POWER TRANSFORMER

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Engineering Department

WEST BENGAL STATE ELECTRICITY TRANSMISSION COMPANY LIMITED
পশ্চিমবঙ্গ রাজ্য বিদ্যুৎ সংবহন কোম্পানি লিমিটেড
(পশ্চিমবঙ্গ সরকারের একটি উদ্যোগ)

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Updates for WBSETCL / TECH SPEC / Rev.-8

1. Pg 6 of 52
   Clause No 5h) has been modified as “Clearances of line terminals **(with fitted connectors)** in Air:”
2. Pg 8 of 52
   Under Clause No 9b) **“the actual length of bottom plate shall be furnished in drawing”** has been added.
3. Pg 13 of 52
   Under Clause No 13), RTCC panel, “**DC supply shall be considered 220V or 110V, whichever applicable**” has been added.
4. Pg 14 of 52
   Under Clause No 13b), Digital RTCC Relay “**Live demonstration of offered digital RTCC relay must be arranged by the Bidder at the laboratory of Central Testing Department of WBSETCL prior to approval, if felt necessary. The bidder shall have to make necessary arrangement without any extra price.**” has been added.
5. Pg 15 of 52
   Under Clause No 13f), RTCC panel “**Dual DC supply with changeover scheme through individual MCB for Indication, Marshalling Box Supply and for Auxiliary Supply of BCU, Annunciator and Repeaters**” has been added.
6. Pg 16 of 52
   Under Clause No 13), RTCC panel, **(Alarms through Annunciator with additional Test, Accept and Reset Push Buttons)** has been added.
7. Pg 18 of 52
   Clause No 15f), has been modified as “220/110Volt ± 10% DC supply”
8. Pg 18 of 52
   Under Clause No 15g), “The transformer rating and diagram plate shall bear a warning statement that the **“Main conservator is fitted with an air cell””** has been added.
9. Pg 18 of 52
   Under Clause No 15h), “Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be externally installed on the top of conservator to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service” has been added.
10. Pg 18 of 52
    Under Clause No 16, the phrase “**with fitted connectors**” has been added.
11. Pg 20 of 52
    Clause No 16, has been modified as “In case of 400/220/33KV, 220/132/33KV Auto Transformer, for each phase one CT, i.e. altogether 3 CTs are to be provided for circulating current protection before Neutral formation. These CTs should be located near the Neutral Bushing**.” Where 220/33 KV Power Transformer has been deleted.**
12. Pg 20 of 52
    Clause No 16, **Current Rating for Bushings of 500 MVA transformer has been added.**
13. Pg 20 of 52
    Clause No 16, Under Bushing Current Transformer, Serial No iii) **“Core identification mark should be embedded with punch at Secondary terminal box”** has been added.
14. Pg 21 of 52
    Under Clause No 18viii), “Current density calculation shall be submitted considering 10% overloading” has been added.
15. Pg 22 of 52
    Under Clause No 20),” In **Case of separately mounted radiator bank arrangement, radiator bank shall generally be placed on the left side of the tank while watching from HV side of the transformer. However, the main tank shall have provision such that cooler banks can be placed on either side of the main tank by simple reconnection without the need of any extra member/pipe maintaining the electrical clearances**.” has been added.
16. Pg 23 of 52
    Under Clause No 23c) “Three-Position switches (Service, Standby and Test) shall be provided for each Fan and Pump to allow flexible selection of the Service and Standby units” has been added.
17. Pg 24 of 52
    Under Clause No 23d) has been modified.
18. Pg 24 of 52
    Clause No 23e),”Separate MCBs for Fan Control and Pump Control” and “DC supply from RTCC through **individual MCB** for CCU, Indication, FOTS signal Box” have been added.
19. Pg 24 of 52
    Clause No 24), NIFPS Clause has been fully modified. **NIFPS is mandatory for all transformers**.

Updates for WBSETCL / TECH SPEC / Rev.-8

20. Pg 26 of 52
    Under Clause No 25.e.5.d), “for local access/configuration etc.” has been added.
21. Pg 26 of 52
    Under Clase No 26, Valve Scheule Serial No 8,9 and 14 have been modified/added.
22. Pg 27 of 52
    Under Clause No 26ii), “All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings” has been added.
23. Pg 27 of 52
    Under Clause No 27, PRD Clause has been modified and Sudden Pressure Relay has been introduced.
24. Pg 28 of 52
    Under Clause No 30b), “All the supervision cable and CT cable terminations at marshalling box and RTCC panel shall be made using Ring Type lugs/socket.” has been added.
25. Pg 30 and 31 of 52
    Clause No 36, Under **Drawings for Controls**, in Serial No vii and ix, FOTS has been added, under **Drawings of Transformers,** Serial No xii, **“**Interconnection Table with proper Ferrule Number” has been added and List under “Other Documents/Drawings of Transformer” has been added.
26. Pg 34 and 35 of 52
    Clause No 40, Serial Number 3iii, vi, vii, viii, ix, xii, xv, xvii, xix, xx, xxii, xxvi, xxx have been modified/added and under Type Test serial no a), b) and d) have been added.
27. Pg 37 of 52
    General Note: D and E have been added.
28. Pg 38 of 52
    Under Clause No 46, Signals for OLTC Main Supply **OFF** and OLTC Control Supply **OFF changed to FAIL**
29. Pg 39 of 52
    Under Clause No 46, **Signals for Cooler Control Fan and Pump OFF changed to FAIL**.
30. Pg 40 of 52
    STP Serial No 8 has been modified. Tertiary winding Capacity (MVA) for 200 MVA and 160MVA changed to **5 MVA.**
31. Pg 43 of 52
    STP Serial No 32 has been modified.
32. Pg 45 of 52
    CT Core Details of Tertiary of 500 MVA Transformer, 220 KV and 33 KV Side of 100 MVA Transformer have been added.
33. Pg 45 of 52
    Serial No 16 regarding Losses has been added in GTP Format.

TECHNICAL SPECIFICATION FOR
POWER TRANSFORMER

1. SCOPE:

This specification covers design, engineering, manufacture & assembly of 3-Phase, 400/220/33KV, 220/132/33 KV, 220/33 KV, 132/33 KV and 132/66 KV Power/Auto Transformer complete with all fittings and accessories required for efficient and trouble-free operations of the transformer, testing at manufacturer's works and customer's premises, supply, loading at factory, delivery at site, unloading, handling, dragging for proper storage at site on the plinth of transformer, if the same is ready at respective site or at suitable location as per direction of site-in-charge of customer.

2. GENERAL REQUIREMENT:

The Transformer shall be multi-winding, oil immersed complying as per Specific Technical parameters and suitable for outdoor installation.

Rated Capacity and Voltage of the Transformers shall be guided by the respective Tender Documents. The specification covers for the following transformers as per present requirement of the company:

a) 400/220/33KV and 220/132/33 KV Auto Transformer with loaded 33 KV tertiary winding.

b) 220/33KV and 132/33 KV Power Transformer

c) 132/66 KV Auto Transformer with unloaded stabilizing winding having two terminals taken out.

Type Test: The transformers should be **Type Tested as per IS 2026 or IEC 60076** in conjunction with their relevant Part. Necessary test documents shall have to be submitted with the bid.

Dynamic Effect of Short Circuit

For 400kV Class Autotransformer:

Bidder should have successfully carried out Dynamic Short Circuit test on offered transformer or similar transformer (as defined in IS 2026 part-5) as on the date of NIT and shall enclose the relevant Test Report and certificate along with bid. Otherwise, their bid shall be considered technically non responsive. This shall be applicable for 400kV class Auto transformer of MVA rating similar or higher than the tendered transformer.

The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer and Bidder shall enclose a compliance sheet to establish the same.

For 220 kV Class Transformer:

Bidders should have successfully carried out Dynamic Short Circuit Test offered transformer or similar transformer (as defined in IS 2026 part-5) as on the date of NIT and shall enclose the relevant Test Report and Certificate along with bid. Otherwise, their bid shall be considered technically non-responsive. This shall be applicable for 220 kV class transformer of MVA rating similar or higher than the tendered transformer.

The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer and Bidder shall enclose a compliance sheet to establish the same.

For 132 kV Class Transformer:

Bidders should have successfully carried out Dynamic Short Circuit Test offered transformer or similar transformer (as defined in IS 2026 part-5) as on the date of NIT and shall enclose the relevant Test Report and Certificate along with bid. Otherwise, their bid shall be considered technically non-responsive. This shall be applicable for 132kV class Transformer of MVA rating similar or higher than the tendered transformer.

The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer and Bidder shall enclose a compliance sheet to establish the same.

Sweep Frequency Response Analysis (SFRA/FRA) shall have to be carried out as special test for each transformer at manufacturer's premises in presence of representative of WBSETCL free of cost. Test result shall have to be handed over to WBSETCL. Before commissioning of the Transformer at site, the same SFRA/FRA test will have to be carried by the test engineers of the manufacturer in presence of customer's representative for comparing the results to take the decisions of the commissioning. **The Testing Engineers & FRA kit for such pre-commissioning site testing shall have to be arranged by the manufacturer free of cost.**

Tests at Manufacturer's works: The Transformers shall be subjected to type & routine test, special tests, and no load & load loss measurement as per relevant IS / IEC as mentioned in the Clause "TEST AT FACTORY AND TESTCERTIFICATES."

Guaranteed Technical Particulars: The Bidder shall furnish all guaranteed technical particulars as called for in this specification along with each copy of Bid submission. Bids lacking information in this respect may not be considered.

Core Materials: Core materials should be directly procured from either the manufacturer or their accredited reputed marketing organization and not through any agencies.

3. STANDARD:

The Power Transformer covered under this specification shall comply with the requirements of the latest edition of the Standards.

i)	IS:2026 (Part I to IV)	- Specification for Power Transformer
ii)	IS:2099&IS:3347	- Bushing for alternating voltage above 1000 volt
iii)	IS:6600	- Guide for loading of oil immersed transformer
iv)	IS:335	- Specification for transformer oil
v)	CBIP	- Manual on transformer
vi)	IEC-60076	- Power Transformer
vii)	IEC-60214	- On Load Tap changer
viii)	IEC-354	- Loading Guide for Oil Immersed Transformer
ix)	IEC-551	- Tr. Sound Level
x)	CEA	- Standard specifications and technical parameters for transformers and reactors (66 KV & above voltage class)

4. DEVIATION:

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

5. GENERAL DESIGN:

a) The Transformer and accessories shall be designed to facilitate easy inspection, cleaning, and repairs. All fittings and accessories shall be designed to ensure satisfactory operation under worst conditions of load and voltage as may be met under working conditions in the system.

b) All materials used shall be of best quality and of the class most suitable for working under the conditions specified. It shall withstand the variations of temperature and atmospheric conditions without undue stressing etc. i.e., not affecting the workability/durability of the various parts of the transformer.

c) All outdoor fittings and accessories, including bushings insulators with their mounting, shall be so designed as to avoid pockets in which water can collect. All electrical connections shall be of ample cross sections for carrying the specified currents continuously without undue heating. All fixing bolts and screws shall be reliable under worst conditions of operations.

d) Transformers shall be suitable for continuous operation with a frequency of 50 Hz and variation of± 3% without exceeding specified temperature rise.

e) Transformer with tertiary winding and all its accessories including Bushing CTs etc. shall be designed to withstand without injury, the mechanical and thermal effects, and any external short circuit to earth and of short circuits at the terminals of any winding. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

f) The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

- 400kV system - 63kA for 1 sec (sym, rms, 3 phase fault)
- 220kV system - 50 kA for 1 sec / 40 kA for 3 sec (sym, rms, 3 phase fault)
- 132kV system - 40 kA for 1 sec / 31.5 kA for 3 sec (sym, rms, 3 phase fault)
- 66kV system - 31.5 kA for 3 sec (sym, rms, 3 phase fault)
- 33kV & 11kV system - 25 kA for 3 sec (sym, rms, 3 phase fault)

g) For parallel operation with other transformers, necessary provision is to be kept in transformer RTCC panel for tap changing operation in any of Master/Follower/Independent mode.

h) Clearances of line terminals (with fitted connectors) in Air:

The clearance of HV, IV & LV terminals after fitted with connectors shall be maintained as specified below:

Highest System voltage of equipment (KV rms)	Phase to Phase clearance (mm)	Phase to earth clearance (mm)
420	4000	3500
245	2000	1800
145	1220	1050
72.5	700	660
36	350	320
52	530	480

i) Transformer shall be designed for full lightning impulse voltage as well as chopped and reduced chopped impulse voltage as per relevant clauses of IS:2026(Pt.-III)/IEC:60076-3

j) **VIBRATION AND NOISE:** Transformer when energizes at normal voltage and frequency with fans & pumps running, shall have minimum hum. Under standard operating condition the abnormal noise shall not exceed the value specified at latest NEMA standard publication TR-1.

k) Over loading of transformer shall be guided by latest IS-6600.

l) Only type tested accessories shall be supplied. All accessories mounted out door shall have contact enclosure tested with IP-55 as per IS: 13947 in order to avoid mal operation during rain or condensation.

m) Insulation resistance of core-clamp link shall be more than 1Giga ohm (independent of temperature variation) and the value can be verified at site.

n) If not specified, the location of conservator may be fixed on left side of the transformer when viewed from HV side.

