank.

(V) Drain and filter valves shall be suitable for applying vacuum as specified

in the specifications.

20. **TAPS**:

The transformer shall be provided with off-circuit taps (for 10000 KV A only).

Transformers with off-circuit tap changing gear shall have taps ranging from +5% to -10% in steps of 2.5% each on H,V. winding for voltage variation. Steps other then 2.5 % are not acceptable.

The tap changing switch shall be located in a convenient position so that it can be operated from ground level. The switch handle shall be provided with a locking arrangement along with tap position indication, thus enabling the switch to be locked in position.

Equipment for only local electrical and local hand operation shall be provided.

21. **CONSERVATOR**:

Conservators should be of sufficient capacity with drain cock, oil gauge and silicagel breather and a shut off valve on the fold pipe between the conservator and the transformer tank located between Buchholz relay and the conservator. Oil gauge shall be mounted on the conservator. The conservator should be provided with arrangement to make it detachable from the main body of the transformer.

22. **BUSHING**:

Transformer shall be provided with bushing insulator on both 33KV and 11 KV sides, 33 KV and 11 KV bushing shall be located on opposite side.

The electrical characteristics of bushing insulators shall be in accordance with 15:2099 as amended from time to time. All type and routine test shall be carried out in accordance with 15:2099. The test voltage for various test as stipulated in 15:2099-1973 are reproduced below­

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Nominal Voltage System | Rated Voltage of the bushing | Visible discharge test | One minute wet & dry withstand test | Lighting Impulse  Test ( Impulse Voltage) |
| 11 KV | 12 KV | 9KV | 35 KV | 75 KV |
| 33 KV | 36 KV | 27 KV | 75 KV | 170 KV |

The dimensions of the 12 KV bushing (11 KV side) shall conform to IS:3347 (Part-III)-1973 and those of 36 KV bushing (33 KV side) shall conform to !5:3347 (part-I)-1973 or the latest version thereof.

23. **SUPPRESSION OF HARMONICS**:

The transformers shall be designed with particular attention to the suppression of harmonic voltage especially in the third and fifth so as to eliminate wave from distortion and any possibility of high frequency disturbance inductive effects or of circulating current between neutral points a1 different transforming stations reaching such as magnitude as to cause interference with postal or other communication circuits.

**24. Breather :**

The conservator shall be fitted with a dehydrating silica gel filter breather. It shall be so designed that,

1. Passage of air is through a dust filter & Silica gel

2. Silica gel is isolated from atmosphere by an oil seal.

3. Moisture absorption indicated by a change in colour of the crystals of the silica gel can be easily observed from a distance.

4. Breather is mounted not more than 1400 mm above rail top level.

**25. Pressure Relief Device**

The pressure relief device provided shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage of the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure of transformer tank. It shall be mounted direct on the tank. A pair of electrically insulated contacts shall be provided for tripping when the device operates.

**26. Buchholz Relay**

Each transformer shall be provided with gas and oil actuated Relay (Buchholz Relay) equipment conforming of IS:3637 double float type with one set of alarm contacts, one set of trip contacts and a testing pet cock. The contacts shall be wired with a P.V.C. armoured cable. A machined surface shall be provided on the top of Relay to facilitate the setting of Relay and to check the mounting angle in the pipe and cross level of the Relay. The pipe work shall be so arranged that all gas arising from the Transformer shall pass into the gas and oil actuated Relay. The oil circuit through the Relay shall not form a delivery path in parallel with any circulating oil pipe. A copper tube shall be connected from the gas collector to a valve located at about 1200 mm above ground level to facilitate sampling with the transformer in service.

**27. Oil Temperature Indicator (OTI)**

The transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent potential free alarm and trip contacts. Maximum reading pointer and resetting device shall be mounted in the local control panel. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be +

1% or better. One NO electrical contact capable of operating at 5 A ac at 230 Volt supply.

