

	xv) Oxidation Stability			
18.	Press Board: i) Make ii) type			
19.	Conductor Insulating Paper i) Kraft paper ii) Thermally upgraded Kraft paper iii) Nomex			
20.	Provision for fire protection system (as per spec), if yes, provide details	Y/N		
21.	Insulation of core bolts, washers, end plates etc.			
22.	Weights and Dimensions: i) Weights: a. Core b. Windings c. Tank d. Fittings e. Oil f. Total weights of complete transformers with oil and fittings ii) Dimensions; a. Overall Height above track b. Overall length c. Overall breadth iii) Minimum bay width required for installation of the transformer iv) Weight of the heaviest package of the transformer arranged for transportation			
23.	Lifting Jacks i) Number of jacks included ii) Type and Make iii) Capacity iv) Pitch v) Lift vi) Height in close position			
24.	Rail Track gauges i) 2 Rails or 3 rails or 4 rails ii) Distance between adjacent rails on shorter axis iii) Distance between adjacent rails on longer axis			

TEST PLAN AND PROCEDURES

No.	Test	U_m	U_m
		≤ 170kV	> 170kV
1.	Measurement of winding resistance at all taps	Routine	Routine
2.	Measurement of voltage ratio at all taps	Routine	Routine
3.	Check of phase displacement and vector group	Routine	Routine
4.	Measurement of no-load loss and current measurement at 90%, 100% & 110% of rated voltage and rated frequency	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only) and measurement of magnetizing current	Routine	Routine
6.	Short Circuit Impedance and load loss measurement at principal tap and extreme taps	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding to earth and between windings	Routine	Routine
9.	Measurement of insulation power factor and capacitance of bushings	Routine	Routine
10.	Full wave lightning impulse test for the line terminals (LI)	Type (for U _m ≤ 72.5kV) Routine (for 72.5kV < U _m ≤ 170 kV)	-
11.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
12.	Lightning impulse test for the neutral terminals (LIN)	Type	Type

13.	Switching impulse test for the line terminal (SI) (Not applicable for $U_m \leq 72.5$ kV)	Type	Routine
14.	Applied voltage test (AV)	Routine	Routine
15.	Line terminal AC withstand voltage test (LTAC) (Not applicable for $U_m \leq 72.5$ kV)	Routine	Type
16.	Induced voltage withstand test (IVW)	Routine	-
17.	Induced voltage test with PD measurement (IVPD)	Routine*	Routine
18.	Measurement of transferred surge on Tertiary due to HV lightning impulse (if applicable)	-	Type
19.	Measurement of transferred surge on Tertiary due to HV Switching impulse (if applicable)	-	Type
20.	Test on On-load tap changer (Tap changer fully assembled on the transformer)	Routine	Routine
21.	Measurement of dissolved gasses in dielectric liquid	Routine	Routine
22.	Check of core and frame insulation	Routine	Routine
23.	Leak testing with pressure for liquid immersed transformers (tightness test)	Routine	Routine
24.	Appearance, construction and dimension check	Routine	Routine
25.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
26.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
27.	High voltage withstand test on auxiliary equipment and wiring after assembly	Routine	Routine
28.	Tank vacuum test	Routine	Routine
29.	Tank pressure test	Routine	Routine
30.	Check of the ratio and polarity of built-in current transformers	Routine	Routine
31.	Temperature rise test	Type	Type
32.	Winding hot-spot temperature rise measurement	Type	Type
33.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
34.	Measurement of Zero seq. reactance	Type	Type

35.	Measurement of harmonic level in no load current	Type	Type
36.	Determination of acoustic sound level	Type	Type
37.	Measurement of power taken by fans and liquid pump motors (Not applicable for ONAN)	Type	Type
38.	Dynamic Short circuit withstand test	as specified in the specification	

*The requirements of the IVW test can be incorporated in the IVPD test so that only one test is required.

Test Procedures

General

Tests shall be carried out as per following procedure. However, IS 2026/IEC 60076 (with latest amendments) shall be followed in general for other tests. Manufacturer shall offer the transformer unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box, RTCC (as applicable) assembled.

1. Core assembly dielectric and earthing continuity test

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 500 MΩ for all cases mentioned above.

2. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 h, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

3. No-load loss and current measurement

As per IEC 60076-1:2011 clause 11.5

4. Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Short circuit impedance and load loss for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps) shall be measured.

5. Measurement of insulation power factor and capacitance of bushings

Bushing shall be tested in UST mode by applying 10kV and 2kV. Tan delta of bushing shall not exceed 0.5% if measured between 10° C and 40° C temperature. If tan delta is measured at a temperature beyond the abovementioned limit, necessary correction factor as per IEEE shall be applicable.

6. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). For such type of transformer test may be carried out with the following sequence:

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank.

- Raise the oil temperature 20-25 deg C above ambient.
- Stop power input and pumps for 6 minutes and observe cooling down trend.
- Restart pumps and observe increased cooling trend due to forced oil flow.