6. TERTIARY WINDINGS:

The 400/220/33KV and 220/132/33 KV transformers shall be provided with delta connected loaded tertiary windings of 33 KV voltage class and shall be suitably rated to withstand the stresses due to short circuit in the system. Transformer with 3-windings shall be of loaded tertiary design.

This stabilizing winding shall be capable of carrying continuously the rated load as specified under S.T.P. The design of the stabilizing winding shall be such that to take care of the effect of transfer surge. Tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

7. TEMPERATURE RISE:

Each Transformer shall be capable of operating continuously at its normal rating without exceeding temperature rise and hot spot limits.

Type of Cooling	Maximum Ambient Temp.	Maximum Top Oil Temp. Rise	Maximum Winding/ Core Temp Rise	Maximum Winding Temp.	Maximum permissible value of Avg. Temp. of Winding after 3 sec of short ckt. Up to 160 MVA
ONAN	50°C	50°C	55°C	105°C	250°C
ONAF	50°C	50°C	55°C	105°C	250°C
OFAF	50°C	50°C	55°C	105°C	250°C

8. THERMAL ABILITY TO WITHSTAND SHORT CIRCUIT:

a) Thermal ability to withstand short circuit shall be demonstrated by calculation and shall be furnished along with the drawing after placement of L.O.A.

b) Designed time period for short circuit withstand and fault current will be taken as per General Technical Specification. The maximum permissible value of the highest average temp of winding after withstanding the above stipulated Short Circuit shall not exceed 250°C and the submitted calculations shall be as per Cl. No. 9.1 of IS: 2026(Part-I)

9. DETAILED TRANSFORMER TANK AND TANK COVER:

a) The tank and cover shall be fabricated from low carbon steel plate of adequate size and suitable for welded construction. The tank so welded shall be reinforced by stiffener of structural steel for general rigidity. Each tank cover shall be of adequate strength and shall not distort when lifted.

b) The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without damage when using plates or rails. **The base plate shall have following minimum thickness and the actual length of bottom plate shall be furnished in drawing.**

Length of tank (m)	**Minimum plate thickness (mm**
Flat bases	
Over 2.5 m but less than 5m	20
Over 5 m but less than 7.5m	26
Over 7.5 m	32

c) The tank shall be designed to have sufficient strength to withstand without distortion-

(i) Under full vacuum at an internal pressure. of 3.33KN/sq.mm. absolute (25 torr) for one hour and permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in	Permanent deflection (in mm.)
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

(ii) Transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m^2 whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figures specified under vacuum test above and

(iii) The tank shall be designed to have sufficient strength to withstand mechanical shock during transport.

d) The internal and external surface including structural steel work and oil filled chambers are to be painted after removing all rust and scale of foreign adhering matter or grease by sand blasting or other approved method. All steel surfaces in contact with insulating oil shall be painted with **two coats of heat-resistant oil insoluble insulating paint**.

e) All steel surface exposed to weather shall be given **a primary coat of zinc chromate** and shall be applied immediately after cleaning. The second coat shall be of an oil and weather resisting nature and of shade or colour easily distinguishable from the primary. The final coat shall be of **epoxy** paint of minimum thickness of 80 microns and weather resisting non-fading paint of shade No. 631 of IS:5. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. **The successful Bidder shall submit detailed painting procedure during detailed Engineering for approval**.

f) All paints shall be carefully selected to withstand heat and weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

g) The tank construction of Power Transformer up to 100 MVA rating shall be of Conventional type **Top Cover or Bell Tank** construction. The tank construction of transformer having rating of more than 100 MVA irrespective of voltage classes and no. of winding shall be of **Bell Tank** construction. Tank should be provided with adequately sized inspection covers, either in circular shape or in rectangular shape, preferably at diagonally opposite sides of the tank to access the active part and one at each end of the tank cover for easy access of the lower end of the bushings, earthing connections and tap changers etc. for inspection. Inspection covers shall be bolted type and shall not weigh more than 25 kgs. Handles shall be provided on the inspection cover to facilitate its lifting. To make joints oil tight, **nitrile rubber gaskets** shall be cut to size and shape to avoid joints on gaskets as far as practicable. All tank gaskets/O-rings used shall be of NBR (Acrylonitrile Butadiene Rubber) suitable for temperature conditions expected to be encountered during operation. The gasket material and additives should be fully compatible with transformer insulating fluid/oil. The gasket should not contain oil soluble Sulphur compounds. The properties of all the above gaskets/O-Rings shall comply with the requirements of type-IV rubber of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened. It shall be fitted with pockets for thermometer and for the bulbs of oil and winding temperature indicators. The thermometer pockets shall be fitted sufficiently above on the surface of the top cover of main tank with a captive screwed top to prevent ingress of water. The pockets shall be located in position of maximum temperature and it shall be possible to remove bulb without lowering the oil in the tank.

h) Tank MS plates of thickness >12 mm should undergo Ultrasonic Test (UT) to check lamination defect, internal impurities in line with ASTM 435 & ASTM 577.

i) Bi-directional flanged rollers for moving the transformer on rail gauge (1676 mm) shall be provided. The direction of the roller through 90^{o} (degrees) can be changed by jacking up the assembly. Bi-directional rollers can be locked in required direction by bolting the roller mounting pad welded on the base of the tank and bi-directional flanged rollers bracket with bolts. The tank shall be provided with all fittings and accessories.

j) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the center of the working surface.

k) Lifting lugs shall be provided on all parts of transformer requiring independent handling during assembly or dismantling. In addition, the transformer shall be provided with lifting lugs and bosses properly secured to the side of the tank for lifting complete transformer assembly filled with oil either by crane or by pulley. Pulling lugs shall also be provided to facilitate movement of transformer horizontally.

l) The transformer tank shall be equipped with the valves and plugs as mentioned **under Sl. No 26** with standard screw connection for piping.

Any other valves & plugs other than those mentioned above, are also to be provided as per requirement.

m) For Three winding Transformer **6no. thermometer pockets should be provided for WTI & 2 no. for OTI**. Amongst 6 no. pockets for WTI, three (3) will be used for direct connection with the WTI in MK of Transformer. Balance three no. (3) shall be provided with PT 100 sensor and Current Converter Unit (CCU) at MK for WTI repeater at the RTCC panel to be installed in Control Room. Similarly, amongst Two (2) no. pocket for OTI, one will be used for direct connection with OTI in MK of Transformer. Balance one no. shall be provided with PT 100 sensor and Current Converter Unit (CCU) at MK for OTI repeater at the RTCC panel to be installed in Control Room.

n) For Two winding Transformer 4no. thermometer pockets should be provided for WTI & 2 no. for OTI. Amongst 4 no. pocket for WTI, two (2) will be used for direct connection with the WTI in MK of Transformer. Balance Two (2) shall be provided with PT 100 sensor and Current Converter Unit (CCU) at MK for WTI repeater at the RTCC panel to be installed in Control Room. Similarly, amongst Two (2) no. pocket for OTI, one (1) will be used for direct connection with OTI in MK of Transformer. Balance one no. (1) shall be provided with PT 100 sensor and Current Converter Unit (CCU) at MK for OTI repeater at the RTCC panel to be installed in Control Room.

o) Design shall be such that Tank cover can be lifted independently without lifting active part of core, winding etc.

p) A step ladder with anti-climbing arrangement shall be provided with each transformer to step into the top of the tank.

10. CORE:

The magnetic circuit shall be core type. Each limb shall be joined with top and bottom yokes. The laminations shall be made from high grade non-ageing cold rolled grain-oriented silicon alloy of HI -B or its equivalent grade steel. The insulation of lamination shall be coated with oxide/silicate/phosphate coating or any coating inert to the action of hot transformer oil. The core should be bottom mounted.

The core shall be of stepped cross-section. The yokes shall be clamped by means of end frames and yoke bolts and limbs shall be clamped by means of clamp plates. Enough lifting lugs is to be provided on end frames so that core with windings can be lifted when required.

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 angles to the plane of lamination which may cause local heating.

The insulation for the core to bolts and core to clamps shall be such as to withstand a test voltage of 2 (two) KV rms at 50 Hz for one minute.

The maximum flux density in any part of the core and yoke at the rated MVA, voltage & frequency shall be such that less than 10% continuous over voltage condition does not exceed 1.9Tesla.

For consideration of over fluxing, the transformer shall be suitable for continuous operation for values of over fluxing at (i) 110% (ii) one minute for 125% and (iii) 5 seconds for 140% of rated voltage.

The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively.

The prime core materials are only to be used. Bidders should furnish following document as applicable as a proof towards use of prime Core material to be submitted before the stage inspection:

(a) Invoice of supplier
(b) Mill's test certificate
(c) Packing List
(d) Bill of lading
(e) Bill of entry certificate by Custom.
(f) Description of material, electrical analysis, physical inspection, certificate for surface defects, thickness, and width of the materials.
(g) Place of cutting of core materials

11. WINDINGS:

The Material of winding conductor should be of electrolytic grade copper of minimum 99.90% purity and free from scales, spills, splits, and other defects. The windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repair is possible. The coils shall be supported between adjacent sections by insulating spacers, and the barriers. Bracing and other insulation used in the assembly of the windings shall be arranged to ensure a free circulation of the oil and to reduce hot spots in the windings. The stacks of windings shall receive adequate shrinkage treatment before final assembly and the same shall be assembled in dust-controlled chamber.

Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.

The insulation of the coils shall be such as to withstand the full electrical strength of the windings. All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil, and shall not soften or otherwise be adversely affected under the operating conditions. The dielectric strength of winding insulation shall confirm to values given in IS: 2026, as amended up to date, or as per specific Technical Parameters.

All threaded connections shall be provided with locking facilities.

All leads from the windings to the terminal board and bushings shall be rigidity supported to prevent injury from vibration. Guide tubes shall be used where practicable.

The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and windings shall be vacuum dried and suitably impregnated with insulating oil. The copper conductors used in the coil assembly shall be best suited to the requirements and all permanent current carrying joints in the windings and the leads shall be welded or brazed. Oil ducts shall be such as will not impede the free circulation of oil through windings assembly.

The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

12. TAP CHANGING MECHANISM:

The transformer shall give full load output on all taps. The transformer shall operate without danger on any tapping at the rated MVA within a voltage variation of ±10% of the rated nominal voltage.

For 132/33KV & 220/33 KV transformer ON LOAD TAP CHANGER with bi-directional power flow shall be provided on the 132KV voltage winding & 220KV winding respectively. The tapping range shall be +10% and —10% in 1.25% equal steps. Remote Tap Changer Panel shall also be provided to be installed at our Control Room.

For 132/66KV, 220/132/33 KV & 400/220/33KV Auto Transformer Tap coil with bi- directional power flow shall be provided at 132 KV, 132 KV and 400 KV sides respectively of the transformer. The tapping range shall be + 10% and —10% in 1.25% equal steps. **Transformers with constant ohmic impedance characteristics are preferred.** However, to match with existing system other type may have to be supplied.

Remote Tap Changer Panel shall also be provided to be installed at our Control Room. In Tap Position Indicator sufficient terminals are to be provided for sending inputs for SCADA/SAS.

13. ON LOAD TAP CHANGER:

The OLTC shall be of high-speed transition resistor type. This shall be designed suitable for remote control operation from RTCC Panel in the control room to be supplied by the manufacturer in addition to being capable of local manual as well as local electrical operation.

The on-load tap changer shall include the following: -

a) An oil immersed tap selector and arcing switch or arc suppressing tap selector, provided with reactor or resistor for reduction of make and break arcing voltages and short circuits.
b) Motor driven Mechanism
c) Control and protection devices
d) Local/Remote tap changer position indicator
e) Manual/Electrical operating device.

The on-load tap changer shall be designed so that the contacts do not interrupt arc within the main tank of the transformer. The tap selector and arcing switch or arc suppressing tap selector switch shall be located in one or more oil filled compartments. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank. Those compartments shall be designed to prevent the oil in tap selector compartment from mixing with the oil in the transformer main tank.

An oil surge relay with trip float arrangement shall be provided for the OLTC unit.

The tap changer shall be capable of permitting parallel operation with either existing or future transformers of the same type as Master or Follower.

The manual operating device shall be so located on the transformer that it can be operated by a man standing at the level of the transformer track. It shall be strong and robust in construction.

The control scheme for the tap changer shall be provided for independent control of the tap changers when the transformers are in independent service. In addition, provision shall be made so that under parallel operation the tap changer will give alarm and visual indication for becoming out of step. Visual indication during the operation of motor shall also be incorporated. The tap change control must ensure step by step operation under all operating conditions.

Necessary interlock blocking independent control when the units are in parallel shall be provided.

Under parallel operation, as may occur if the contactor controlling one tap changer sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Details of out of step protection provided for the taps should be furnished in the bid.

The contactors and associated gear for the tap change driving motors shall be housed in a local kiosk mounted on the transformer. The motors shall be suitable for operation with 3-phase 400 volts, 50 cycle external power supply.