**28. Winding Temperature Indicator (WTI)**

i. A device for measuring the hot spot temperature of the winding shall be provided. It shall comprise the following.

ii. Temperature sensing element

iii. Image Coil.

iv. Auxiliary CTS, if required to match the image coil, shall be furnished and mounted in the local control panel.

v. 150 mm dial local indicating instrument with maximum reading pointer mounted in local panel and with adjustable electrically independent ungrounded contacts, besides that required for control of cooling equipment, one for high winding temperature alarm and one for trip.

vi. Calibration device.

vii. Two number NO electrical contact each capable of operating at 5 A ac, 230 Volt supply.

viii. The scale on the dial of the thermometer should be 0 Deg.C to 150 Deg.C. The angular displacement of thermometer should be 270 Deg. The signaling contact of WTI & OTI shall be set to operate at the following temperature:

a. OIL : Alarm-80 deg. C, Trip – 90 deg. C

b. WINDING : Alarm-85 deg. C, Trip – 95 deg. C

**29. MARSHALLING BOX**

i) Sheet steel (not less than 2 mm thick), weather, vermin and dust proof marshaling box fitted with required glands, locks, glass door, terminal Board, water-tight hinged and padlocked door of a suitable construction shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. The box shall have sloping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshaling box. The degree of protection shall be IP-55. The temperature indicators shall be so mounted that the dials are visible by standing at the ground level.

ii) The schematic diagram of the circuitry inside the marshaling box be prepared and fixed inside the door under a prospane sheet.

iii) The marshaling box shall accommodate the following equipment:

a) Temperature indicators

b) Terminal blocks and gland plates for incoming and outgoing cables.

c) Space heater with thermostat and MCB

All the above equipment except (b) shall be mounted on panels and back of panel wiring shall be used for inter-connection. The temperature indicators shall be so mounted that the dials are not more than 1600 mm from the ground level and the door (s) of the compartment(s) shall be provided with glazed window of adequate size.

iv) To prevent internal condensation, a metal clad heater with thermostat shall be provided. The heater shall be controlled by a MCB of suitable rating mounted in the box. The ventilation louvers, suitably padded with felt, shall also be provided. The louvers shall be provided with suitable felt pads to prevent ingress of dust.

v) All incoming cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and associated compartment shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

**30. OFF- LOAD TAP CHANGER**

a) Each transformer shall be provided with voltage control equipment of the tap changing type of varying the effective transformation ratio while the transformer is off load and without producing phase displacement. The tap changing switch shall be located in convenient position so that it can be operated locally from ground level. The switch handle will be provided with locking arrangement along with tap position indication thus enabling the switch to be locked in position. Off load tap changer shall confirm to the specifications of IEC 60214-1:2003.

b) The tap which are to be provided on HV winding shall vary from plus 5% to minus 10% in equal step of 2.5% each.1.5.16.Fittings

31. **CENTRE OF GRAVITY** :

The centre of gravity of the assembled transformers shall be low and as near the vertical centre line as possible. The transformers shall be stable with or without oil. If the centre of gravity is eccentric relative to truck either with or without oil, its location shall be shown on the outline drawing.

32. **ACCESSORIES AND FITTING**:

Each transformer shall be provided with the following accessories and fittings in accordance with the details to the extent these are specified in IS:2026-1977.

a. Inspection cover

b. Name plate

c. Diagram plate

d. Two earthing terminals

e. Lifting lugs for conservator ­

f. Dehydrating breather

g. Thermometer (dial type with one contact for alarm).

h. Magnetic type oil level gauge (150 mm dia.) with low oil level alarm contacts and with three position of oil marked as follows ­

Minimum (-) 5°C

(+) 32°C

Maximum (+) 98° C

i. Oil filling hole and cap

j. Air release device

k. Pressure release device

i. Gas and oil actuated relay

m.. Filter valves (Lower valve to be also used as drain valve).

n. Terminal marking plate

o.Bi-directional roller

p. Thermometer pocket .

q. Winding temp. indicator with alarm & trip.

r. Bimetallic connectors 7 Nos suitable for ACSR DOG

s. Marshalling Box (MB).

t. Cooling Accessories

A. Requisite number of radiators provided with :

i) One shut off valve on top

ii) One shut off valve at bottom

iii) Air release device on top

iv) Drain and sampling device at bottom

v) Lifting lugs.