7. Temp. Rise Test as per IEC: 60076

This test shall be generally carried out in accordance with IEC 60076-2. The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer.

3-Winding Loss = HV (Max MVA) + LV (Max MVA).

The Contractor before carrying out such test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a “finger print” for the units to be tested only with short term heat run test.

Headspace extraction and Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. Infrared Thermography to be conducted during the temp rise test.

Oil sample shall be drawn before and after temperature rise test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

- Purchaser’s order number and transformer site designation.
- Manufacturer’s name and transformer serial number.
- Rating of transformer

- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75° C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.
- Temperature rise limits as per specification

Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30 minute intervals:

- time
- Voltage between phases
- Current in each phase and total power
- Power in each phase and total power
- Frequency
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting of the test then after every four hours till the temperature stabilised and finally during temperature stabilised for each rating (ONAN/ONAF/ODAF (or OFAF); ONAN/ONAF).

Notes:

The probes may be left in position provided the reliability and integrity of unit will not be jeopardized during its long life expectancy.

Winding temperature rise test:

- Record the 'hot' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half-hourly readings of the quantities as specified for the top oil temperature rise test.

- Provide a table of readings, after shut-down of power, giving the following information;
 - a) Time after shut- down:
 - b) Time increment:
 - c) Winding resistance: At least 20 minutes reading
 - d) Resistance increment:
 - e) x , where x is the time after shut-down divided by the thermal time constant of the winding: and
 - f) Y , where $Y = 100 (1 - e^{-x})$
 (Any graphical/computer method used to determine the temperature of a winding by extrapolation to the instant of power shut-down shall produce a linear curve.)
- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

8. Dielectric Tests

Following Test shall be performed in the sequence given below as per IEC 60076-3:2013 clause 7.2.3 shall be followed:

- a) Lightning impulse tests (LI, LIC, LIN)
- b) Switching impulse (SI)
- c) Applied voltage test (AV)
- d) Line terminal AC withstand test (LTAC)
- e) Induced voltage test with partial discharge measurement (IVPD)

9. Measurement of transferred surge on LV or Tertiary due to HV Lightning impulse

Following tests shall be carried out with applying 20% to 80% of rated Impulse & Switching impulse (upto 60% for IV, Sr. No. 7 & 8 of below table) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
1	FW	1.1	2.1, N & 3.2	-	3.1
2	FW	1.1	2.1, N & 3.1	-	3.2
3	SW	1.1	N & 3.2	2.1	3.1
4	SW	1.1	N & 3.1	2.1	3.2
5	FW	2.1	1.1, N & 3.2	-	3.1
6	FW	2.1	1.1, N & 3.1	-	3.2
7	SW	2.1	N & 3.2	3.2	3.1
8	SW	2.1	N & 3.1	3.1	3.2

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap.

Where 1.1 : HV Terminal

2.1 : IV Terminal

3.1 & 3.2 : LV or Tertiary Terminal

Acceptance criteria

Transfer surge at Tertiary should not exceed 250kVp at any conditions for 400kV Voltage class Transformer. For other transformer it shall be below the impulse level of LV winding.

10. Chopped wave & full wave lightning impulse test for the line terminals (LIC & LI) and Switching impulse test

Chopped wave lightning impulse and Switching impulse test shall be performed at normal and extreme taps on Unit-1, Unit-2 and Unit-3 respectively for 1-Ph unit, otherwise R ph, Y Ph and B Ph respectively for 3-Ph unit. All the parameters as per IEC:60076-3 shall be mentioned in the report.

11. Measurement of power taken by fans and oil pumps (100 % cooler bank)

Losses of each fan and pumps including spare shall be measured at rated voltage and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, Applied voltage, measured current, frequency and make shall be furnished in the test report.

12. Dynamic short circuit withstand test

The test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-LV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out on HV. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

- i) Dissolved gas analysis
- ii) Frequency response analysis
- iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

13. Sweep Frequency Response Analysis (SFRA)

This measurement is conducted as per IEC 60076-18:2012, the SFRA measurement shall include end to end open circuit measurement, end to end short circuit measurement, Inductive inter winding measurement and Capacitive inter winding measurement.