RTCC Panel:

The supplier shall furnish, in addition to the equipment above, the following accessories (Either **a)** or **b)**) mounted in a separate Remote Tap Changer Control (RTCC) panel to be installed in each of the WBSETCL's Control Room for remote operation. DC supply shall be considered 220V or 110V, whichever applicable.

a) **Bay Control Unit** (IED should be IEC61850, Edition II compliant having rear port)–

i) BCU shall be provided for data acquisition and control of Power Transformer. The BCU must be supplied from Relay manufacturer, already enlisted in WBSETCL maker's list as on date of NIT conforming all the requirements of latest IS/IEC and the latest WBSETCL Control & relay specification. It is also to be considered that the sub-station may be required to run without air-conditioning plant.

ii) Live demonstration of offered IED must be arranged by the Bidder at the laboratory of Central Testing Department of WBSETCL prior to approval, if felt necessary. The bidder shall be required to make necessary arrangement without any extra price.

iii) Communication Port: BCU shall be PRP compliant (2 No FO port) for SAS with IEC 61850 protocol, Edition II with additional one front port for direct access with proprietary protocol. **Supply of Red Box** is also to be considered for integration of the BCU to a non-PRP compliant network. All inputs and outputs must be user programmable. The bay control units shall be equipped with enough programmable I/O modules for interfacing with the process inputs and outputs. Extension should be possible with additional I/Os via fiber-optic communication and process bus.

iv) The supply of BCU shall be inclusive of necessary Licensed Software and Hardware (Connecting Cord/ Converter) for interfacing with PC.

v) If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

vi) A graphic user interface (GUI) display shall be provided in each bay control unit. All alarms related to the respective bay shall be displayed in the BCU through its LED's or in its GUI display as an alarm list/scroll.

vii) The exact number of digital inputs shall be as per detailed engineering requirement. Apart from that, BCU wise 20% spare I/Os shall be kept for WBSETCL use in future. General note and signal lists for BCU are available in clause no. 45 and 46.

b) Digital RTCC Relay

The relay shall be of reputed make and shall be in successful operation for at-least Two years for transformer OLTC application.

i) Digital RTCC relay should be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and can be easily configurable. If it is supplied as a draw out type module, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors.

ii) Live demonstration of offered digital RTCC relay must be arranged by the Bidder at the laboratory of Central Testing Department of WBSETCL prior to approval, if felt necessary. The bidder shall have to make necessary arrangement without any extra price.

iii) The digital RTCC relay shall be provided in the RTCC panel. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

(i) In Manual Mode: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.
(ii) In Auto Mode: In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

iv) Master / Follower/ Independent/ Off mode
Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other transformer banks/three phase transformer in the follower made by operating the master unit.
Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected.

v) Raise/Lower: The remote OLTC scheme offered shall have provision to raise or lower taps only for the complete bank of three 1-phase transformers. Individual single phase OLTC operation shall not be possible from the remote-control panel.

vi) The Digital RTCC relay shall incorporate all the control facilities specified in this specification. The Digital RTCC relay shall be provided for controlling all three phases of a transformer bank. Each Digital RTCC relay shall have integration feature for parallel operation of at least 4 nos. 3-ph transformers or 12 nos., 1-ph transformers working in parallel. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

vii) Communication between the Digital RTCC relays in order to execute the commands for parallel operation shall be implemented using hardware and communication protocol, suitable up to a maximum length of 1km.

viii) Digital RTCC relays shall communicate with SCADA using IEC 61850, EDITION II protocols to monitor, parameterize & control OLTC. Any software required for this purpose shall be supplied. The software supplied will not have restriction in loading of multiple computers for downloading and analyzing the data. The vendor shall provide necessary provision for SCADA integration with the existing/ future SCADA system. Software shall indicate the current overview of all measured parameters of the connected transformer on-line in real time.

ix) It shall be possible to communicate/integrate with all digital RTCC relays of different make located at different locations in the substation by making hardwire and using IEC 61850, EDITION II communication link. The integration of existing conventional RTCC panel with Digital RTCC panel of different make shall also be possible. Digital RTCC relays shall be PRP compliant for SAS with latest 61850 protocol including one front port for direct access with proprietary protocol. Supply of Red Box is also to be considered for integration of the digital RTCC relays to a non-PRP compliant network. All inputs and outputs must be user programmable. The digital RTCC relays shall be equipped with enough programmable I/O modules for interfacing with the process inputs and outputs. Extension should be possible with additional I/Os via fiber-optic communication and process bus.

x) The supply of IED shall be inclusive of necessary Licensed Software and Hardware (Connecting Cord/ Converter) for interfacing with PC.

xi) The Digital RTCC relay shall have programmable Binary Inputs, Binary outputs, and Analog inputs as per signal list furnished in the Annexure. For Employers future use, it shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

xii) Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.

xiii) "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.

c) The RTCC Panel shall be provided with Raise and Lower Push Button Switch, Manual/ SAS mode selection features, Master / Follower/ Independent/ Off mode selection features for control of OLTC.

d) Remote tap position indicator and other required devices. One chart showing the voltage corresponding to tap position indicator shall be engraved on a metal sheet and the same shall be fixed near the tap position indicator on the RTCC (Panel). In Tap Position Indicator sufficient terminals are to be provided for sending inputs for SCADA/SAS.

e) An indication lamp showing tap changing in a progress.

f) Dual DC supply with **changeover scheme** through **individual MCB** for Indication, Marshalling Box Supply and for Auxiliary Supply of BCU, Annunciator and Repeaters.

g) Name plate of each component & relays.

h) Winding & Oil temperature (0^{O} —150^{O}C) repeaters to be connected to winding and oil Temperature meter housed in the main Transformer Marshalling Box at outdoor. In addition to above necessary arrangements are to be made in RTCC panel for Hot spot temperature indication and alarm by optical sensor method.

Complete particulars of the tap changing gear and capacity of the motor shall be stated in GTP. An under-voltage relay shall be incorporated to monitor the AC control circuit voltage of tap changer. Audible Alarm and annunciation shall be provided for failure of control circuit supply, failure of 400 V AC supply to the motor. All the relays requisite for remote tap change operation shall be provided in RTCC panel. The OLTC should have been Type Tested.

In addition to other requirements, following minimum indications and alarms **(Alarms through Annunciator with additional Test, Accept and Reset Push Buttons)** shall be provided:

From DM Box

a. INCOMPLETE STEP (alarm)

b. OLTC motor overload protection (alarm)

c. Supply to DM Motor fail (alarm)

d. OLTC Control supply fail (alarm)

e. OLTC Control Supply Healthy (Indication)

f. OLTC IN PROGRESS (Indication Lamp with Hooter)

g. Local / Remote Selector switch positions in DM Box (Indication)

h. OLTC in BCU Mode/ SCADA Mode (Indication)

i. OLTC Tap position indications for transformer units

j. OLTC upper/lower limits reached (alarm)

k. Independent/ master/ Follower (Indication)

l. Independent-combined-remote selector switch positions of CMB (For 1 Phase Transformer)

m. OLTC Out of Step (alarm)

From Marshalling Box

a. 415V, AC Mail Supply Fail (alarm)

b. 415V, AC Standby Supply Fail (alarm)

c. Failed to transfer (alarm)

d. Each Fan Fail (alarm)

e. Each Pump Fail (alarm)

f. Fan/Pump Control Supply Fail (alarm)

g. Oil Flow Low for each Pump (alarm)

h. Each Fan/Pump On (indication)

i. Fan/Pump in Local manual (indication)

j. Fan/Pump in Local Auto (indication)

k. Fan/Pump Control in Remote Mode (indication)

l. Main/Standby Supply On (indication)

In case of parallel operation or 1-Phase Transformer unit banks, OLTC out of step alarm shall be generated for discrepancy in the tap positions.

14. INSULATING OIL:

Oil for **first filling together with 5% extra oil** shall be supplied with each transformer. The oil shall comply in all respect with the provisions of the latest edition IS:335 (as amended up-to-date) of specification for New Insulation oils for transformers and switchgears. Particular attention shall be taken to deliver the oil free from moisture having uniform quality throughout in non-returnable steel drums. The quantity of oil for first filling of each transformer shall be stated in the offer.

The oil should have the following characteristics:

SL. NO.	CHARACTERISTICS	REQUIREMENT
1.	Interfacial tension at 27°C (min)	0.04 N/m
2.	Electrical strength (Breakdown voltage)	60 KV (rms) after treatment
3.	Resistivity at 90°C /27°C	$35x10^{12}$ /$1500x10^{12}$ Ohm-cm
4.	Dielectric dissipation factor (tan delta at 90°C max.)	0.002

After site processing through filtration and before commissioning, the moisture content shall be as follows:

a) Less than 72.5 KV : 25 ppm
b) 72.5 KV to 145 KV : 20 ppm
c) Above 145 KV : 15 ppm

15. CONSERVATOR VESSEL:

a) The conservator is a vessel for oil preservation. The oil level in the conservator shall not be below the level of the H.V. bushing caps unless the bushings are of oil sealed type construction. The size of the conservator tank shall have adequate capacity with highest and lowest visible level to meet the requirement of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100°C.

b) The conservator shall have **one filter valves at suitable location**, in addition to the valve specified in the accessories for the main tank. The **conservator with sump** shall also have a **small drain valve and sampling cock**, the latter so arranged as not to interfere with oil lines. The oil level gauge shall be mounted on the conservator. The oil level at gauge shall have three indications viz., oil level at 30°C shall be marked on the gauge and indicating range shall be minimum to maximum level.

c) There shall be one "Atmoseal type" sealing to prevent direct contact of transformer oil with the atmospheric air to retard oxidation and contamination of oil.

d) The oil connection from the transformer tank to the conservator vessel shall be arranged at a rising angle of 3 to 9 degree to the horizontal up to the Buchholz relay. The inside diameter shall be 50mm/80mm as per capacity of the transformer and IS:3639.

e) Valves shall be provided at the conservator to cut off the oil supply to the transformer after providing a straight run of pipe for at least five times internal diameter of the pipe on the tank side of the Buchholz relay and at least three times the internal diameter of the pipe on the conservator side of the Buchholz relay. The pipe connecting the transformer tank with conservator will project above the lowest point in the conservator such that the portion below the pipe acts as a sump where the impurities in conservator will be collected.

f) Magnetic oil level gauge with low oil level alarm suitable for 220/110Volt ± 10% DC supply shall be provided.

g) Atmoseal type conservator shall be filled with oil to a level appropriate to the filling temperature. The oil shall be separated from atmosphere by a flexible air cell of nitrile rubber reinforced with nylon cloth air cell. Flexible air cell of nitrile rubber shall be able to withstand max temp of oil considering continuous operation as well as considering overloading of transformer as per relevant IS/IEC. The connection of air cell to the top of the conservator is to be made by air proof seal to prevent entry of air to the conservator. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell"**.

h) Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be externally installed on the top of conservator to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

i) OLTC Conservator shall have oil indicator made of glass.

j) **Dehydrating Filter Breather**: Conservator shall be fitted with a dehydrating filter breather. It shall be designed to facilitate the followings:

i) Passage of air through silica gel.

ii) Silica gel is isolated from atmosphere by an oil seal.

iii) Two breathers (of identical size) shall be connected in parallel for main conservator tank. **A stop valve shall be provided for each breather and for the common pipe line. The same arrangement shall be made for OLTC tank conservator by providing adequate size of two identical breathers.**

iv) Breathers are to be maintained approx. at a height of 1200mm above rail top level.

v) Moisture absorption indicated by a change in colour of the silica gel can be easily observed from ground level.

16. BUSHING:

Bushing shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushing and grounded parts. Bushings of identical voltage rating shall be interchangeable. All bushings shall be equipped with suitable terminals of approved type and size and shall be suitable for bimetallic connection, if necessary. The insulation class of the high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the high voltage winding.

All main windings, tertiary windings and neural leads shall be brought out to outdoor through bushings which shall be so located that the full flashover strength will be utilized and phase to phase and phase to earth clearance shall be more than minimum value specified below **with fitted connectors**. Location and arrangement of bushing shall follow Indian Standards.

Each bushing shall be so coordinated with the transformer insulation that flashovers will occur outside the tank.

All porcelain used in the bushings shall be made of the wet process, be homogeneous and free from cavities or other flaws. The glazing shall be uniform in colour and free from blisters, burns, and other defects. Upper portion of Bushing made of Porcelain & lower portion made of Epoxy/porcelain is also acceptable.

If not specifically mentioned, the offered bushings shall be of Resin Impregnated Polymer (RIP) / Resin Impregnated Synthetic (RIS) type for 52KV and above.

HV Neutral bushing shall be of 36 KV class for 400 KV & 220 KV class transformers. Bushing for 33 KV delta tertiary winding i.r.o. 160 MVA, 200 MVA, 315 MVA or higher Transformer shall be of 52 KV class.

RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

All OIP bushings are to be hermetically sealed and shall have provision of measurement of capacitance and tan-delta without dismantling of the bushing.

Rating plate of bushing shall be provided near each type of bushing with terminal marking and physical position as per IS:2026.

Bushing for 36KV shall be Solid porcelain or oil communicating type.

The electrical and mechanical characteristic of bushings shall conform to IS:2099 and IS:3347. The characteristic of the oil used in the bushing shall be the same as that of the oil in the transformer.