B. Air release device and oil drain plug on oil pipe connectors.

i) Terminal marking plates for Main Transformer.

ii) Off-Load Tap Changer.

iii) HV Bushing with terminal connector and arcing horn.

iv) LV Bushing with terminal connector.

v) LV Neutral Bushing for ground connection

**N. B. -** The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer. **The order no. and date must clearly be mentioned on the rating plate.**

33. **CLEARING AND PAINTING**:

Before painting and filling with oil, all non gal-vanished parts shall be completely clean, free from rust, scale and grease and all external surface cavities shall be filled by metal deposition.

Interior of all transformer tanks and oil filled chamber and internal structural steel work shall be cleaned of all scales and rust by sand blasting. Incase the process of sand blasting is not adopted it is to be thoroughly cleaned by chipping, wire brushing and sand papering etc.

These surface shall be painted with hot oil resisting varnish. or paint as per contractor's standard practice.

External surface shall be given a priming coat of anti rust primer and two finishing coats of durable oil and weather resisting paint or enamel. The colour, of the finishing coats shall be admiralty grey conforming to no. 632 of ISS colour for ready mixed prints (second revision).

34. **PACKING**:

The packing may be in accordance with the supplier's standard practice but he should give full particulars of packing for the approval of the purchaser. Special arrangement should e made to facilitate handling and to protect the projecting connections for damage in transit.

The' transformer shall be shipped filled with oil.

All parts shall be adequately marked to facilitate fixed erection, Boxes and crates shall be marked with the contract number shall have packing list enclosed showing the parts contained therein.

35. **TESTS**:

The transformer shall be completely assembled and tested at the factory. If the purchaser desires to send its representative. all tests shall be witnessed by him. Test shall be performed in compliance with IS:2026-1977 or any other authoritative standard agreed upon between the purchaser and the manufacturer.

**i)ROUTINE TEST**:

All the transformers shall be subjected to the following routine test as per 15:2026/1977 at the manufacturer' works.

The tests are to be carried out in accordance with the details specified in 15;2026 or as agreed upon between the purchaser 'and the manufacturer- ­

a.. Measurement of winding resistance

b. Measurement of voltage ratio polarity and check of voltage vector relationship ­

c. Measurement of impedance voltage and short circuit impedance (principal tapping) and load loss

d. Measurement of no load losses and current

e. Measurement of Insulation resistance

*f.* Separate source voltage withstand test

g. Induced over voltage withstand test

h. Oil leakage, gas collection, oil surge and test on gas actuated relays.

i. Air pressure test *for* tank as per ISS.

j. Absorption index i.e. insulation resistance for 15 seconds and 60 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10 mt/R1 mt)

k. Oil leakage test of transformer tank at a pressure equal to normal pressure plus 35 kN per sq mtr measured at the base of tank.

l. Measurement of neutral unbalance current (not to exceed 2% of full rated current of transformer)

**ii)TYP E TEST**:

In addition to above routine test, the transformer may be subjected to the following type test as specified in IS:2026, *for* which no extra charge shall be paid if the prototype transformer has not been tested *for* type test: ..

a. Measurement of winding resistance

b. Measurement of voltage ratio and - check of voltage vector relationship

c. Measurement of impedance voltage and short circuit impedance (principal tapping) and load loss

d. Measurement of no load losses and current.

e. Measurement of Insulation resistance

f: Lightning impulse voltage withstand test.

g. Temperature rise test

h. Short circuit withstand test

i. Off load tap changer tests (as per BS:4571 / BS EN 60214 )

j. Tank Vacuum test

k. Tank Pressure test

If records of type tests done on a transformer which is essentially a representative of the one being purchased. are furnished to the purchaser, may accept these, as evidence of type tests instead of actual test.

**iii)Pre-Commissioning Tests**

After the transformer is assembled & installed, following pre-commissioning tests and checks shall be done before putting the transformer in service.