14. Routine tests on Bushings: Routine test on bushings shall be done as per IEC 60137.

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
A	Raw Material & Components							
1.	Winding Conductor (PICC)/ (CTC)/ Lead wires	(a) Visual & Dimensional check of Conductor: Thickness & width of bare conductor, thickness of paper, surface covering, no. of conductors, finish of conductor and finish of PICC/CTC	One sample per type per lot	IS 1897 IS 13730 As per approved drawing	Bare conductor: Width(mm) Tolerance (in ± mm) Up to 3.15 - 0.03 3.16 to 6.30 - 0.05 6.31 to 12.5 - 0.07 12.51 to 16 - 0.10 > 16 - 0.13 Thickness (mm) Tolerance (in ±mm) For Width (mm) (2-16) (16-40) 0.8 to 3.15 - 0.03 0.05 3.15 to 6.30 - 0.05 0.07 6.30 to 10 - 0.07 0.09 Insulated conductor: Paper Covering Tolerance (%) thickness (mm) 0.25 to 0.5 - 10 Over 0.5 to 1.3 - 7.5 Over 1.3 - 5	P	V	W/V
		(b) Resistivity at 20 deg.C		IS 13730	For annealed conductor: 0.01727 ohm /mm ² /m (max) For half hard conductor: 0.01777 ohm-mm ² /m (max)	P	V	W/V
		(c) Insulation test for bunched conductor/between strands of CTC (if applicable)		IS 13730	Maximum Charging current 1A at 250V AC/ 500V DC for 1 minute.	P	V	W/V
		(d) Elongation test for annealed conductors (if applicable)		IS 7404 IS 13730	Thickness elongation (mm) % Up to 2.5 30 (min.) >2.5-5.6 32 (min.)	P	V	-
		(e) Proof strength of work hardened conductor		IS 7404 IS 13730	As per design requirement	P	V	-

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*			
						Sub-Vendor	Manufacturer	Customer	
		(f) Radius of corner of bare conductor		IS 7404 IS 13730	Thickness (mm) Up to 1.0 - 1.01 to 1.60 - 1.61 to 2.24 - 2.25 to 3.55 - 3.56 to 5.60 - (Tolerance ±25%)	Corner Radius (mm) 0.50 x nominal thickness 0.50 0.65 0.80 1.00	P	V	V
		(g) Copper purity		As per plant standard	OEM Standard		V	V	V
		(h) Oxygen Content		As per plant standard	OEM Standard		V	V	V
		(i) Epoxy Bonding Strength (Bonded CTC)		As per plant standard	As per plant standard		P	V	V
2.	Kraft Insulating Paper (for covering of PICC/CTC)	(a) Visual check & Measurement of Thickness	One sample per type per lot	IEC 60554-3-1 IEC 60554-3-5 IEC 60554-2, Methods of Test	Paper to be smooth, unglazed surface, free from dust particles and no surface defect Thickness tolerance within specified value ±10%		P	V	--
		(b) Density			Nominal value ±0.05 gm/cm ³				
		(c) Substance (grammage)			Thickness(µm) Sub(g/m ²) 50 40 65 52 75 60 90 72 Tolerance: For material ≤45 g/m ² ±10% For material >45 g/ m ² ±5%				
		(d) Moisture Content			8 % max				
		(e) Tensile Index (Machine Direction)			93 NM / gm (min)				
		(f) Tensile Index (Cross-machine Direction)			34 NM / gm (min)				
		(g) Elongation at Break (MD)			As per IEC 60554-3-1				
		(h) Elongation at Break (CD)			As per IEC 60554-3-1				
		(i) Electric Strength in Air			As per IEC 60554-3-1				
		(j) Ash Content			1 % max				
		(k) PH of Aqueous extract			6 to 8				
		(l) Conductivity of Aqueous extract			10 mS / m (max)				
		(m) Air Permeability			0.5 to 1.0 µm / Pa.s				
		(n) Tear Index (MD)			5 mN m ² / g (min)				
		(o) Tear Index (CD)			6 mN m ² / g (min)				
		(p) Water Absorption (Klemn Method)			10 %				

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		(q) Heat Stability i) Reduction of Degree of Polymerization ii) Reduction of Bursting Strength iii) Increase of Conductivity of Aqueous extract.			Type test report			
		(r) DP Value			As per IEC 60554/Manufacturer's std. practice			
		(s) Storage Period			As per Manufacturer's std. practice			
		(t) Storage in controlled Environment			As per Manufacturer's std. practice			
3.	Thermally upgraded Paper/Aramid Paper (if applicable)	Manufacturer's std. practice			As per Manufacturer's std. practice			
4.	(i) CRGO Mother coil / Laminations	Check following documents (a) Invoice of Supplier (b) Mill's Test certificate (c) Packing List (d) Bill of Lading (e) Bill of Entry (f) manufacturer's identification slip/unique numbering of prime CRGO coil	Each Lot (100% of coils)	IS 3024 IS 649 IEC 60404 ASTM 4343	As per approved design	P	V	V
		Check points:						
		(a) Visual check, check for coil width & thickness from nameplate	10% of coils		Visually defect free, as per design requirement			
		(b) Cutting Burr	One sample per lot		Less than 20 micron burr/ As per IS/ mutual agreement while ordering			
		(c) Bend / Ductility test			As per IS 649/IS 3024 Completion of one 160° bend without fracture			
		(d) Surface insulation resistivity check			Average value: 10 Ω cm ² (min.) Individual value: 05 Ω cm ² (min.)			
		(e) Accelerated Aging test (type test)			4% (max.) increase in measured specific total loss			
		(f) Test on stacking factor			As per table no. 4 of IS 3024			
		(g) Test for specific Watt loss test	One sample	IS 3024	As per table no. 2 of IS 3024	--	P	V
		(h) Magnetic Polarisation	from offered lot	IS 3024	As per appropriate tables of IS 3024	--	P	V
		(i) Grade of CRGO		Approved drawing/ Document	Approved Drawing/Document/ Manufacturer standard	P	V	V
		(j) Permeability at 800 A/m		Document		P	V	V