Main terminals shall be solder less and "Terminal Connectors" shall be as per cl. No. 19 of this technical specification. The spacing between the bushings must be adequate to prevent flash over between phases under all conditions of operation.

All bushings shall be suitable for heavily polluted atmosphere and minimum creepage distance shall be taken as **31mm per KV**.

Where Bushing mounted Current Transformers are specified, the bushing shall be removable without disturbing the current transformers.

Bushings of identical rating shall be interchangeable to optimize the requirement of spares.

Polymer/composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution, and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer.

RIP Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover, without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/documents of packing for approval during detail engineering. Detail method for **storage of bushing** including accessories shall be brought out in the instruction manual.

Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before dispatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

Tan Delta value of RIP condenser bushing shall be 0.005 (max.) in the temperature range of 20°C to 90°C. The measured Tan Delta value at site should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) and in no case shall exceed 0.005 during warrantee period. No temperature correction factor is applicable.

Tan Delta value of OIP condenser bushing shall be 0.004 (max.) at ambient temperature. The measured Tan Delta value at site should not exceed by 0.001 w.r.t. factory results and in no case shall exceed 0.004 during warrantee period. No temperature correction factor is applicable.

Bushing Current Transformer:

i) Current transformer shall comply with IS:2705/IEC-185.

ii) It shall be possible to remove the turret mounted current transformers from the Transformer Tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

iii) Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/marshalling box using separate cables for each core. Core identification mark should be embedded with punch at Secondary terminal box.

iv) The technical parameters of Bushing current transformer indicated under Specific Technical Parameters are to be followed One no. Bushing CT (One core, Class: PS) for each phase of 220KV, 132KV, 33KV (tertiary winding) as well as LV winding of 50MVA, 31.5MVA & 20MVA and Neutral side shall be provided.

v) No of Bushing CT's required for

a. 400/220/33KV Transformer and 220/132/33KVTransformer

HV winding	-	3no
IV Winding	-	3no
LV winding (Tertiary)	-	3no
Before Neutral winding	-	3no

b. 220/33KV transformer

HV winding	-	3no
LV winding	-	3no
Before Neutral winding	-	3no

c. Other transformer

HV winding	-	3no
LV winding	-	3no
Neutral winding	-	1no

In case of 400/220/33KV, 220/132/33KV Auto Transformer, for each phase one CT, i.e. altogether 3 CTs are to be provided for circulating current protection before Neutral formation. **These CTs should be located near the Neutral Bushing.**

The voltage and current rating of the bushings shall be as follows:

Highest System Voltage (KV rms)	**Current Rating (Amps.)**
A. For 500 MVA TR:	
420 (HV)	1250
245(IV)	2000
52(LV)	3150
36(Neutral)	2000
A. For 315 MVA TR:	
420 (HV)	800
245(IV)	1250
52(LV)	3150
36(Neutral)	2000
B. For 200/160MVA TR:	
245(HV)	800
145(IV)	1250
52(LV)	3150
36(Neutral)	2000

C. For 80 MVA, 50MVA, 31.5MVA & 20MVA	
145(HV)	800
36(LV)	2000
36(Neutral)	2000
D. For 100/80/50MVA, 220/33KV TR:	
245(HV)	800
36(LV)	2000
36(Neutral)	2000
E. For 31.5MVA, 132/66KV TR:	
132(HV)	800
66(LV)	800
66(Neutral)	800

The minimum withstand value of cantilever load of bushings for 60 sec. shall be as follows (refer IS:2099-1986 Cl. 5.5)

420KV	-	2500N
245KV	-	1600N (for 315MVA Tr.) & 1250N (for 200/160MVA TR).
145KV	-	1250N
72.5KV	-	3150N
52KV	-	3150N
36KV	-	1250N/2000N

17. CABLE END BOX:

If specifically mentioned in BOQ, Transformer will be fitted with cable end box suitable for cable termination as per required size of cable. Cable box arrangement shall be with suitable type of bushing and dry type termination of suitable size & run for HV and LV of Transformer. The cable box entry shall be of suitable type and shall be designed such that it shall be able to withstand without any deformity the electrical, thermal, and mechanical stresses & forces developed due to rated short circuit current during any terminal fault inside the cable box. The flange joints of cable boxes shall be secured with suitable & proper sized and nos. of stainless steel HTS nuts and bolts.

18. TERMINAL CONNECTOR:

i) The bushing shall be equipped with suitable terminals for connector as specified herein.

ii) Each terminal (including the neutral) shall be distinctly marked on both the primary and secondary side in accordance with the diagram of connection supplied with the transformers.

iii) Vertical/horizontal/universal type bi-metallic, rigid connector for bushing stud shall be provided.

iv) Clamp and connector shall be made from Cold Forged Aluminum Alloy Plate i.e. Extruded Aluminum Clamp and Connector shall be processed through Cold forging for 220KV, 132KV, 72.5KV, 52KV & 36KV Bushing and Casting type connector for 400KV class bushing.

v) The Nuts & Bolts associated with equipment of connector pieces shall be MS Hot dip galvanized. Quality of Nuts & bolts shall conform to relevant IS of latest edition.

vi) Minimum thickness at any point of current carrying part of any clamp & connector shall not be less than 12mm.

vii) From outermost hole edge to nearest edge of any clamp & connector the distance shall not be less than 10mm.

viii) The current density of Aluminum/Copper shall be considered as 0.75/1.75A/sq.mm. Current density calculation shall be submitted considering 10% overloading.

ix) Minimum thickness of Bimetal in bimetallic connection shall be 2mm.

x) **Approved vendor for Clamp & Connector is mentioned in WBSETCL portal.**

19. COOLING SYSTEM & COOLER GROUP:

Type of cooling for this transformer (as per capacity rating) under this specification shall be as follows:

a) Three winding transformer (220/132/33 KV of 200/160 MVA Tr. & 400/220/33KV 500/315MVA) capacity transformer shall employ ONAN/ONAF/OFAF type cooling. ONAN rating shall be about 60% of OFAF rating. ONAF rating shall be 80% of OFAF rating and OFAF shall be 100% rating of capacity of transformer.

b) Two winding transformer (132/33KV) of 50MVA Capacity transformer & 220/33KV of 100/80/50MVA capacity transformer shall employ ONAN/ONAF/OFAF type cooling. ONAN rating shall be about 60% of OFAF rating. ONAF rating shall be 80% of OFAF rating and OFAF shall be 100% rating of capacity of transformer.

c) Two winding/Auto transformer (132/33KV & 132/66KV) of 20MVA & 31.5MVA capacity transformer shall employ ONAN/ONAF type cooling. ONAN rating shall be about 65% of ONAF rating.

The whole cooler plant shall be grouped as indicated below:
For ONAN/ONAF cooling: 2×50% cooling banks consisting of radiators & fans. 1(one) standby fan for each bank shall be provided.
For ONAN/ONAF/OFAF cooling: 2 x 50% cooling banks consisting of radiators, adequate no. of fans and oil pumps. There shall be at least one stand by pump and fan for each bank of radiators. There would be 2 x 100% oil pumps and motors for cooling and one such oil pump shall feed both the radiator banks. The other pump would remain as standby.

20. RADIATORS:

The transformers up to 50 MVA Capacity shall have body mounted radiators, whereas transformers above 50 MVA capacity shall have separate plinth & structure mounted radiator and all transformers shall be fitted with detachable radiator consisting of a series of separate circular/elliptical/rectangular, etc. tubes or fins, welded at their top and bottom into headers which in turn are connected to the tank by means of bolted, oil tight, flanged joints.

In Case of separately mounted radiator bank arrangement, **radiator bank shall generally be placed on the left side of the tank while watching from HV side of the transformer**. However, **the main tank shall have provision such that cooler banks can be placed on either side of the main tank by simple reconnection without the need of any extra member/pipe maintaining the electrical clearances.**

There shall be indicating butterfly or similar valves fitted in between the tank and the headers, which can be kept in open or closed position. There shall also be filter valves for circulation of oil, at each of top and bottom header. One air release plug at the top header shall be provided.

The radiator tubes/fins shall be seamless and made of mild steel/CRCA and in order to prevent rusting epoxy paint of 80 microns shall be applied and minimum wall thickness not less than 1.2 mm, with a clean bright internal surface free from rust and scale. They shall be suitably braced to protect them from mechanical shocks normally met in transportation.

A separate blanking plate shall be supplied to permit the blanking of the main oil connection to each cooler unit when the same is detached. Each cooler unit shall have a lifting eye, oil drain valve at the bottom and a vent at the top.

The bid shall clearly specify the time limit for operation of a transformer carrying full load without forced cooling. The motor operated fans shall be provided for AF rating and oil circulation pumps for OF rating.

All Power transformers shall be installed at new/old substation of WBSETCL anywhere in West Bengal. For 50 MVA transformers, radiator assembly shall be placed along the bushing sides (preferably on HV sides only). For transformers above 50 MVA rating, in case of separate plinth & structure mounted radiators, actual orientation of radiator bank shall be finalized during approval of drawings based on site condition and related approved drawings.

21. COOLING FANS:

a) The radiator stacks shall be provided with **A.C. 3 Phase Motor driven Fans** for Forced Air cooling. The fan motors shall be suitable for continuous operation. Blades shall be suitably painted for outside use.

b) The fans shall operate without any abnormal noise. They shall be fitted with guards of close mesh-wire-netting for safety. The terminal connections and the greasing caps of the fan motors shall be accessible without the need of removing any fan guard.

c) Fan shall be so located so that they are **readily accessible for inspection and repair.**

d) Cooling fans shall not be directly mounted on radiator bank to avoid undue vibration on the same. These shall be located in such a manner as to prevent ingress of rain water. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

22. OIL PUMPS:

Each cooler unit shall consist of a totally enclosed, oil immersed motor-pump, and a forced air cool heat exchanger. Motor & pump shall be enclosed in an oil tight container with motor leads brought through hermetically sealed bushings. Moving parts of motor & pump shall be readily removable without dismantling of cooler and with minimum spillage of oil. Pump shall have open type impeller to permit oil circulation when pump is idle. Heat exchangers, fans and oil pumps shall be completely interchangeable.

Radiators shall be connected to the tank by machined steel flanges welded to Radiator Bank and to the tank through proper gaskets. At each such connection there shall be provided on the tank and indicating shut off valve which can be fastened in either open or closed position.

An oil flow indicator with alarm contacts shall be furnished with each pump assembly to indicate normal pump operation and direction of oil flow. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.

Oil pump shall be capable of dealing with the maximum output of the transformer and total head which may occur in service and with the varying head due to change in the viscosity of the oil.

Suitable precautionary arrangement should be provided to arrest mal-operation of the main tank Buchholz relay due to starting of the forced oil pumps.

23. COOLER CONTROL:

a) Cooler units shall be suitable for operation with 415 volts, 3 phase, 50 Hz. A.C. power supply. Main and standby power AC supply shall be given for cooler control and source selected through contactor.

b) Cooler control equipment for oil pump and fan motors shall be mounted in a marshalling cabinet adjacent to the transformer and shall include necessary MCB with automatic control and annunciation equipment and switches for remote and local control.

c) Three-Position switches (Service, Standby and Test) shall be provided for each Fan and Pump to allow flexible selection of the Service and Standby units.

d) Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)

b) Cooler Supply failure (standby)

c) Control Supply failure

d) Failed to transfer AC Supply

e) Cooling fan failure for each bank

f) Cooling pump failure for each pump

g) Common thermal overload trip

h) Main/ Standby Source ON

i) No oil flow/reverse flow for pumps

e) Main 415 Volt, 3-phase AC supply for control of cooler banks shall be taken to cooler control cabinet. Separate MCBs of suitable rating for Fan and Pump Control each shall have to be provided. The **supply to cooler fans and oil pumps motors** shall be made through **individual MCB with overload trip arrangements**. The control scheme for the cooler shall be so designed to ensure satisfactory operation of cooler groups as specified in the specification.

f) DC supply from RTCC through **individual MCB** for CCU, Indication, FOTS signal Box.

g) The switching in or out of the cooling equipment shall be controlled by winding temperature and there shall be provision for automatic switching in or out at pre-determined temperature differences which should be capable of adjustment and setting at will. Hunting of the transformer cooling equipment should be avoided.

h) The bidder shall specify the loading of the transformer in case of failure of one or more set of fans or pumps.

i) Remote control of cooling equipment and its alarm and indicating devices shall be provided in the RTCC panel. Indication for operation of individual fan group and oil pump shall also be provided in the RTCC panel.

24. NITROGEN INJECTION FIRE PREVENTION SYSTEM (NIFPS)

All the transformers shall be equipped with NITROGEN INJECTION FIRE PREVENTION SYSTEM (NIFPS) in line with Clause No 46 ix of Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.

Necessary arrangement for incorporating fire prevention and extinguishing system by Nitrogen injection drain & stir system-NIDS (also referred as Nitrogen injection fire prevention system-NIFPS) shall be provided. The flanges/gate valves shall be provided with blanking plates during transportation.

Sufficient quantity of valves, flanges, pipelines shall have to be provided to protect the whole portion of transformer & surroundings from fire hazard. Details of location & size of the flanges, valves, dummy pipe, and other pipelines for incorporating the NIDS / NIFPS shall be finalized during detailed engineering. The exact details including size of additional outlet/inlet pipes, valve with flange and other features like provision of non-return valve in conservator, spare 'NO' contact in PRV etc., for the fire protection system shall be considered.