Dry out test

Megger Test

DC Resistance measurement of windings

Ratio test on all taps

Phase relationship test (Vector grouping test)

Buchholz relay (alarm & trip) operation test

Low oil level (in conservator) alarm

Temperature Indicators

Marshalling kiosk

Magnetising current

* Insulation resistance test
* Dielectric test on oil

**iv)The following additional checks shall be made:**

All oil valves are in correct position closed or opened as required.

Thermometer pockets are filled with oil.

Oil is at correct level in the conservator.

Earthing connections are made.

Colour of Silica gel is blue.

Bushing arcing horn is set correctly and gap distance is recorded

v) **FURTHER TESTS**:

The purchaser reserves the right of having other reasonable test carried out at his own expanses either before shipment or at site to ensure that the transformer complies with the requirements of these specifications.

36. **INSPECTION**:

All tests and inspection shall be made at the place of manufacturer unless otherwise specially agreed upon by the manufacture and purchaser at the time *of* purchase. The manufacturers shall provide the inspector representing the purchaser all reasonable facilities, without charges, to satisfy him that the material is being furnished in accordance with this specification.

The purchaser has the right to have the test carried out at his own cost by an independent agency whenever there is dispute regarding the quality of supply.

**37. STAGE INSPECTION**

The purchaser reserves the right to carry out stage inspection of power transformers. During stage Inspection compliance of following particulars shall be checked**.**

1. Core assembly – weight,diameter, window height, leg centre, stack width, stack thickness, thickness of laminations, proof towards prime source of laminations

b) Windings – weight , conductor size, I.D., O.D & height of winding, major and minor insulations for both H.V and L.V windings

c) Tank – weight, length, breadth, height and thickness of plates of transformer tank, quality of fittings and accessories.

The supplier shall offer for final inspection of the transformers subject to clearance of the stage inspection report by the purchaser

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38, **TEST REPORTS**:

After all tests have been completed, seven certified copies of each test report shall be furnished. Each report shall supply the following information ­

a. Complete identification data including serial number of the transformer

b. Method of application, where applied, duration and interpretation of results for each test.

c, Temperature data corrected to 75°c including ambient temp.

d. Tolerance on test result shall conform to the relevant clause of IS:2026.

39. **DRAWlNG DATA AND GUARANTEED TECHNICL PARTICULARS** :

As far as possible after the award of the contract the supplier shall supply four copies of drawings which will describe the equipment in details for approval.. The following drawings for each item are to be supplied as part of this contract­

a. Outline dimensional drawings of transformer and accessories.

b. Assembly drawings and weights of main' component parts

c. Drawing giving the weights for foundations

d. Tap changing and name plate and diagram

e. Test reports

f. Descriptive literature and data on transformer construction, winding, bushings heat exchange, tap changing gear etc.

**40. DEVIATION FROM THE SPECIFICATIONS:**

Should be clearly listed and brought out at schedule of deviation, Annexure-‘F’ only.

41. **CRGO Core**:

i) It is to be noted that only imported fresh Cold Rolled Grain Oriented (CRGO), Silicon Steel Sheets are to be used for the manufacture of transformers use of imported secondhand/ defective/ used/ scrap CRGO sheets are not allowed. During pre-dispatch inspection and testing of transformers by the authorised representative of JBVNL if it is found that imported secondhand/ defective/ used scrap CRGO steel sheets have been used in the transformer by the supplier the entire lot shall be rejected. and Purchase order may be cancelled and no further order for supply of transformer shall be placed in future by JBVNL to the supplier.