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
				Test Method IS 3024/ IS 649				
		(k) Compliance to Quality Control Order of DHI		IS 3024		P	V	V
5.	Pre-compressed Press Board/ Laminated pre-compressed pressboard	(a) Visual & dimensional check, thickness, width and length	One sample of each size (thickness) per lot of pressboard	IEC 60641-3-1 IEC60763-3-1 IEC 60641-2, IEC60763-2 Methods of Test	No surface defects	P	V	V
	(b) Apparent Density (g/cm ³)	Up to 1.6 mm TK - 1.0-1.2 >1.6-3 mm - 1.1-1.25 >3-3.6 mm - 1.15-1.30 >6-8 mm - 1.2-1.3						
	(c) Compressibility in air (C) (in %)	Up to 1.6 TK- 10 % >1.6-3 mm - 7.5 % >3-3.6 mm - 5 % >6-8 mm - 4 %						
	(d) Reversible part Compressibility in air (C _{rev}) (in %)	Up to 1.6 TK- 45 %; >1.6-3 mm - 50 % >3-3.6 mm - 50 %; >6-8 mm - 50 %						
	(e) Oil Absorption	Up to 1.6 mm TK - 11 min > 1.6-3 mm - 9 min > 3 - 3.6 mm - 7 min > 6-8 mm - 7 min						
	(f) Moisture Content	6% max. / As per relevant std. & Manufacturer's std. practice						
	(g) Shrinkage in air (MD, CD & PD)	MD - 0.5 % max, CD- 0.7 % max, Thick - 5 % max						
	(h) pH of aqueous extract	6-9 for solid boards						
	(i) Conductivity of aqueous extract	Up to 1.6 - 5 max (mS/m) > 1.6-3 mm- 6 max, > 3-3.6 mm - 8 max > 6-8 mm TK - 8-10 max						
	(j) Dielectric Strength in Air	Up to 1.6 - 12 kV/ mm > 1.6-3 mm - 11 kV/mm > 3-3.6 mm - 10 kV / mm > 6-8 mm TK - 9 kV/mm						
	(k) Dielectric Strength in Oil	Up to 1.6 - 40 kV/ mm > 1.6-3 mm - 35 kV/mm > 3-3.6 mm - 30 kV / mm > 6-8 mm TK - 30 kV/mm						
	(l) Ash Content (%)	1 % maximum						
	(m) Elongation (MD, CD)	MD CD						

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		(n) Tensile strength (MD, CD)			Up to 1.6 - 3 % 4 % >1.6-3 mm - 3 % 4 % >3-3.6 mm - 3 % 4 % >6-8 mm TK - 3 % 4 %			
		(o) Internal Ply Bond strength (for laminated pre compressed boards) <ul style="list-style-type: none"> Dried (tested at 23°C) Dried (tested at 120°C retention) Oil impregnated (tested at 23°C) Aged for 1 week at 120°C in oil (tested at 23°C retention) 			As per relevant std./ Manufacturer's std. practice			
		(p) Flexural strength (MD, CD) (for Laminated pre compressed Boards) (MPa)			As per relevant std./ Manufacturer's std. practice			
		(q) Contamination Dielectric Liquids (for laminated pre compressed press boards) <ul style="list-style-type: none"> Neutralization value (mg KOH/g) Sludge content (mg/l) Dissipation factor 			As per relevant std./ Manufacturer's std. practice			
6.	Perma-wood	(a) Visual & dimensional check, thickness, width & length	One sample of each size per lot	IS 3513 IS 1708 IS 1736 IS 1998 IEC 61061 Approved document	Shall be free from surface defect	P	V	V
	(b) Density	0.8 to 1.3 gm/cc						
	(c) Moisture content	IS 3513/IS 1708						
	(d) Oil Absorption at 90 °C	Min 5%						
	(e) Dielectric Strength at 90 °C	Min 60 KV						
	(f) Tensile strength	Min for LD - 700 KV /cm ²						
	(g) Compressive strength test	Min for LD - 1400 KV /cm ²						
	(h) Shear strength age-wise	Min for LD - 450 KV /cm ²						
	(i) Thickness	Thickness (mm) Tolerance (±mm) 10 to 25 - 1.2 26 to 50 - 1.4 51 to 150 - 2.0						
	(j) Shrinkage (MD, CD)	IEC 61061/Plant standard						
	(k) pH Value							
	(l) Breakdown voltage, parallel to the laminations							
7.	Porcelain Bushings (Hollow)	(a) Visual & dimensional check.			10% Sample per lot As per IS /			
	(b) Power frequency voltage withstand test	As per IS 3347/IS 8603/ IEC 60137						