In case of fire detection mode, signals from the following shall be used to activate the NIFPES:

(i)Heat / fire detectors (sensors); (Arc Sensors shall not be accepted)
AND
(ii) Operation of either of the protective relays [Buchholz relay or Pressure Relief Valve (PRV)]
AND
(iii) Operation / Feedback of tripping of associated circuit breakers.

Transformer shall be electrically isolated after which only the NIFPES shall operate. In case of some problem in main protection the NIFPES shall derive the operation signals from the backup protection system. The exact logic for system activation in fire detection mode shall be finalized during detailed engineering and in consultation with the user.

The NIFPES shall be provided with IEC 61850, Edition II compatible port for integration with user's PRP compliant SAS system. Configuration file as may be required for integration with SAS System shall be furnished by NIFPS OEM.

A drain oil storage tank for each transformer shall be provided at suitable location. The oil storage tank shall have non-corrosive, waterproof, epoxy coated, mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPES. **The total capacity of storage tank shall be more than 12% of transformer tank oil to avoid over flowing of oil considering that drained oil volume shall be around 10% of transformer tank oil.** All the pipes and physical connections from transformer to storage tank shall be in the scope of NIFPS OEM / Contractor.

Desired functional verification of NIFPES shall be conducted by the utility/ user at the works of NIFPES manufacturer and at site.

25. TEMPERATUREMETERS:

a) One dial type gas thermometer (having 150 º scale, with accuracy of 1.5% of FSD) of robust design and weather proof casing shall be provided for temperature indication of oil of all type power transformers shall be housed in the ground mounted marshalling box to indicate the hot oil temperature. Both alarm and trip contacts shall be provided. Maximum oil temperature indicating pointer shall also be provided. Remote indication of oil temperature shall be provided in RTCC and as such the oil temperature indicator shall be suitable for the same.

b) Indicating type winding temperature indicator: All transformers shall be provided with a device for indicating the combination of top oil temperature and heating by winding current calibrated to follow the hottest spot temperature of the transformer winding. The device shall have a dial type indicator, and in addition an indicating pointer to register the hottest temperature reached. The temperature indicator shall be connected to CT secondary current in one phase of each winding of the transformer. It shall have sufficient contacts for switching in and switching out the cooling employing ONAF/OFAF system with Alarm as well as trip contacts.

c) For 500/315MVA, 400/220/33KV and 200/160MVA, 220/132/33KV transformers having three separate winding temperature indicators shall be provided each with potential free contacts for control, indication, alarm and trip with independent facility for setting the contacts at any temperature over the whole working range of 20°C to 150°C. Each mercury contact / micro switch shall have adjustable 10°C overlapping (between ON & OFF) to prevent hunting of cooling fans and/or forced oil pump motors. The winding temperature indicator shall be connected to one phase of each winding of HV/IV/LV windings. Those temperature indicators shall be housed in ground mounted marshalling box. The Accuracy Class of WTI shall be ± 1.5% or better, temperature indicator dial shall have linear gradations to clearly read at least every 2°C.

d) Two separate winding temperature indicators with potential free mercury contacts / micro switches for control, indication, alarm & trip shall be provided in two winding transformers with independent facility for setting the contacts at any temperature over the whole working range of 20°C to 150°C. Each mercury contact / micro switches shall have adjustable 10°C overlapping (between ON & OFF) to prevent hunting of cooling fans and/or Oil pump motors. Both the Winding temperature indicator shall be housed in ground mounted marshalling box for all two winding transformers shall be connected to one phase of each HV & LV winding. The accuracy class of WTI shall be ±1.5% or better temperature indicator did shall have linear gradation to clearly read at least every 2°C.

e) In addition to WTI & OTI, optical sensors are to be used for hotspot temperature measurement:

1. Adequate no of optical temperature sensors of at least 14 numbers with the unit as specified below:

   Two winding transformers: 7+7 spares (1+1 spare in each phase of HV & LV winding & 1+1 spare in top oil)
   For Auto Transformer: 7+7 spares (1+1 spare in each phase of HV & IV winding & 1+1 spare in top oil)
   Number of channels in display box shall be minimum 7.
2. Probes shall be all silica, Teflon jacketed fiber with perforation/slits in outer jackets to allow complete filling. The probes shall not get damaged / affected during filtration of the transformer. The fiber with Teflon jacket shall be strong enough to withstand the severe conditions prevailing inside an EHV Transformer.
3. This optical sensor measuring system shall be of direct measurement non calibrating type. Temperature range of the system should be – 30ºC to + 200ºC & accuracy of +/- 2ºC.
4. A temperature measuring system having at least 7 channels shall be mounted on a separate enclosure having degree of protection IP 56 (preferably type tested unit) to measure the temperature from the optical sensors.
5. The measuring unit shall be capable to retain temperature data for at least 90 days at 1-minute interval for all channels and shall have facility to download these data. The system shall have following key features:

a) Fixing arrangement of sensor at suitable location of the winding in such a way that it will be mechanically protected allowing efficient and secure mounting of sensor tip in the winding in compliance with the annexure E of IEC60076-2.

b) The temperature recording of the monitor channels will be obtained in RTCC Panel in control room through repeater along with LED display unit in RTCC Panel.

c) Alarm output with programmable set points as per user's choice.

d) IEC 61850, EDITION II Protocol on RS 485 or RS 232 ports for local access/configuration etc.

e) User friendly software to allow easy configuration to monitor for data logging and retrieval.

6. Location of optical temperature sensors inside the transformer shall be finalised during detailed engineering.

26. VALVES:

Sl No	Valve Position	Valve name	Location	Type
1	Tank	Drain Valve	Bottom	Gate
2		Filter Valve	Top	Gate
3		Filter valve	Bottom	Gate
4		Sampling Valve	Top	Globe
5		Sampling Valve	Bottom	Globe
6		Buchholz Relay shutoff Valve	At both end of relay	Gate
7		Air Release plug	On tank top	
8		Oil Inlet/Outlet Valve	Bottom	
9		Valve for vacuum Application		Gate
10	Main Conservator	Filter Valve		Gate
11		Drain Valve		Gate
12		Sample Valve		Gate
13		Air Release Plug		
14		Aircell Equalizing Valve		Gate/Globe
15	OLTC Conservator	Oil filling Valve		Gate
16		Drain Valve		Gate
17		Suction Valve		
18		OSR shut off valve		
19	OLTC	Drain cum Filling Valve		Gate
20		Tank Equalizing valve		Gate/ Needle
21	Buchholz relay	Bleed Valve with Pet Cock		
22	NIFPS	Drain Valve	Top	Gate
23		N2 Injection Valve	Bottom	Gate
24		TCIV		
25	Pump	Non-Return Valve		
26	Cooler bank	Radiator shut Off Valve	Top	Butterfly
27		Radiator shut Off Valve	Bottom	Butterfly
28		Header Isolation Valve	Top	Butterfly
29		Header Isolation Valve	Bottom	Butterfly
30		Header Air Release Plug		
31		Header filter Valve		Gate

i) Any other valves other than those mentioned above for improvement of operation and maintenance facility if required & pointed during drawing approval stage shall also be within the scope of supply of manufacturer.

ii) All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings.

iii) All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

iv) Gland packing/gasket material shall be of "O" ring of nitrile rubber for all the valve's flanges.

v) All the flanges shall be machined.

27. PRESSURE RELIEF DEVICES/ SUDDEN PRESSURE RELAY/ GAS ACTUATED RELAY:

- One PRD of 150 mm Diameter is required for every 30000 Liters of oil. However, at least two numbers PRDs shall be provided with two sets of electrically insulated NO contacts shall be provided for Alarm/Tripping. It shall be of sufficient size to release pressure rapidly that may be generated within the tank to prevent damage to any part of the transformer. It shall operate at a static pressure less than the hydraulic test pressure of the tank. Suitable canopy shall be provided to prevent ingress of rain water. It shall be mounted on the cover of main tank and shall be designed to prevent gas accumulation.

- Sudden Pressure Relay/ Rapid Pressure Rise Relay (for 220kV and above transformer) One number of Sudden Pressure Relay/ Rapid Pressure Rise Relay with alarm or trip contact (Terminal connection plug & socket type arrangement) shall be provided on tank of transformer/reactor. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water.

- **Gas actuated relay:** One double float gas detector relay (Buchholz relay) of reputed make with alarm and tripping contacts to detect accumulation of gas and sudden changes of oil pressures, complete with two shut-off valves and flange coupling to permit easy removal without lowering oil level in the conservator tank. **A bleed valve for gas venting and test valve is to be provided**. Pressure relief device & Buchholz relay shall be tested for IP: 55 protections in accordance with IS: 13947 to avoid mal operation due to ingress of moisture. Suitable canopy shall be provided to prevent ingress of rain water.

28. GROUNDING TERMINALS/EARTHING ARRANGEMENT:

a. Two grounding terminals capable of carrying for 3 (three) seconds the full short circuit current of the transformer shall be provided at positions close to the bottom **at two corners of the tank** for bolting the earthing terminals to the tank structure to suit local condition.

b. **Neutral Earthing Arrangement**: The neutral terminal of auto-transformer & two winding transformers shall be brought to the ground level by **adequately sized brass/tinned copper grounding bar** (considering the system fault level as stated in STP) supported from the tank by using porcelain insulators. The end of the tinned copper bar shall be brought to the bottom of the tank at the convenient point for making bolted connection to two nos. galvanized steel grounding flat connected to sub-station grounding mat.

29. RATING, DIAGRAM AND PROPERTY PLATES:

The following plates shall be fixed to the transformer tank **at an average height readable from the transformer base level.**

a) A rating plate bearing the data specified in the appropriate clauses of IS:2026.

b) A diagram plate showing the internal connections and the voltage vector relationship of the several windings in accordance with the IS and in addition, a plan view of the transformer giving the correct physical location of the terminals. No load voltage shall be indicated in each tap. The winding temperature C.T. and the thermometer pocket shall also be indicated in the said plate.

c) A plate showing the location and function of all valves and air release plugs and plate material preferably in stainless steel.

d) An indoor cubicle for remote control of coolers, position of tap, alarm and indicating devices with the help of control equipment, annunciation, relays, indicating instrument, etc.

e) A separate rating plate embossing different losses obtained after relevant test for each transformer is to be provided.

f) A rating plate for each type of bushing shall be provided and to be fixed at the base of the bushing.

30. GROUND MOUNTED MARSHALLING BOX:

a. A suitable weather proof cubicle for housing the control, equipment, terminal block etc., made of 3 mm sheet steel, shall be provided for each transformer. The box shall accommodate all (i) winding and oil temperature indicators and (ii) control and protection equipment for cooling plant.

b. All terminal blocks for cable connection shall be located in this box. Terminal blocks shall be of 1100 Volt grade "Elmex/Connect well" make and have continuous rating to carry the maximum expected current on the terminals. The terminal block shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material to protect from moisture ingress. Insulating barrier shall be provided between the terminals. The terminal blocks shall have locking arrangement to prevent its escape from the rails. **20% spare terminals are to be provided**. These spare terminal blocks shall be uniformly distributed on all the terminal block column. All terminal blocks shall be numbered for easy identification. Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks. All the supervision cable and CT cable terminations at marshalling box and RTCC panel shall be made using Ring Type lugs/socket.

c. The marshalling box shall be provided with cubicle lamp with door switch, space heater with differential thermostat and removable cable gland plate etc. Cable shall enter from the bottom of the box.

d. Marshalling box of each type shall be tested for IP-55 in accordance with **IS:13947**.

e. All internal wiring shall be carried out with 1100 Volt grade PVC insulated stranded copper conductor of 2.5 sq. mm or larger size as per scheme requirement.

31. WIRING:

All control, alarm and indicating devices provided with the transformer shall be wired up to the terminal blocks in the marshalling box.

Wiring from transformer to the cubicle shall be done with PVC wires in conduit or by PVC armored cable of 1100 V grade. Minimum wire size shall be 2.5sq mm copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.

All devices and terminal blocks within the marshalling box shall be identified by marking corresponding to the circuit in schematic or wiring diagram. All fuses shall be of cartridge type and IS marked.

Phase marking on each terminal bushing (including neutral) shall be distinctly made on both the primary, secondary, and tertiary winding side in accordance with the connection diagram of the transformer.

Inter connection of wires in between transformer and marshalling box will be in the scope of the contractor.

32. CENTER OF GRAVITY:

The center of gravity of the assembled transformer shall be low and as near the vertical center line as possible. The transformer shall be stable with or without oil. **Location of Centre of Gravity shall be shown on the outline general arrangement drawing.**

33. CLEANING AND PAINTING:

Before painting or filling with oil, all non-galvanized parts shall be completely clean and free from rust, scale and grease and all external rough surfaces on castings, shall be made smooth. The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and rust by sand blasting or other approved method. These surfaces shall be painted with an oil resisting varnish or paint.