The inspecting officer will submit the photocopies of above documents alongwith the inspection report.

ii) Each lamination shall be insulated such that it will not deteriorate due to mechanical pressure and the action of hot transformer oil.

iii) The core shall be constructed either from high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to HIB grade with lamination thickness not more than 0.23 mm to 0.27 mm or better.

iv) The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density with + 12.5 % voltage variation from rated voltage or frequency variation of -5% shall not exceed 1.9 Tesla. The bidder shall provide saturation curve of the core material proposed to be used. Laminations of different grade(s) and different thickness (s) are not allowed to be used in any manner or under any circumstances.

v) Following documents shall be submitted during stage inspection as proof towards use of prime core material:

a) Purchase order

b) Invoice of the supplier

c) Mills test certificate

d) Packing list

e) Bill of lading

f) Bill of entry certificate to customs

vi) Core material shall be directly procured either from the manufacturer or through their accredited marketing organization of repute and not through any agent.

vii) The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.

viii) The insulation structure for the core to bolts and core to clamp plates, shall be such as to withstand 2000 Volt DC voltage for one minute.

ix) The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core assembly shall not deviate from the vertical plane by more than 25 mm.

x) All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding.

xi) The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.

xii) The core clamping structure shall be designed to minimize eddy current loss.

xiii) The framework and clamping arrangements shall be securely earthed.

xiv) The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.

xv) Oil ducts shall be provided, where necessary, to ensure adequate cooling inside the core. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.

xvi) The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination, which may cause local heating. The supporting framework of the cores shall be so designed as to avoid the presence of pockets, which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.

xvii) The construction is to be of `boltless core’ type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits.

xviii) The temperature gradient between core & surrounding oil shall be maintained less than 200C. The manufacturer

xix) Stage level inspection for core construction shall be carried out by the owner.

**42. Control Connections and Wiring Terminal, Board and Fuses**

a) Normally no fuses shall be used anywhere. Instead of fuses MCBs (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements, a HRC fuse can be accepted.

b) All wiring connections, terminal boards, fuses, MCBs and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be sweated together to prevent seepage of oil along the wire.

c) Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC. All wiring to a panel shall be taken from suitable terminal boards.

d) When 400 volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 400 volts Danger Notice must be affixed to the outside of the junction boxes or marshalling box. Proper colour code for Red, Yellow, Blue phases wires shall be followed. All circuits, in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The function of each circuit shall be marked on the associated terminal boards.

e) All box wiring shall be in accordance with relevant IS. All wiring shall be of stranded single core copper (48 strands) of 1100 Volt grade and size as under:

**Technical Specifications**

* CT circuits – 2x2.5 sq.mm.
* AC/DC Power circuit – 1x2.5 sq.mm.
* All other circuit - 1x2.5 sq.mm.

f) All wires on panels and all multi-core cables shall have ferrules, for easy identifications, which bear the same number at both ends, as indicated in the relevant drawing.

g) The same ferrule number shall not be used on wires in different circuits on the same panels.

h) Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.

i) Stranded wires shall be terminated with tinned terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire terminated. Wiring shall, in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.

j) Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded (48 No.) copper wire or strip having a cross section of not less than 2.5 sq. mm. Where strip is used, the joints shall be sweated.

k) The wiring diagram for marshalling box shall preferably be drawn as viewed from the back and shall show the terminal boards arranged as in services.

l) Terminal blocks shall be 1100 volts 10 Amp grade moulded material complete with stud type brass terminal, washers, nuts and identification strips.

m) Terminal block rows should be spaced adequately not less than 100 mm apart to permit convenient access to external cables and terminations.

n) Terminal blocks shall be placed with respect to the cable gland (at a minimum distance of 200 mm) as to permit satisfactory arrangement of multi-core cable tails.

o) Terminal blocks shall have separate pairs of terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall be adequately protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards.

p) All interconnecting wiring, as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Transformer supplier.

q) The schematic diagram shall be drawn and fixed under a transparent prospane sheet on the inner side of the marshalling box cover.

r) All marking of terminals shall follow IS 11953

**43. In house Inspection and Testing**

a) The supplier shall carry out a comprehensive inspection and testing during manufacture of the transformer. An indicative of checks to be carried out during manufacturing are given below.

b) This is, however, not intended to form a comprehensive program as it is supplier’s responsibility to draw up and carry out such a program duly approved by the purchaser.

c) The supplier shall carry out type tests, special tests and routine tests on the transformers.

d) Only one no. transformer of each rating will be subjected to type test.

e) All type , special and routine tests shall be carried out at supplier cost.

f) The pre-shipment checks shall also be carried out by the supplier.

g) The requirements of onsite tests are as listed in the specifications.

h) Certified test report and oscillographs shall be furnished to the purchaser/consultants for evaluation. The Supplier shall also evaluate the test results and rectify the defects in the equipment based on his and the Purchaser’s evaluations of the tests without any extra charges to the Purchaser. Manufacturer’s Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.

i) The bidder shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity.

**44. Checks during Manufacturing**

**Tank and conservator**

* Inspection of major weld.
* Crack detection of major strength weld seams by dye penetration test.
* Check correct dimensions between wheels, demonstrate turning of wheels, through 90o and further dimensional check.
* Leakage test of the conservator.

**Core**

* Sample testing of core materials for checking specific loss properties, magnetization characteristics and thickness.
* Check on the quality of varnish if used on the stampings.
* Check on the amount of burrs.
* Visual and dimensional check during assembly stage.
* Check on completed core for measurement of iron loss.
* Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
* High voltage DC test (2 kV for one minute) between core and clamps.

**Insulating Material**

* Sample check for physical properties of materials.
* Check for dielectric strength
* Check for the reaction of hot oil on insulating materials.

**Winding**

* Sample check on winding conductor for mechanical continuity and electrical conductivity.
* Visual and dimensional checks on conductor for scratches, dent mark etc.
* Sample check on insulating paper for PH value, electric strength.
* Check for the bonding of the insulating paper with conductor.

**Technical Specifications**

* Check for the reaction of hot oil and insulating paper.
* Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.
* Check for absence of short circuit between parallel strands.

**Checks before Drying Process**

* Check condition of insulation on the conductor and between the windings.
* Check insulation distance between high voltage connections, between high voltage connection cables and earth and other live parts.
* Check insulating distances between low voltage connections and earth and other parts.
* Insulating test for core earthing.

**Checks during Drying Process**

* Measurement and recording of temperature and drying time during vacuum treatment.
* Check for completeness of drying.

**Assembled Transformer**

* Check completed transformer against approved outline drawing, provision for all fittings, finish level etc.
* Jacking test on the assembled Transformer.
* Check for proper packing and preservation of accessories like radiators, bushings, explosions vent, dehydrating breather, rollers, Buchholz relay, control cubicle connecting pipes, Off Load Tap Changing & conservator etc.
* Check for proper provision of bracing to arrest the movement of core and winding assembly inside the tank.
* Gas tightness test to conform tightness.

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**45. TEST PROCEDURES**

A. **Oil leakage Test:**

The tank and oil filled compartments shall be tested for oil tightness completely filled with air or oil of viscosity not greater than that of insulating oil conforming to IS: 335 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 KN/m2 measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air and during that time no leak shall occur.

**B. Pressure Test**

Where required by the Purchaser, one transformer tank of each size together with its radiator, conservator vessel and other fittings shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35

kN/m2 whichever is lower, measured at the base of the tank and maintained for one hour.

**C. Vacuum Test**

One transformer tank of each size shall be subjected to the vacuum pressure of 760 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of 3.33 kN/m2 (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999) without affecting the performance of the transformer.

**46. Testing Equipment/Meter Calibration:**

All testing equipments / meters used shall be calibrated within valid time limit at NABL accredited laboratory. Calibration seals provided by the calibrating agency on testing equipments / meters shall be in good condition.

**Rejection**

The Purchaser may reject any transformer if during tests or service any of the following conditions arise:

a) No load loss exceeds the guaranteed value.

b) Load loss exceeds the guaranteed value.

c) Impedance value exceeds the guaranteed value by + 10% or more.

d) The difference in impedance values of any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.

e) Oil or winding temperature rise exceeds the specified value.

f) Transformer fails on impulse test.

g) Transformer fails on power frequency voltage withstand test.

Transformer is proved to have been manufactured not in accordance with the agreed specification