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
8.	Polyester Resin Impregnated Glass Fiber Tape	(a) Visual Check	IEC One sample per lot per size	IS 15208	Free from visual defect	P	V	--
		(b) Verification of shelf life			To be used within self-life period not to be used after expiry of period			
		(c) Dimensional Check • Thickness • Width			• 0.25 to 0.35 mm (± 0.07) / as per manufacturer's design • 20 to 50 mm (± 2)			
		(d) Tensile Strength			200 N/mm (min)			
		(e) Resin Content			27 ($\pm 3\%$)			
		(f) Softening point of resin			Max 200 °C			
		(g) Storage Condition			As per cl. 15.3 of IS 15208			
		(h) Elongation			4% (Max)			
9.	Lacquer (in case it is used)	Manufacturer's std. practice			As per Manufacturer's std. practice	P	V	--
10.	Condenser Bushing (OIP/RIP/RIS)	Routine Test	100%	IEC 60137				
		(a) Visual and Dimensional check			No visible damage	P	W	W
		(b) Lightning impulse withstand test (if applicable)			As per IEC 60137			
		(c) Measurement of dielectric dissipation factor and capacitance at room temperature			Tan Delta - 0.5%		P	V
		(d) Dry power frequency voltage withstand test			As per approved GTP	P	W	V
		(e) Measurement of Partial Discharge (PD)			As per IEC - No flash-over/ puncture		W	V
		(f) Pressure Test (for OIP condenser bushing)			No leakage	P	W	V
		(g) Test tap insulation test			As per IEC 60137			
		(h) Tightness test			No leakage	P	W	V
		(i) Creepage distance			As per approved GTP	P	W	W
(j) Test of oil before carrying out routine test on bushing (for OIP bushing) • BDV	• BDV: Min 70 kV • Water content: Max 5 ppm • Tan Delta at 90°C Max:0.0025	P	W	V				

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		<ul style="list-style-type: none"> Water content Tan delta at 90°C IFT at 27°C 			<ul style="list-style-type: none"> IFT at 27°C: Min 0.04 N/m 			
		Method & Positioning of Storage			As per bushing manufacturer's guideline		P	--
11.	Buchholz Relay	Routine test (a) Type & make (b) Porosity (c) High voltage (d) Insulation resistance (e) Element test (f) Gas volume test at 5° ascending towards conservator (g) Loss of oil & Surge test	100%	IS 3637	As per approved drawing No leakage 2 KV for 1 min. withstand Minimum 10 MΩ by 500 VDC megger No leakage at 1.75 Kg /cm ² oil pressure for 15 mins GOR - 1: 90 to 165 CC GOR - 2: 175 to 225 CC GOR - 3: 200 to 300 CC GOR - 1: 70 to 130 CC GOR - 2: 75 to 140 CC GOR - 3: 90 to 160 CC	P	W	V
12.	Bimetallic Terminal Connector	Routine test (a) Dimensional (b) Visual check (c) Tensile strength (d) Resistance (e) Galvanizing test (if required)	100%	IS 5561	As per approved drawing Free form defects As per type test report As per type test report As per type test report	P	W	V
13.	Marshalling Box/ Cooler Control Cabinet	(a) Dimensional & Visual check (workmanship, clearances, ferruling, labeling, accessories, earthing terminals, mounting/ lifting details, 20% spare TBs etc.) (b) Verification of paint shade, thickness & adhesion (c) All Functional Check at max & min rated operating voltage, electrical control operations, alarms, interlocks and sequential operations (d) BOM check for Component type, make & rating (e) DOP check by thin paper insertion method	100%	Approved drawing and specification	As per approved drawing As per approved drawing As per approved drawing As per approved drawing As per technical specification	P	P/W	W/V

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						Sub-Vendor	Manufacturer	Customer
		(f) Degree of Protection (IP Class) verification			As per type test report / approved drawing			
		(g) Check for sealing gasket (EPDM rubber for outdoor/ neoprene rubber for indoor)			Free form defects			
		Routine test						
		a. HV test at 2kV (for 1 min) for auxiliary winding			1 min withstand			
		b. Verification of wiring and its routing			Firm and aesthetic			
		c. IR test at 500 V for 1 min			1 min withstand			
14.	Remote Tap Changer Control Panel (if applicable)	(a) Dimension & Visual Check	100%	Approved drawing and specification	As per approved drawing	P	P/W	W/V
		(b) 2kV test for Auxiliary wiring			1 min withstand			
		(c) Paint shade & Thickness			As per approved drawing			
		(d) Wiring routing check			Firm and aesthetic			
		(e) Functional Check			As per approved drawing			
		(f) Verification of BOQ			As per approved drawing			
15.	Air cell (Flexi Air Separator)	Make, Visual check of surface finish of complete air cell & Dimensions	100%	IS 3400	No surface defects. As per approved drawing	P	W	V
		Routine test						
		(a) Pressure test at 0.105 Kg /cm ² (10Kpa) for 24 hrs			No leakage for 24 hours	P	W	V
		(b) 10 times inflation and deflation test at 0.105 Kg /cm ²			No deformation	P	W	V
		Type tests on basic fabric i. Oil side coating compound ii. Air side inner/outer coating iii. Rubber coating (inner/outer) iv. Coated fabric	One sample per lot of raw material		Tensile strength & elongation at break: ISO 1421 Tear resistance: ISO 4674-1 Coating adhesion: ISO 2411 Gas permeability: ISO 7229	P	W	V
16.	Roller Assembly	(a) Visual & Dimensions.	One sample per lot	IS 5517 IS 2004	Free from surface defect	P	V	--
		(b) Mechanical Properties & Chemical composition of raw material used for shaft & roller forging	One sample per melt/heat treatment batch	IS 28 IS 2026	For shaft as per MS EN8, BS 970-1 For roller wheel of cast iron IS 210 For roller wheel of Cast steel IS 1030			
17.	Oil & Winding Temperature Indicator	(a) Type & make	100%	--	As per approved drawing	P	P/W	V
		(b) Accuracy			± 1.5% of FSD			