Except for nuts, bolts, and washers, which may have to be removed for maintenance purposes, all external surfaces shall receive **a minimum of three coats of paint**. The primary coat shall be applied immediately after cleaning. The second coat shall be of oil paint of weather resisting nature and of a shade or colour easily distinguishable from the primary, and the final coats shall be applied after the primary coat has been touched up where necessary. **The final coat shall be of a glossy, oil and weather resisting non-fading paint of battle ship grey colour.**

All interior surfaces of mechanism chamber and kiosks except those which have received anti-corrosion treatment shall receive three coats of paints applied to the thoroughly cleaned metal surface. The final coat shall be of light-colored anti-condensation paint.

34. PACKING & TRANSPORTATION LIMITATIONS:

The manufacturer shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the manufacturer to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and Bill of quantity of these items shall be included in the relevant drawing/document.

Power Transformer is to be transported in an atmosphere of nitrogen or dry air at positive pressure.

Necessary arrangement shall be ensured by the manufacturer to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. The nitrogen or dry air cylinder provided to maintain positive pressure can be taken back by the manufacturer after oil filling. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

The Transformer during transportation shall also be fitted with at least one electronic impact recorders (on returnable basis) to measure the movement due to impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the manufacturer before delivery. The recording shall commence in the factory before dispatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be downloaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks from the placement of the Transformer on the foundation, manufacturer shall communicate the interpretation of the data.

The transformer Main Tank with Core-coil assembly shall be shipped/ transported filled with inert gas due to transport weight regulation. If the transformer is equipped with inert gas pressure system, then a low-pressure alarm device is to be provided. The alarm device shall be required for extended storage at site.

Special attention shall be paid in packing the accessories & spares to avoid moisture ingress. All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with the contract number and shall have a packing list enclosed showing the parts contained therein.

The Bushings shall be crated & packed and transported as per standard guide line of the Bushing Manufacturer. All care should be taken to avoid any damage of the porcelain due to vibration during transport.

35. LABELS:

Labels shall be provided for all apparatus such as relays, switches, fuses contained in any cubicle or marshalling kiosk.

Descriptive labels for mounting indoor or inside cubicles and kiosks shall be of material that will ensure permanence of the lettering. A mat or stain finish shall be provided to avoid dazzle from reflected light. Labels mounted on dark surfaces shall have white lettering on a black background Danger notice shall have red lettering on a white background. All plates shall be of material which will not be corroded. Labeling shall be clear, concise and adequate.

Labels for mounting outdoors shall be weather and corrosion proof formed by etching to ensure permanence.

Labels shall be attached to panels with brass screws or with steel screws which have received rust preventive treatment.

Labels should have lettering sizes of at least 1 to 1.5 mm stroke width and 3 to 6 mm height.

36. CONTRACT DRAWINGS ANDMANUALS:

After placement of P.O., six copies of following drawings, manuals and literatures shall be submitted to the Chief Engineer, Engineering (O&M) Department, Bidyut Bhaban (9thfloor), Salt Lake, Kolkata - 700091.

Drawing for Controls:

i) Schematic diagram of transformer cooler control
ii) Schematic diagram and location of WTI and OTI
iii) General arrangement of ground mounted Marshalling Box for all type of transformer.
iv) Schematic diagram of manual and push button control of on load tap changer.
v) Abbreviation table for OLTC and RTCC.
vi) Explanatory note for RTCC and transformer cooler
vii) General Arrangement & scheme drawing for RTCC and FOTS
viii) Wiring diagram of ground mounted Marshalling Box for each type of Transformer.
ix) Wiring diagram of RTCC panel and FOTS.
x) Drawings other than there mentioned above if required as per provision of Technical Specification for Erection & Maintenance are also to be submitted.

Drawings of Transformer:

(i) General outline drawing showing front, side elevation, plan of the transformer and accessories with detailed dimensions and detailed legend.
(ii) Detailed foundation plan drawing.
(iii) Drawing of each type of bushings, lifting dimensions, clearance between Terminals of different voltage level and ground, quantity of insulation oil, name plate details etc.
(iv) Operation and maintenance guide for transformer and ON LOAD TAPCHANGER.
(v) Transport Outline Drawing
(vi) Valve Schedule Plate
(vii) Measured Loss Plate

(viii) Clamp & Connectors
(ix) Rating Plate Diagram
(x) Oil filling instruction Plate, Instruction Plate for Erection
(xi) Roller locking arrangement
(xii) Interconnection Table with proper Ferrule Number
(xiii) Drawings other than those- mentioned above if required as per provision of Technical Specification for Erection & Maintenance is also to be submitted.

Other Documents/Drawings of Transformer:

(i) General Technical Specification in the format given
(ii) Cooling Calculation justifying Radiator Surface Area and Number of Fans and Pumps
(iii) Dynamic and Thermal Short Circuit Withstand calculation
(iv) Flux Density Calculation
(v) Current Carrying Calculation
(vi) Painting Procedure Details
(vii) Radiator Details, Core Frame Earthing Arrangement, Winding Assembly Details
(viii) HV Neutral Earthing Arrangement
(ix) Cross- sectional Drawing showing Location of FOTS Sensors and
(x) Cross- sectional Drawing showing Location of 03 No HV Neutral CTs, where CTs are required before neutral formation
(xi) Documents/Drawings other than those- mentioned above if required as per provision of Technical Specification for Erection & Maintenance is also to be submitted.
(xii) **Test Plan Details of Transformer and associated accessories including NIFPS**

Four (04) copies of approved drawings and literatures for each transformer along with soft copy shall be submitted for our record and distribution to site.

Instruction Manuals:

Six (06) copies of operation, maintenance and erection manuals in English language shall be supplied for each transformer against each P.O. The manuals shall be bound volumes and shall contain the drawings and information required for erection, operation, and maintenance of the power transformer. The manuals shall include amongst other, the following particulars.

a) Marked erection prints identifying the components parts of the power transformers as dispatched, with assembly drawings.

b) Detailed dimensional drawings, assembly and descriptions of all the components.

37. TENDER DRAWING, LITERATURE AND TYPE TEST CERTIFICATES:

One copy of each drawings incorporating the following particulars along with one set of complete type test report on similar transformer carried out as per IS & IEC in Govt.

Recognized Test House or Laboratory/NABL accredited Laboratory shall be submitted by each bidder with each copy the bid to the Purchaser for the purpose of evaluation of bid as follows:

General outline drawing showing dimensions, net weights of transformers, tap changing gear, marshalling box and their shipping weights.

Sectional views showing the general construction features and disposition of various fittings and accessories.

Bushing drawing showing full details of construction of HV/LV/Tertiary condenser bushing and other technical data, weight of bushing assembly etc.

Dimension of the largest part to be shipped and the position in which these are to be transported.

Technical literature on tap changing control, cooling system, relays meters and general construction feature for winding temperature indicators, Buchholz relays, oil temperature indicator, Oil pumps, pressure release device (where required) etc.

Transformer similar to offered one should have type tested as per relevant IS.

38. TRANSFORMER LOSSES, EVALUATION OF BID &ACCEPTANCE

Rating of Transformer	Guaranteed Maximum No Load Loss on principal tap at Rated Voltage and frequency (in KW)	Guaranteed Maximum Load Loss (Copper + stray loss) at rated current on principal tap at75 ^{O}C in HV-IV combination for Auto Transformer & HV-LV combination for Two winding Transformer (in KW)		Maximum allowable Auxiliary Loss (in KW)
		Load Loss	I^2R Loss	
20 MVA 132/66 KV	17	130	110	2
31.5 MVA 132/66 KV Auto Transformer	20	150	128	2
31.5 MVA 132/33KV	18	110	93.5	2
50 MVA 132/33KV	25	125	105	3
80 MVA 132/33 KV	35	200	170	5
50 MVA 220/33 KV	28	123	100	5
80 MVA 220/33 KV	39	196	160	5
100 MVA 220/33 KV	43	245	200	5
160 MVA 220/132/33 KV Auto Transformer	30	200	145	6
200 MVA 220/132/33 KV Auto Transformer	35	260	190	8
315 MVA 400/220/33 KV Auto Transformer	75	440	330	10
500 MVA 400/220/33 KV Auto Transformer	90	500	375	15

a) Loss Capitalization will not be done.

b) The losses shall be firm and no positive tolerance should be allowed.

c) No weightage shall be given for supply of transformer with losses less than the specified value.

d) Bidder must specify the offered losses as “FIRM”.

e) REJECTION: WBSETCL may reject any transformer during tests or in service if any of the individual loss exceeds the permissible maximum value specified in the table.

39. STAGE INSPECTION:

Stage inspection will be carried out by the customer on Core, Coil & Tank during the manufacturing stages of the transformer. The manufacturer will have to call for the stage inspection and shall arrange the inspection at manufacturer's premises or manufacturer's bidder's premises free of cost. Stage inspection of core and coil will be carried out on 1 (one) number Transformer against each Purchase order or a particular design. On the basis of satisfactory Stage Inspection, manufacturer will proceed further. The following stage inspection shall be carried in one inspection.

Prior to stage inspection following documents shall have to be submitted by manufacturer for verification:

1) Document related to prime core, procurement establishing traceability vide relevant Cl. of Technical Specification of Power Transformer.
2) Documents for coil establishing traceability.

Following tests have to be carried out in stage inspection.

I. On Core

1) Flux density checking of assembled core (without having any insulating tape etc. rapped around the core) vis-à-vis measurement of step thickness, lamination width etc.
2) Window height, leg center dimension, core diameter of assembled core.
3) Physical verification of core in respect of lamination thickness, bend, camber and waviness etc.
4) Carlite test, Watt loss and Ageing test on the sample of prime core. (Core sample shall be selected during stage inspection and sent to any NABL accredited laboratory for tests under Sl.No.4)
5) Loss measurement of Prime core (Loss/Kg).
6) 2KV test between core and Yoke clamps.

II. On Coil

1) Physical verification of HV, IV and LV wound coil for 160MVA,200 MVA,315 MVA and 500MVA Power Transformer (without any outer insulation).
2) Measurement of resistance of each finished coil (HV, IV &LV).
3) Measurement and current density calculation of each winding.
4) Copper purity test (after cutting from finished coil offered for inspection).

Calibration Certificates of all measuring instrument to be used during stage and final inspection shall be produced and that will be in conformity to our relevant Clauses of GCC/Technical Specification.

III. On Tank

1) Physical inspection & Dimension Checking of Main Tank
2) Vacuum Withstand Test on the Main Tank.
3) Pressure Withstand Test on the Main Tank.
4) Leakage Test of the main Tank.

40. TEST AT FACTORY AND TEST CERTIFICATES:

All Routine and Acceptance tests at manufacturer's works shall be carried out in presence of WBSETCL's representative in compliance with IS: 2026/ IEC 60076 (as amended up-to- date) on the transformers. The entire cost of acceptance test, routine test and special test as follows that are to be carried out as per relevant IS shall be treated as included in quoted price of transformer.

1. The Contractor shall offer the transformer for final testing with confirmation of readiness of transformer along with all accessories at least 15 (fifteen) days prior to the actual date when the tests will be carried out**. Factory Routine test Report shall have to be submitted along with Inspection Call Letter.**
2. Internal test report of each transformer and test reports of prime core and coil from NABL accredited laboratory shall be submitted at least 7(seven) day prior to date of testing. Offer for final test shall be accepted after receiving above documents.
3. After final testing 6 (six) copies of test reports of each transformer along with soft copy and soft copy of final drawing shall be submitted to the Chief Engineer, Engineering (O&M) Department prior to issuance of formal MICC & DI letter.

The following tests are to be carried out as a part of routine tests as per IS:2026 / IEC 60076 and as per our standard requirement:

i) Measurement of winding resistance of each winding at all taps
ii) Measurement of voltage ratio for all sets of windings at all taps
iii) Check of Polarity and vector group
iv) Measurement of no-load loss and current measurement at 90%, 100% & 110% of rated voltage and rated frequency
v) Short Circuit Impedance and load loss measurement at principal tap and extreme taps voltage for each pair of winding.
vi) Measurement of insulation resistance between windings and between windings and earth & Polarization Index. IR value is to be measured before and after impulse test.
vii) Measurement of insulation power factor and capacitance between winding to earth and between windings
viii) Measurement of insulation power factor and capacitance of bushings
ix) Tan delta of bushing at variable frequency **(using Frequency Domain Spectroscopy)**
x) Regulation at rated load and at unity, 0.8 lagging power factors
xi) Efficiencies at u.p.f. and 0.8 p.f. at 50%, 75% and 100% loading.
xii) Separate source voltage withstand test (AV) and Line terminal AC withstand voltage test (LTAC)
xiii) Induced over voltage withstand test with Partial Discharge measurement (IVPD).
xiv) Tests on on-load Tap changer (Tap changer fully assembled on the transformer).
xv) Magnetic balance test (for three phase Transformer only) and measurement of magnetizing current
xvi) Oil leakage test on tanks and all oil filled compartment of transformer shall be tested as per CBIP for 12 hours (minimum) filled with oil for which no oil leak shall occur.
xvii) Test on pressure relief device, Buchholz, OSR and Sudden Pressure Relay.
xviii) Operation of Tap changer from RTCC as well as from OLTC
xix) High voltage withstand test on auxiliary equipment and wiring after assembly and Other Tests on RTCC, Cooler Control Cabinet and Marshalling Box.
xx) Check of core and frame insulation. (to withstand a voltage 2 KV AC for 1 minute).
xxi) Zero Sequence Impedance measurement.
xxii) Check of the ratio and polarity of built-in current transformers
xxiii) Frequency Response Analysis (FRA) in factory and field (sub-station) for all voltage classes & rating for all transformers against each P.O.
xxiv) Switching Impulse test for 500/315MVA, 400/220/33KV transformer
xxv) Full wave Lightning Impulse test for the line terminals for 80/50 MVA 132/33 KV, 31.5 MVA 132/66KV, 100/80/50 MVA 220/33 KV, 200/160 MVA 220/132/33 KV & 500/315MVA, 400/220/33KV transformer as per IS/IEC
xxvi) Chopped wave lightning impulse test for the line terminals (LIC), applicable for 220 KV and above. This test shall be carried out on HV, IV & LV limb in case of three winding transformer and HV & LV limb in case of two winding transformer.
xxvii) BDV measurement of transformer oil.
xxviii) DGA of Transformer oil after type test
xxix) Functional test of Fiber Optic sensor types hot spot measurement system
xxx) Appearance, Construction, Visual, and Dimension checking of transformer.