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						Sub-Vendor	Manufacturer	Customer
		(c) HV test at 2kV for 1 min between all terminals & earth (d) Switch contact operation test (e) Contact Rating			Withstand for 1 min Operation within $\pm 2.5^\circ$ C of setting As per Manufacturer's std.			
18.	Pressure Relief Device	(a) Type & Make (b) Air Pressure Test (c) Liquid Pressure Test (d) Switch/contact testing (e) Leakage test at 75% operating pressure (f) HV test (g) Functional test/Calibration (h) Contact Rating	100%	As per specification	As per approved drawing & free from defect Operate at Specified pressure ± 0.07 kg/cm ² Satisfactory operation at pressure release No leakage for 24 hrs 2 kV withstand for 1 min As per Manufacturer's std.	P	P/W	W/V
19.	Magnetic Oil Level Gauge (MOG)	(a) Type & make (b) Dial Calibration for level (c) 2kV HV test for 1 min between all terminal & earth (d) Leak test with air for 6 Hours (e) Switch/contact operation test (f) Contact Rating	100%	--	As per approved drawing & free from defect Check pointer position for Max, Min and center level (within tolerance as per specifications) Withstand for 1 minute No leakage at 4 kg/cm ² Operate at Min level indication As per Manufacturer's std.	P	P/W	W/V
20.	Valves (Gate, Globe & Butterfly)	(a) Type, make & visual check for material of valve body, gate wedge, spindle and gland (b) Dimension check (c) For Gate & Globe Valve: (i) Body test at 1.5 MPa (2 minutes) (ii) Seat test at 1.0 MPa (2 minutes) (iii) Seepage test at 2 kg/cm ² for 12 hrs. (d) For Butterfly valve: (i) Pressure test through body and spindle (ii) Pressure test for diaphragm (iii) Oil seepage test (oil 105 \pm 5 °C, pressure of 1.5 kg/cm ² for 24 hrs.)	100%	IS 778	As per approved drawing & no visible defect No leakage (i) No leakage at 5 kg/cm ² for 10 minutes (ii) Max 6 drops/min at 1.5 kg/cm ² (iii) No leak in body and spindle Max 6 drops/min through disc	P	W	V
21.	Transformer Oil	Routine Test	100%	IS: 335 IEC 60296	As per technical specification	P	W	W

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
22.	Tank, Tank-cover, Turret, Conservator & Accessories	(a) Visual check of welding joints including earthing connection, matching of tank with cover & Dimensional check after final welding	100% One per design	IS 6855 CBIP Manual on Transformer 2013	Free from defect	P	W	V
		(b) Visual Check for a fit up for butt welds on tank walls, base & cover			Check for proper welding			
		(c) DP test on Butt welds after fit up & load bearing welds (lifting logs, bollards, jacking pads)			Check for proper welding			
		(d) Air leakage test on assembled tank with turrets & on conservator			No leakage			
		(e) Visual check of paint shade, paint film thickness (inside & outside) & film adhesion, primer application			Paint thickness Outside: 155 micron Inside: 30 micron No peel-off Or As per approved drawing			
		(f) WPS (Weld procedure specification) approval			Details to be furnished As per Specification/ASME Sec IX			
		(g) PQR (Process Qualification Record)			Details to be furnished As per Specification/ASME Sec IX			
		(h) Welders Qualification			Details to be furnished As per Specification/ASME Sec IX	P	W	V
		(i) UT (Ultrasonic test) of tank MS Plate of thickness >12mm.			Details to be furnished As per Specification/ASME Sec IX			
		(j) RT (Radiography test) of butt weld in bottom plate of tank after fit up (if any)			Details to be furnished As per Specification/ASME Sec IX			
		(k) Verification of PWHT (Post weld heat treatment)			Details to be furnished As per Specification/ASME Sec IX			
		(l) Surface cleaning by Shot/sand blasting			Details to be furnished as per Specification			
		(m) Tank - i. Pressure test (PT) ii. Vacuum test (VT) iii. Adhesion test iv. Visual Inspection inside transformer tank before PT & VT test			i. Withstand-Twice the normal head of oil or normal head+ 35 KN/m ² whichever is lower, maintained at base of bank for 8 hrs. ii. Withstand- 3.33 KN/ m ² for 1 hr. ii. Details to be furnished as per manufacturer's standard. iv. Inputs required as per specification	P	W	V

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		(n) Chemical composition & mechanical property of steel (for tank, tank-cover, conservator, turrets and accessories)		IS 2062 BS 4360	As per relevant standards	P	W	V
23.	Radiators	(a) Chemical composition & mechanical property of raw material	100%	BS EN 50216-1 IS513 Manufacturer's drawing	As per relevant standards	P	W	W/V
		(b) DP test on lifting lugs welds			No welding defect			
		(c) Surface cleaning of header support and bracing details by sand/shot blasting			Free from surface defect			
		(d) Air pressure test on elements			As per relevant standards /CBIP			
		(e) Dimensional check after final welding			As per approved drawing			
		(f) Air pressure test on radiator assembly by water dipping method			2 kg /cm ² for 30 minutes - no leakage			
		(g) Visual check of paint shade, paint film thickness & film adhesion			As per tech spec, coating thickness more than 70 micron			
		(h) WPS (Weld Procedure Specification) approval			Details to be furnished, if applicable as per Specification/ASME Sec IX			
		(i) PQR (Process Qualification Record)			Details to be furnished, if applicable as per Specification/ASME Sec IX			
		(j) Welders Qualification			As applicable As per Specification/ASME Sec IX			
24.	OLTC (as applicable)	(a) HV test on Auxiliary circuit (2kV for 1min).	100%	IS 8468 IEC 60214	To Withstand for 1 min	P	P/W	V
		(b) Operational test of complete OLTC including functional check of driving mechanism			Satisfactory operation			
		(c) Pressure test on diverter switch oil compartment			No leakage at 10 Psi for 1 hour			
		(d) Mechanical Operation test of diverter switch (endurance test)			No defect after 5000 operations			
		(e) Mechanical test of tap selector motor drive			500 satisfactory operations between extreme taps			
		(f) Sequence test			Switching time within permissible limit			
		(g) Visual & Dimensional check			Free from defects, dimensions as per drawing			
		(h) Operational test on Surge relay			Satisfactory working of trip & reset			
		(i) Milli volt drop/contact resistance measurement after Mechanical test.			As per standard			
		(j) Condition of Silver plating on contacts			Good condition			
		(k) Measurement of Tan delta			To be provided (value to be used for benchmark) as per manufacturer's standard			

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		(l) Helium Test (barrier board leakage test)- For externally mounted OLTC Type tests: (a) Temperature rise of contacts (b) Switching tests (c) Short circuit current test (d) Transition impedance tests (e) Mechanical tests (f) Tightness test (g) Dielectric tests	Type test report to be submitted by OEM		To be provided as per manufacturer's standard As per IEC-60214-1			
25.	Digital RTCC Relay/ Automatic Voltage Regulating Relay (AVR) (if applicable)	(a) Check of Binary input and output signal along with HMI display nomenclature (b) Check availability of spare binary input and output terminal (c) Check communication interface (d) Test for complete function include tap position indication, raise and lower command execution	100%		as per specification/manufacturer's standard			
26.	Cooling Fans & motor	(a) Type, Make & visual check (b) Power consumption, rating test (c) HV test (3kV Power frequency withstand test for 1 min) (d) Insulation resistance value	100%	IS 2312	As per approved drawing, no visual damage/ defect As per approved drawing Should withstand 2 MΩ (minimum) with 500 V DC megger	P	W	V
27.	Nitrile Rubber Gasket	(a) Visual check (b) Dimensions (c) Shore Hardness (d) Tensile Strength (e) Compression set test (f) Elongation at break (g) Accelerated aging in air (at 100 ± 2° C for 72 hours) (h) Accelerated aging in oil (at 100 ± 2° C for 72 hours) (i) Time period between manufacturing of gasket and its use	1 sample / Lot	ISO 7619-1 ISO 815 ISO 37 ISO 3865 IS 11149	Free from cracks and pin holes Within tolerance 70 ± 5 IRHD 12.5 N/mm ² min 35% (max) at 70 ± 1° C 250% min Change in harness: ±15 IRHD Tensile strength change: 20% (max) Elongation change: max +10%/ -25% Change in hardness: ±8 IRHD Tensile strength change: 35% (max) Volume change: +20%/ -8%	P	W	V
28.		(a) Visual Check		IS 11149	Free from cracks & pinholes	P	W	V

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Sr. No.	Item/Components	List of Tests	Sampling rate	Reference/ Standard	Acceptable Value	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
	EPDM Gasket for Marshalling Box	(b) Dimensional check (Thickness & Width) (c) Tensile Strength (d) Elongation at break (e) Shore Hardness check as per DIN-53505 (f) Compression test (in air) as per DIN, ISO 815	1 sample / Lot		Within tolerance As per IS 11149 As per IS 11149 As per IS 11149 As per IS 11149			
29.	Bushing CT	Dimensions (Visual check for ID/OD, thickness) Routine test (a) Verification of terminal marking & polarity (b) Overvoltage inter-turn test (c) Determination of error (d) HV Test (Dry power frequency withstand test on secondary winding) (e) Accuracy Ratio (f) Secondary winding resistance for PS/PX class (g) Knee point voltage & excitation current for PS/PX class	100%	IS 16227 IEC 61869-2	As per approved drawing As per IS 16227/ IEC 61869-2 Rated current withstand for 1 min As per IS 16227/ IEC 61869-2 3 kV AC for 1 min withstand As per IS 16227/ IEC 61869-2 As per IS 16227/ IEC 61869-2			
30.	Oil circulating pump (as applicable)	(a) Visual check (b) No load running test (rpm, input power and current) (c) (d) HV test (2kV power frequency withstand voltage test for 1 min) (e) Oil pressure test on pumps at 5kg/cm ² for 30 min (f) Locked rotor test	100%	IS 9137	no visual damage/ defect Satisfactory performance & no load losses within limit Should withstand No leakage Satisfactory operation of protection	P	P/W	V
31.	Oil flow Indicator (as applicable)	(a) Type, Make & Visual check (b) Dial & Calibration (c) Contact Rating (d) Dielectric Test between terminals and earth (e) Leak test at 7 kg/cm ² for 2 min (f) Alarm & trip operation check (g) Full flow check	100%	--	(a) As per standard document, no visual damage/defect (b) As per standard document (c) As per standard document (d) Shall withstand 2 kV for 1 min (e) No leak	P	P/W	V
32.	Power/Control Cable	Review of Supplier's TC for physical & electrical tests as per specification/drawing.	Random	--	As per standard document	P	P	V

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						Sub-Vendor	Manufacturer	Customer
33.	Silica Gel Breather	(a) Dimension, Type and model check (b) Check of healthiness & colour of Silica gel (c) Pressure test by blanking oil cup end	100%	-	(a) Within tolerance, Type and model as per drg (b) No visible defect, Gel colour is blue/Orange (c) No leak at 0.35 kg/cm ² (for 30 Min)	P	W	-
34.	Drum for insulating oil	(a) Visual check of inside cleanliness and outside coat (b) Dimensional check (thickness, height & diameter) (c) Leakage test on drum (d) Drop test (e) Hydraulic test	100%	IS 1783 -1	As per specifications/ IS 1783-1			

Sr. No.	Item / Process	Sampling rate	Reference / Standard	Acceptable Value	Category of Responsibility*			
					Sub- Vendor	Manufacturer	Customer	
B	IN-PROCESS INSPECTION							
I	CRGO Lamination for core							
	1. Visual check, check length & slitting dimension	One sample of each lot of CRGO	IS 3024	Prime CRGO and Free from defect	--	P	V	
	2. Dimensional check			As per design Drawings	--	P	V	
	3. Check for burr			Less than 20 micron	--	P	V	
	4. Check for Edge bow			As per IS 3024 L< 250mm, H<= 2mm L>= 250 mm, H<= 3mm	--	P	V	
II	Core Building							
	1. Visual check (frame assembly, arrangement of insulation, bonding of polyester tape)	100%	--	Free from defect	--	P	W	
	2. Measurement of Total stack height		As per design drawings		within specified tolerance of design	--	P	W
	3. Core Diameter				within specified tolerance of design	--	P	W
	4. Check window width, window height and diagonal of frame				within specified tolerance of design	--	P	W
	5. Assembly of limb Insulation & plates				As per design	--	P	V
	6. Rectangularity of Core Assembly				As per design	--	P	V
	7. Check for Overlaps & air gap at joints				As per design	--	P	V
	8. Check leaning/ inclination of Core				No leaning	--	P	V
	9. Earthing of Core (check of insulation resistance between CC-CL, CC-Yoke bolt, CL-Yoke Bolt by 2kV megger)				Proper connection	--	P	V
	10. Limb Clamping & Binding				As per design drawings	--	P	V
	11. Insulation test between core & core clamp / frame				As per specification	shall withstand 2.5 kV DC for 1 min.	--	P
	12. Yoke Bolt Tightness			Design drawing	As per design		P	V
	13. Loss measurement on built up core assembly OR validation by software			As per specification / GTP	Within limit as per GTP	--	P	W
	14. Built-up core sample collection for watt loss verification		1 sample per design	To be furnished	As per declared/offered value of Watt loss value	--	P	V
III	Winding/coil							
	1. Nos. of discs	100%	As per approved drawings / Factory drawing	As per Factory drawing	--	P	V	

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