The following Type/Special tests are to be carried out for **at least on one of each type of transformer** against each purchase order without any price implication:

a) Temperature rise test (IS 2026, Part- II)

b) Arrangement of separately mounted radiator bank at both sides of transformer shall be physically verified alternately during final testing.

c) Full wave Lightning Impulse withstand Tests in all phases (including chopped and reduced chopped wave) for 132KV class & below (IEC 60076-3/ IS:2026, Part- III,2009. This test shall be carried out on HV, IV & LV limb in case of three winding transformer and HV & LV limb in case of two winding transformer.

d) Measurement of power taken by fans and liquid pump motors

e) Checking of acoustics noise level.

f) Pressure & vacuum test on finished empty tank during stage inspection.

The pressure & vacuum test on remaining finished empty tank of each type against each P.O. shall also to be carried out at the tank manufacturer premises in presence of representative of transformer manufacturer. Tanks under same P.O. may be supplied by maximum two different manufacturers to facilitate delivery schedule. In that case, pressure & vacuum test of at least on tank from each manufacturer shall have to be carried out at the tank manufacturer premises. Test reports of all the tanks are to be submitted to the Chief Engineer, Engineering Department for approval and clearance towards use of the said tank.

41. TEST ON ASSOCIATED EQUIPMENT:

Porcelain Bushings, Windings Temperature Indicating Devices. Dial Thermometers, Buchholz Relays, Auxiliary Meters, Motor Starting Contactors, Control devices, insulating oil and other associated equipment covered by the contract shall be certified by the contractor to have been tested in accordance with the relevant IS specification by the manufacturer. The contractor shall furnish a certificate of compliance of the relevant tests, for all auxiliary apparatus. Six certified copies of the aforesaid test reports shall have to be furnished.

42. TOLERENCES

As per the clause of the IS 2026/ IEC 60076 tolerances will be applicable to certain guaranteed values as depicted in the following tables:

SL	Item	Tolerance
1	Voltage ratio at no load on principal tapping for a specified first pair of windings	The lower of the following values: ±0.5 % of declared ratio ±1/10 of the actual percentage impedance on the principal tapping
2	Voltage ratio on other tapings, same pair	To be agreed, but not less than the lesser of the values in a) and b) above
3	Voltage ratio for further pairs	To be agreed, but not less than the lesser of the values in a) and b) above

4	Short-circuit impedance for: – a separate-winding transformer with two windings, or – a specified first pair of separate windings in a multi-winding transformer a) principal tapping b) any other tapping of the pair	 When the impedance value is ≥10 %: ±7.5 % of the declared value When the impedance value is <10 %: ±10 % of the declared value When the impedance value is ≥10 %: ±10 % of the declared value When the impedance value is <10 %: ±15 % of the declared value
5	Short-circuit impedance for: – an auto-connected pair of winding, or – a specified second pair of separate windings in a multi-winding transformer a) principal tapping b) any other tapping of the pair c) further pairs of windings	 ±10 % of the declared value ±15 % of the declared value for that tapping to be agreed, but ≥15 %
6	No-load current	+30 % of the declared value

NOTE - For certain auto-transformers and booster transformers the smallness of their impedance justifies more liberal tolerance. Transformers having large tapping ranges, particularly if the range is asymmetrical, may also require special consideration. On the other hand, for example, when a transformer is to be combined with previously existing units, it may be justified to specify and agree on narrower impedance tolerances. Matters of special tolerances shall be brought to attention at the tender stage, and revised tolerances agreed upon between manufacturer and purchaser.

NOTE - 'Declared value' should be understood as meaning the value declared by the manufacturer.

43. DRYING OUT AT THE MANUFACTURER'SWORKS:

All the Tests shall be conducted after complete Drying out at the works. The transformer shall be dispatched complete after being dried out under vacuum and filed with inert gas, ready to be put into commission, without further drying out at site.

44. SUPERVISION OF ERECTION, TESTING &COMMISSIONING:

The MANUFACTURER shall arrange for the services of their Supervisor/Engineer from the manufacturer during erection, testing and commissioning of the equipment at sites at free of cost as many times as required by WBSETCL.

45. General Note

A) A tentative I/O signal list of BCU of RTCC is mentioned in the technical specification. However, the detail exhaustive I/O signal list will be finalized during detail Engineering. **All ICD files should be ready and configured based on the final I/O signal list before offering final inspection of the transformer**.

B) The manufacturer of the transformer should be responsible for making necessary arrangement to depute the Engineer from the OEM for BCU of RTCC towards extending active support at the site level while integration of the same with SAS during commissioning stage of the transformer at the respective sites without any additional cost implication.

C) The OEM of the transformer is required to carry out all the acceptance tests including oxidation test at CPRI for the transformer Oil supplied to the site. The sample to be collected from WBSETCL site in presence of the authorized representative of WBSETCL.

D) 4-20 mA signal shall be taken from FOTS Signal Box to temperature scanner/ Repeater and to AI of BCU. OEM have to ascertain that there will not be any signal loss in this arrangement. FO Cable Details are to be recommended by the FOTS OEM.

E) In Schematic drawings of Marshalling Box, RTCC and DM Box proper ferruling of Control and Power wires are to be furnished and provided in actual.

F) All the equipment (OTI, WTI, switches, contactors etc.) used in transformer, Marshalling Box, DM Box and RTCC shall be from WBSETCL Makers' List.

46. Signal lists

Signals Related To	Signal Type	Signal Details	Remarks
CCU (WTI)	Analog Input	WTI Temperature of **each** winding (HV, IV & LV)	
OTI		OTI Temperature	
FOTS		FO equipment Temperature of **R-Ph** HV winding	
		FO equipment Temperature of **Y-Ph** HV winding	
		FO equipment Temperature of **B-Ph** HV winding	
		FO equipment Temperature of **R-Ph** IV/LV winding	
		FO equipment Temperature of **Y-Ph** IV/LV winding	
		FO equipment Temperature of **B-Ph** IV/LV winding	
		FO equipment Temperature of Oil	
OLTC		OLTC Tap Position Indication	
	Binary Input	OLTC Main Supply ON	
		OLTC Main Supply FAIL	
		OLTC Control Supply ON	
		OLTC Control Supply FAIL	
		Tap Changer Out of Step	
		Tap Changer in progress	
		Tap Changer ON LOCAL	
		Tap Changer ON REMOTE (Manual Mode)	
		Tap Changer ON REMOTE (SAS Mode)	
		Tap Changer STUCK UP	
		Tap Changer MOTOR O/LTRIP	
		Tap Changer UPPER LIMITREACHED	
		Tap Changer LOWER LIMITREACHED	
		Tap Changer in Independent Mode	
		Tap Changer in Master Mode	
		Tap Changer in Follower Mode	
	Binary Output	OLTC Tap Raise	
		OLTC Tap Lower	
Marshalling Box	Binary Input	Cooler control Main AC Supply ON	
		Cooler control S/By AC Supply ON	
		Cooler control Main AC Supply Fail	
		Cooler control S/By AC Supply Fail	
		Cooler control FAILED TOTRANSFER	
		MB Main DC Supply ON	
		MB Main DC MCB Trip	
		MB Indication DC Supply ON	
		MB Indication DC MCB Trip	
		MB CCU DC Supply ON	
		MB CCU DC MCB Trip	

Signals Related to	Signal Type	Signal Details	Remarks
Marshalling Box	Binary Input	Fan Control Local Auto	
		Fan Control Local Manual	
		Pump Control Local Auto	
		Pump Control Local Manual	
		Cooler control Each Oil Pump ON	
		Cooler control Each Oil Pump FAIL	
		Cooler control Each Oil Pump STUCK	
		Cooler control Each Pump Oil Flow Reverse/Low	
		Cooler control Main Fan ON of **each** Fan	
		Cooler control Main Fan FAIL of **each** Fan	
RTCC		Fan Control in AUTO in RTCC	
		Fan Control in MANUAL in RTCC	
		Pump Control in AUTO in RTCC	
		Pump Control in MANUAL in RTCC	
	Binary Output	Operate Fan control from RTCC	These contacts shall be configured to operate, when the Current value exceeds a pre-set limit/Oil Temp exceeds a preset value
		Operate Pump control from RTCC	

SPECIFIC TECHNICAL PARAMETERS

SI. NO	DESCRIPTION	ITEMS	TECHNICAL PARAMETERS
1	Rated capacity	a) 500/315MVA	3-ph Auto transformer with tertiary winding
		b) 200/160 MVA	3-ph Auto transformer with tertiary winding
		c)100/80/50/31.5/20MVA	3-ph Two winding transformer/Auto Transformer
2	Voltage Rating	a) 500/315 MVA	400/220/33 KV
		b) 200/160 MVA	220/132/33 KV
		c) 100/80/50/31.5/20MVA	220/33KV, 132/33 & 132/66KV (as per Tender)
3	Maximum system voltage (KV)	For 400 KV/ 220 KV/ 132 KV/ 66KV/33 KV	420/245/145/72.5/36
4	Cooling	For 500 MVA/315 MVA/200 MVA/160 MVA/ 100 MVA/ 80 MVA / 50MVA	ONAN/ONAF/OFAF
		31.5 MVA / 20 MVA	ONAN/ONAF
5	Rating at different type of cooling	For All Rating	60% / 80% / 100%; 65%/100% for 31.5/20MVA, 132/33KV & 132/66 KV TR.
6	Type of Transformer	For All Rating	Outdoor Type Interconnection Power Transformer
7	Tertiary winding voltage (KV)	for 160 MVA, 200 MVA, 315 MVA & 500 MVA	33
8	Tertiary winding Capacity (MVA) for 500 MVA, 315 MVA,160MVA (Combined loading shall not exceed the rated capacity)	For 500/315MVA	5 MVA
		For 200 MVA	5 MVA
		For 160MVA	5 MVA
9	System frequency (Hz)	For All Rating	50 ± 3%
10	No. of phases in system	For All Rating	3
11	System Earthing	For 500/315 MVA, 200MVA & 160MVA	(i) Effectively earthed, Neutral Solidly earthed. Tertiary of 33 KV winding is ungrounded.
		For 100/80/50/31.5/20MVA	(ii) 33KV system is earthed through grounding transformer for 220/33KV &132/33KV transformer

12	**Insulation level of the winding (withstand)**		
	i) 1.2x50 micro-second lightning impulse (KVP)	For 400/220/132/66/33 KV	1300/950/550/350/170 KV
	ii) Tertiary winding of 400/220/33 & 220/132/33 KV Transformer (KVP)	For 52 KV Tertiary	250 KV
	iii) Power frequency withstand (KV rms)	For 400/220/132/66/33 KV	570/395/230/155/70
	iv) Power frequency withstand -Tertiary winding of 220/132/33 K V Transformer (KV rms) & 400/220/33KV Transformer	For 33 KV Tertiary	95
13	System fault level (KA).	400 KV	63 KA FOR 1 SEC
		220 KV	40 KA FOR 3 SEC
		132 KV	31.5 KA FOR 3 SEC
		66 KV	31.5 KA FOR 3 SEC
		33 KV	25 KA FOR 3 SEC
14	250/2500 micro sec Switching Surge withstand voltage (KVp)	for 500/315 MVA	1050 for HV side of 400KV Transformer
15	Partial Discharge level		500 Pc.
16	Insulation winding level of HV (N)	i) 1.2×50 micro-second Lightning impulse (KVp)	95
18		ii) Power Frequency withstand (KV rms)	38
19	Maximum hot spot temperature at ^{O}Centigrade over weighted average temp of 32 Degree C		98 ^{O} Centigrade
20	Type of tap changer	i) For transformer of all rating	On Load Type
		ii) Tapping range	+ /- 10% in 16 equal steps @ 1.25%
21	Partial Discharge level	For 220 & 132 KV	500 Pc.

22	Vector group	500/315 MVA	YNaod11
		200 MVA	YNaod11
		160 MVA	YNaod11
		100 MVA/ 80MVA/ 50MVA/ 31.5/20 MVA	YNd1
		31.5 MVA 132/66 KV Auto Transformer	YNa0
23	Short circuit level (KA)	400KV (1 Sec)	63
		220KV (3 Sec)	40
		132 KV (3 Sec)	31.5
		66 KV (3 Sec)	31.5
		33KV (3 Sec.)	25
24	Minimum creepage Distance(mm) of bushing	400KV	13020
		220 KV	7595
		132 KV	4495
		66 KV	2248
		33 KV	1116
		52KV	1612
25	Impedance voltage at 75°C (The impedance volt at HV-IV for 3 winding transformers Guaranteed)	500/315 MVA	10.3 at max voltage tap 12.5 at principal tap 15.4 at min voltage tap (Between HV-IV)
		200 MVA	12.5 Between HV-IV
		160 MVA	12.5 Between HV-IV
		100 MVA/ 80 MVA/ 50MVA/31.5MVA	13.2 at max voltage tap 12..5 at principal tap 11.8 at min voltage tap (Between HV —LV)
26	Type of insulating media	For All Rating	Mineral insulating oil immersed.
27	Indoor or Outdoor type	For All Rating	Outdoor
28	Insulation level to earth of neutral terminal	For All Rating	Similar to 33KV bushing for transformer above 31.5MVA
29	Auxiliary AC supply to Fans, Tap Changer etc.(volt)	For All Rating	3-ph, 400 ±10%
30	Auxiliary DC supply for alarm and tripping (volt)	For All Rating	220 ±10%

31	Altitude above mean sea level	For All Rating	Less than 1000 mt
32	Terminal Connectors	400/220/33KV Transformer & 220/132/33KV	Twin ACSR Moose / ACSR Moose based on current rating
		33 KV Tertiary	For 1.5-inch Aluminum pipe/ACSR Moose.
33	Acoustic noise level (DB) of all transformers	For All Rating	As per NEMA Publication TR-1.
34	**Insulating level of bushing** 1.2/50 microsecond lightning impulse withstand voltage (KVP)	400 KV	1425
		220 KV	1050
		132 KV	650
		66 KV	350
		33 KV	170
		Tertiary 33 KV	250
		HV Neutral	170
35	Insulating level of bushing One minute Power frequency withstand voltage (KV rms) (dry & wet)	400 KV	630
		220 KV	460
		132 KV	275
		66 KV	155
		33 KV	70
		Tertiary 33 KV	95
		HV Neutral	70
36	Width of Rail Gauge (mm)	For All Rating	1676

Annexure- 1

Definitions of a similar transformer

[As per IS-2026 PART-5]

Transformers similar to a reference transformer can be identified by comparison using the following non-exclusive list of critical features:

1. Same type of operation, for example generator step-up unit, distribution, interconnection transformer as the reference unit.
2. Same arrangement of main windings and geometrical sequence as the reference unit.
3. Same type of main windings for example, helical, disc, layer, pancake, as the reference unit.
4. Absorbed power at short-circuit (rated power per unit short-circuit impedance) between 30% and 130 % of that of the reference unit.
5. Axial forces and relative winding stresses (ratio of actual stress to critical stress) at short-circuit not exceeding 120% of those in the reference unit;
6. Same type of winding conductors, for example, aluminum, aluminum alloy, annealed or hardened copper, metal foil, wire, flat conductor, continuously transposed conductors and epoxy bonding, if used, as the reference unit.
7. Same manufacturing processes as the reference unit.
8. Same clamping and supporting arrangement.
9. Same conceptual design, for example dry-type, oil-immersed type, core type with concentric windings, sandwich type, shell type, circular coils, non-circular coils as the reference unit.

CORE DETAILS OF BUSHING CT

Sl. No	Description	Core No.	Application	Current Ratio	Output Burden (VA) at Lower Ratio	ISF (<)	Accuracy Class as per IS 2705	Min Knee point Voltage (V)	Max CT Secondary Winding Resistance	Max excitation current at Knee point Voltage
i)	400KV side, 220KV side & Neutral of **500 MVA,** 400/220/33KV Transformer	1	Protection	1600/1A			PS Class	1600V	4.0	30 at Vk/2
ii)	400KV side, 220KV side & Neutral of **315 MVA**, 400/220/33KV Transformer	1	Protection	1000/1A			PS Class	1000V	2.5	30 at Vk/2
iii)	220KV side, 132KV side & Neutral of **200 MVA** Transformer	1	Protection	1000/1A			PS Class	1000V	2.5	30 at Vk/2
iv)	220KV side, 132 KV Side & Neutral of **160 MVA** Transformer	1	Protection	800/1A			PS Class	1000V 800V	2.5	30 at Vk/2
v)	132KV side & Neutral of **80 MVA** Transformer	1	Protection	800-400/1A			PS Class	1000V	2.5	30 at Vk/2
vi)	132KV side & Neutral of **50 MVA** Transformer	1	Protection	400-300/1A			PS Class	800V 600V	1.5	30 at Vk/2
vii)	220KV side & Neutral of **100MVA / 80 MVA / 50 MVA**	1	Protection	400/1A			PS Class	800V	1.5	30 at Vk/2
viii)	33KV side of **50MVA** Transformer	1	Protection	1000/1A			PS Class	500V	2.5	30 at Vk/2
ix)	132KV side & Neutral of **31.5 MVA /20 MVA**	1	Protection	150/1A			PS Class	600V	1.5	30 at Vk/2
x)	33KV side of **31.5 MVA /20 MVA**	1	Protection	800/1A			PS Class	400V	2.5	30 at Vk/2
xi)	33KV side of **80 MVA Transformer**	1	Protection	1600/1A			PS Class	1000V	4	30 at Vk/2
xii)	66 KV side of **31.5MVA** Transformer	1	Protection	300-150/1A			PS Class	300V	4	30 at Vk/2
xiii)	Tertiary winding of **500 MVA**	1	Protection	2000/1A			PS Class	2000V	2.5	30 at Vk/2
xiv)	Tertiary winding of **315 MVA**	1	Protection	2000/1A			PS Class	2000V	2.5	30 at Vk/2
xv)	Tertiary winding of **200 MVA**	1	Protection	1200/1A			PS Class	1200V	2.5	30 at Vk/2
xv)	Tertiary winding of **160 MVA**	1	Protection	1000/1A			PS Class	1000V	2.5	30 at Vk/2
xvi)	33KV side & Neutral of **100 MVA**	1	Protection	2000/1A			PS Class	2000V	2.5	30 at Vk/2

	Guaranteed Technical Particulars (GTP) of Offered Transformer (To be submitted separately for separate MVA capacity of Transformer in case of common Tender)	
SL	DESCRIPTION	SUBMISSION
1	**General Data of Bidder**	
A	Name & Address of Company	
B	Country of Origin	
C	Business Type of Company (e.g. Manufacturer/ Supplier / Transporter etc.)	
2	**General Data of Transformer**	
A	Conforming Applicable Standards (including Bushing &other)	
B	Conceptual Design of Transformer (e.g. Outdoor oil immersed core type /Indoor dry core type/etc.)	
C	Type of Operation of the Transformer (e.g. Interconnection / Distribution Generator step-up) *Interconnection means used in Transmission Grid SS	
D	Rated Frequency (in Hz)	
E	Number of Phase	
F	Rated MVA Capacity of the Transformer (ONAN/ONAF/OFAF)	
G	Rated No-load Voltage of the Transformer (HV/IV/LV)	

H	No Load Current in percent of Full Load current at rated KV & rated frequency a Normal Tap	
I	Vector Group	
J	Type of Cooling	
K	Rating at Different Cooling	
3	**Thermal Data**	
A	Temperature rise of top oil (in º C) above ambient temperature of 50 º C measured by thermometer with ONAN/ONAF/OFAF cooling	
B	Temperature rise of winding measured by resistance: With ONAN/ONAF/OFAF cooling, in º C	
C	Limit of hot spot temperature in º C for which the transformer is designed	
4	**Impedance Data**	
A	Percentage Impedance Between HV & IVat highest tap/normal tap/lowest tap	
B	Percentage Impedance Between HV & LV	
C	Percentage Impedance Between IV & LV	
D	Zero Sequence Impedance at 75 º C for Highest Tap/Normal Tap/Lowest Tap a 100% rating	

5	**Efficiency & Regulation**	
A	Efficiency (in percent) at unity power factor at75°C	
B	a) At 50% Full Load	
C	b) At 75% Full Load	
D	c) At Full Load	
E	Regulation at Unity Power factor	
F	Regulation at 0.8 lagging Power factor	
6	**Core**	
A	Net core area in sq. meter	
B	Material & Grade of core Laminations	
C	Thickness of stampings (mm)	
D	Maximum flux density (in Tesla) at 100% rated no load voltage and rated frequency	
E	Maximum flux density (in Tesla) at 110% rated no load voltage and rated frequency	
F	Over Excitation withstand time (secs) at 110% / 125%/140%	
G	Noise level (in db.) when energized a normal voltage and normal frequency at no load.	

7	**Main Winding**	
A	Number of Winding	
B	Type of Winding (e.g. Helical / Disc/ layer /pancake) in HV/IV/LV	
C	Arrangement of main winding & Geometrical sequence	
D	Brief Details of Material of Winding Conductors	
E	Conductor Area **(Sq. cm)** of Winding (HV/IV/LV)	
F	Maximum Current Density **(in A/Sq.cm)** of Winding (HV/IV/LV)	
G	Winding Insulation for HV - Type & Class, Graded or ungraded	
H	Winding Insulation for IV - Type & Class, Graded or ungraded	
I	Winding Insulation for Tertiary Winding - Type & Class, Graded or ungraded	
J	Insulation Material Between HV-IV-Tertiary	
K	Insulation Material Between Core & Winding	
L	Type of Axial Support of winding: HV/IV/Tertiary	
M	Type of Radial Coil support : HV/IV/Tertiary	

8	**Tertiary Winding**	
A	Rated KV	
B	Maximum continuous MVA Capacity	
9	**Insulation Level**	
A	**Lightning Impulse** (LI) Withstand KV peak of HV Winding /IV/ LV Tertiary/HV Neutral Winding For 400/220/33 KV o 220/132 /33 KV Auto Transformer HV Winding/ LV/ HV Neutral winding for 220/33 KV or 132 /33 KV Two Winding.	
B	**Switching Surge** withstand KV peak (for 400 KV Transformer) for HV Winding	
C	**Power Frequency** Withstand Voltage KV rms for HV/IV/Tertiary/ HV Neutra Winding	
D	**Partial Discharge Level** (in pc) at 364 KV Between phase &Ground	
E	**RIV (in micro Volts)** at 1.1 times minimum phase to ground voltage	
10	**Bushings**	
A	Manufacturer of HV/IV/Tertiary/HV Neutral/LV Neutral	
B	Type of HV/IV/Tertiary/HV Neutral/LV Neutral	
C	Rated KV of HV/IV/Tertiary/HV Neutral/ LV Neutral	

D	Rated Current of HV/IV/Tertiary/HV Neutral/LV Neutral	
E	LI Voltage (1.2/50 micro-sec) HV/IV/Tertiary/HV Neutral/ LV Neutra (KVp)	
F	Power Frequency Withstand Voltage (Dry) : HV/IV/Tertiary/HV Neutral/ LV Neutral (KV rms)	
G	Power Frequency Withstand Voltage (Wet) : HV/IV/Tertiary/HV Neutral/ LV Neutral (KV rms)	
H	Minimum clearance between phases in AIR: HV/IV/Tertiary(mm)	
I	Minimum clearance between phases in OIL: HV/IV/Tertiary(mm)	
J	Minimum clearance between Bushing Line Terminal to Tank: HV/IV/Tertiary (mm)	
K	Creepage Distance (in mm): HV/IV/Tertiary/HVN/LVN	
11	**Tap Changer**	
A	Manufacturer	
B	Type	
C	Total Tap Range (+) percent to (-) percent of Voltage	
D	Percent of Voltage per tap step	
E	Time (in second) for total tap change	

F	Tapping provided on (winding)	
12	**TANK**	
A	Type of Transformer Tank (e.g. Bell Type / Top Cover)	
B	Thickness of Top Cover plates (mm)	
C	Thickness of Tank Bottom Plates (mm)	
D	Thickness of Tank side Plates (mm)	
E	Thickness of Radiator Fin (mm)	
F	Approximate weight: Core (in Kg)	
G	Approximate weight: Windings (in Kg)	
H	Approximate weight: Tank & Fittings (in Kg)	
I	Approximate weight: Oil (in Kg)	
J	Approximate weight: Total weight (in Kg)	
K	Approximate required quantity of oil, in Liters	First Filling Oil- 5% Extra Oil-
L	Radiator Fitting arrangement (Tank mounted/Separate)	
13	Whether optical sensor for Hot Spo temperature measurement provided? (yes/no)	
14	Whether Electronic Impact Recorder provided? (yes/no)	
15	Mention Manufacturer of 1) Core, 2) Transformer Oil and NIFPS (if applicable)	
16	Guaranteed Maximum **a)** No Load Loss on principal tap at Rated Voltage and frequency (in KW), **b)** Load Loss (Copper + stray loss) at rated current on principal tap at 75 ºC in HV-IV combination for Auto Transformer & HV-LV combination for Two winding Transformer (in KW) **c)** Maximum allowable Auxiliary Loss (in KW)	NLL: LL: I2R Loss: Aux Loss: