

Chapter - 4

STANDARD MANUFACTURING QUALITY PLAN (MQP)

Working Group Members

Mr. S. K. Negi	- GETCO
Mr. M. M. Goswami	- POWERGRID
Mr. Y. V. Joshi	- GECO
Mr. Krishnan	- Mahindra Intertrade
Mr. Gautam Bhatia	- ENPAY
Mr. Baghel	- ATSA Conductors
Mr. Bharat Tolia	- Bharat Corrub
Mr. R S Thakkar	- GETCO

CHAPTER - 4

STANDARD MANUFACTURING QUALITY PLAN (MQP)

It is a contract document between customer and supplier to express commitment for delivery of transformer as per agreed technical specification and match the type tested design.

Over a period of time as the transmission grid has grown leaps and bounds, with HVDC and 765 kV AC network, this commitment document is gaining importance, because of rise in transformer failure rate and causing anxiety to maintain uninterrupted supply for consumer and industry. Customer always wishes that transformer manufactured and delivered must perform defect free service for its "specified design life". It is always a challenge for supplier (manufacturer) to keep consistency in material used and manufacturing process, which are the main cause for variation in quality of transformer. While customer practically cannot monitor them and not expected to do so, manufacturers are on their toes to offer cost competitive and cost effective product. The cost of material plays an important role, considering the fact that majority of parts and components like bushing, OLTC, tank body, radiators, insulation, copper, core material etc. are outsourced. The selection of material, its grades / type and design philosophy ultimately decide the loss capitalization figures of final product. On the manufacturing process front, seamless integration of parts / components through mechanical and electrical design is the prerequisite. The change in sub-vendors and skilled manpower time to time at factory also require due diligence to control and maintain the consistency of manufacturing process. Therefore a "balanced view" is needed to manufacture and deliver ideal Transformer meeting contract specification and match type tested design.

It is evident from above background that there is need of mutually agreed manufacturing quality plan (MQP). Apart from primary objective to have ideal transformer as per customer wish as explained above, the major benefit of MQP would be timely delivery and any conflict shall be address upfront, so that manufacturing could take place uninterrupted in a faithful manner. The role of design review is important to provide all necessary inputs for structuring the MQP.

It is proposed in this power transformer standardisation manual to have MQP covering following elements:

1. Material quality and characteristics.
2. Stage inspection of material.
3. Stage inspection and manufacturing process.
4. Routine and Acceptance tests.
5. To capture "Signature values".
6. Product dimension and physical condition before dispatch.

It is equally very important that Transformer is manufactured in a dust free clean environment with humidity control. Any compromise on this aspect will have adverse effect in expected design life of Transformer, however good is the quality of material used.

Standard Manufacturing Quality Plan (MQP) has been designed in a manner to share the responsibility depending upon the source of supply, testing, location and criticality of test for the performance of Transformer. Responsibility of sub-vendor is important for testing of raw material and components (P), but manufacturer has to play a role of verification (V) as they have to integrate them for actual design of transformer. Similarly, responsibility of manufacturer is crucial for routine tests (P) but customer has to actively witness (W) these tests to ensure that results are complying the contract requirements and design review data.

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
A	Raw Material & Components							
1	Winding Conductor (PICC)/ (CTC)/ Lead wires	1. Visual & Dimensional check of Bare Conductor. Thickness & width of bare conductor, Covered width & thickness 2. Resistivity at 20 deg.C 3. Insulation for bunched conductor a). No. of conductors. b). Thickness & width of bare conductor, Covered width & thickness c). Voltage test between strands 4. Tensile strength and elongation test 5. Hardness test 6. 0.2% Proof strength of work hardened conductor	One sample per type per lot	IS 1897 IS 13730 IS 7401	Bare conductor Width /thick (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 mm - 0.10 Insulated conductor Covering thick(mm) 0.25 to 0.5 - -10 0.51 to 1.25 - -7.5 Over 1.25 - -5 Tolerance (%) -10 -7.5 -5	P	V	W
				IS 13730	For annealed conductor 0.01727 ohm/mm ² / m(max) at 20 deg For half hard conductor 0.01777 ohm-mm ² / m (max)	P	V	--
				IS 13730	As per approved drawing	P	V	W
				IS 7404 IS 13730	Thickness tensile strength elongation (mm) (Nm/m ²) % Up to 2.5 205-265 30 min >2.5-5.6 205-255 32 min	P	V	--
				IS 7404 IS 13730	Max hardness should be RF 65, when measured in Rockwell "F" scale	P	V	--
				IS 7404 IS 13730	As per design requirement	P	V	--

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
		7. Radius of corner of bare conductor		IS 7404 IS 13730	Thickness (mm) Over/Upto Up to 1.0 - 0.50 1.01 to 1.60 - 0.50 1.61 to 2.24 - 0.65 2.25 to 3.55 - 0.80 3.56 to 5.60 - 1.00	P	V	W
2	Kraft Insulating Paper	1. Visual check & Measurement of Thickness 2. Density 3. Substance (grammage) 4. Moisture Content 5. Tensile Index MD 6. Tensile Index CD 7. Elongation at Break MD 8. Elongation at Break CD 9. Electric Strength in Air 10. Ash Content 11. PH of Aqueous extract 12. Conductivity of Aqueous extract 13. Air Permeability 14. Tear Index MD 15. Tear Index CMD 16. Water Absorption (Klemin Method) 17. Heat Stability a.) Reduction of Degree of Polymerization b.) Reduction of Bursting Strength c.) Increase of Conductivity of Aqueous extract.	One sample per type per lot	IEC 60554-3-1 IEC 60554-3-5 IEC 60554-2, Methods of Test	1. Paper to be smooth, unglazed surface & free from dust particles 2. $0.8 \pm 0.05 \text{ gm/cm}^3$ 3. Thick (μm) Sub (g/cm^3) Tolerance 50 40 10 65 52 05 75 60 05 90 72 05 4. 8 % max 5. 93 NMI/gm (min) 6. 34 NMI/gm (min) 7. NA 8. NA 9. NA 10. 1 % max 11. 6 to 8 12. 10 mS/m (max) 13. 0.5 to 1.0 $\mu\text{m/Pa.s}$ 14. 5 mN m^2/g (min) 15. 6 mN m^2/g (min) 16. 10 % 17. Type test report	P	V	--

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
3	CRGO Laminations	<p>Check following documents</p> <p>(a) Invoice of Supplier (b) Mill's Test certificate (c) Packing List (d) Bill of Lading (e) Bill of Entry</p> <p>Check points:</p> <p>1. Visual, Dimension & Thickness 2. Cutting Burr 3. Bend / Ductility test 4. Surface insulation resistivity check 5. Aging test (type test) 6. Test on stacking factor 7. Test for specific Watt loss test</p>	Each Lot One sample per lot	IS 3024 IEC 60404 ASTM 4343	As per approved design 1. Visually defect free, as per design requirement 2. Less than 2 micron burr 3. As per IS 649 4. 10 Ω cm ² min average 05 Ω cm ² min individual 5. 4 % max increase in specific measured loss 6. As per table no. 4 of IS 3024	P	V	--
			One sample from offered lot	IS 3024	Losses as per grade of CRGO lamination used	--	P	V

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
4	Pre-compressed Press Board	1. Visual & dimensional check, thickness, width & length/. 2. Apparent Density 3. Compressibility C 4. Reversible part Compressibility 5. Oil Absorption 6. Moisture Content 7. Shrinkage MD, CD & PD 8. pH of aqueous extract 9. conductivity of aqueous extract 10. Electric Strength in Air 11. Electric Strength in Oil 12. Ash Content 13. Elongation MD, CD 14. Tensile strength MD, CD 15. Ply Bond Resistance 16. Flexural strength MD, CD (Laminated Boards)	One sample of each size per lot	IEC 60641-3-1 IEC 60641-2, Methods of Test	(1) No surface defects (2) Up to 1.6 mm TK -1.0-1.2 >1.6-3 mm TK -1.1-1.25 >3-3.6 mm TK -1.15-1.30 >6-8 mm TK -1.2-1.3 (3) Up to 1.6 -10 %; >1.6-3 mm - 7.5 % >3-3.6 mm - 5 %; >6-8 mm TK -4 % (4) Up to 1.6 -45 %; >1.6-3 mm - 50 % >3-3.6 mm - 50 %; >6-8 mm TK -50 % (5) Up to 1.6 mm TK -11 min > 1.6-3 mm TK - 9 min > 3 - 3.6 mm TK -7 min > 6-8 mm TK - 7 min (6) 6 % max (7) MD -0.5 % max, CD -0.7 % max, Thick -5 % max (8) 6-9 for solid boards (9) 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 (10) 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 (11) 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 (12) 1 % maximum MD CD (13) Up to 1.6 - 3 % 4 % >1.6-3 mm - 3 % 4 % >3-3.6 mm - 3 % 4 % >6-8 mm TK -3 % 4 %	P	V	V

***TC --- Test Certificate PD--> Perpendicular Direction CD--> Cross Direction

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
5	Permaewood	<ol style="list-style-type: none"> 1. Visual & dimensional check, thickness, width & length. 2. Density 3. Moisture content 4. Oil Absorption at 90 °C 5. Electric Strength at 90 °C 6. Tensile strength 7. Compressive strength test 8. Shear strength age-wise 9. Thickness 	One sample of each size per lot	IS 3513 IS 1708 IS 1736 IS 1998	<ol style="list-style-type: none"> 1. Shall be free from surface defect 2. 0.8 to 1.3 gm/cc 3. Max 7% 4. Min 5% 5. Min 60 KV 6. Min for LD - 700 KV/cm² 7. Min for LD - 1400 KV/cm² 8. Min for LD - 450 KV/cm² 9. Thickness (mm) Tolerance (+/- mm) 10 to 25 - 1.2 26 to 50 - 1.4 51 to 150 - 2.0 	P	V	--
6	Porcelain Bushings (Hollow)	<ol style="list-style-type: none"> 1. Visual & dimensional check. 2. Power frequency voltage withstand test 	100% As per IS/IEC	IS 2099	<ol style="list-style-type: none"> 1. As per approved drawing. 2. As per IS 2099 	P	V	--
7	Polyster Resin Impregnated Glass Fibre Tape	<ol style="list-style-type: none"> 1. Visual Check 2. Verification of shelf life 3. Thickness 4. Width 5. Tensile Strength 6. Resin Content 7. Softening point of resin 	Each lot	IS 15208	<ol style="list-style-type: none"> 1. Free from visual defect 2. 12 months 3. 0.25 to 0.35 mm (±0.07) 4. 20 to 50 mm (±2) 5. Min 200 N/mm 6. 27 (±3%) 7. Max 200 °C 	P	V	--
8	Synthetic Rubber Bonded Cork sheet (SRBC)	<ol style="list-style-type: none"> 1. Visual check, thickness, length, width 2. Hardness 3. Compression set 4. Side flow under compression 5. Tensile strength 6. Flexibility 7. Compressibility 8. Recovery 9. Aging in Oil-Finish, Flexibility & change in volume 10. Ph value 	One sample per lot	IS 4253	<ol style="list-style-type: none"> 1. Free from surface defect 2. 70 ± 10 IRHD 3. 85 % max 4. NA 5. 1550 kpa (min) 6. Should be satisfactory when bent though 1800 round the material of diameter three times the thickness of specimen. 7. 25-35 % 8. 80 % min 9. Change in volume .15 % max for 70 hours at 100 deg.c in oil 10. 5-8.5 	P	V	--

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
9	Condenser Bushing	Routine Test (1) Measurement of dielectric dissipation factor and capacitance (2) Dry power frequency voltage withstand test (3) Measurement of partial discharge (4) Pressure test (5) Tightness test (6) Creepage distance (7) Visual & dimensional check	100%	IS 2099 IEC 60137	1. Tan Delta - 66 kV - 0.7% Above 66 kV - 0.4% 2. As per approved GTP 3. As per IEC - No flash-over/ puncture 4. No leakage 5. No leakage 6. As per approved GTP 7. As per approved drawing	P V V V V V V	W -- -- -- -- W W	
10	Buchholz Relay	1. Type & make 2. Porosity 3. High voltage 4. Insulation resistance 5. Element test 6. Gas volume test at 5° ascending towards conservator 7. Loss of oil & Surge test	100%	IS 3637	1. As per approved drawing 2. No leakage 3. 2 KV for 1 min. withstand 4. Min 10 MΩ by 500 V DC megger 5. No leakage at 1.75 Kg/cm ² oil pressure for 15 mins 6. GOR - 1: 90 to 165 CC GOR - 2: 175 to 225 CC GOR - 3: 200 to 300 CC 7. GOR - 1: 70 to 130 CC GOR - 2: 75 to 140 CC GOR - 3: 90 to 160 CC	P V	--	
11	Bimetallic Terminal Connector	1. Dimensional 2. Visual check 3. Tensile strength 4. Resistance	100%	IS 5561	1. As per approved drawing 2. Free form defects 3. As per type test report 4. As per type test report	P V	--	
12	Marshalling Box	1. Dimension & Visual check 2. 2kV test for Auxillary wiring 3. Paint shade & Thickness 4. Wiring routing check 5. Functional Check	100%	Approved drawing and specification	1. As per approved drawing 2. 1 min withstand 3. As per approved drawing 4. Firm and aesthetic 5. As per approved drawing	P V	--	
13	Remote Tap Changer Control Cabinet	1. Dimension & Visual Check 2. 2kV test for Auxillary wiring 3. Paint shade & Thickness 4. Wiring routing check 5. Functional Check 6. Verification of BoQ	100%	Approved drawing and specification	1. As per approved drawing 2. 1 min withstand 3. As per approved drawing 4. Firm and aesthetic 5. As per approved drawing 6. As per approved drawing	P P	--	

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
14	Air cell (Flexi Air Separator)	1. Make, Visual & Dimensions 2. Pressure test at 0.105 Kg/cm ² 3. 10 times inflation and deflation test at 0.105 Kg/cm ²	100%	IS 3400	1. As per approved deawing 2. No leakage for 24 hours 3. No deformation	P	P	--
15	Roller Assembly	1. Visual & Dimensions. 2. Mech. Properties & Chemical composition of raw material used for shaft & roller forging	One sample per melt/ heat treatment batch	IS 8500	1. Free from surface defect 2. 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	P	V	--
16	Oil & winding Temperature Indicator	1. Type & make 2. Calibration 3. 2kV HV test for 1 min between all terminals & earth 3. Switch contact operation test	100%	--	1. As per approved drawing 2. ± 1.5% of FSD 3. Withstand for 1 min 4. operation within ± 2° C of setting	P	P	--
17	Pressure Relief Device	1. Type & Make 2. Operating air pressure 3. Switch/contact testing 4. HV test	100%	IS 2500	1. As per approved drawing & free from defect 2. No leakage 3. Satisfactory operation at pressure release 4. 2 kV withstand for 1 min	P	P	--
18	Magnetic Oil Level Gauge (MOG)	1. Type & make 2. Dial Calibration for level 3. 2kV HV test for 1 min between all terminal & earth 4. Leak test 5. Switch/contact operation test	100%	--	1. As per approved drawing & free from defect 2. Check pointer position for Max, Min and center level 3. Withstand for 1 minute 4. No leakage at 4 kg/cm ² 5. Operate at Min level indication	P	P	--
19	Valves	1. Type, make & Visual 2. Leakage test/ Seepage test	100%	IS 778	1. As per approved drawing & free from defect 2. No leakage	P	P	--
20	Transformer Oil	Routine Test as per IS 335	100%	IS 335 IEC 60296	As per IECMA specification (see Chapter 6)	P	V	V

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
21	Tank & Accessories	<ol style="list-style-type: none"> 1. Check for a fit up for butt welds on tank walls, base & cover 2. DP test on Butt welds after fit up & load bearing welds 3. Visual & Dimensional check after final welding 4. Air leakage test on assembled tank with turrets & on conservator 5. Visual check of paint shade, paint film thickness & film adhesion 6. Tank - <ol style="list-style-type: none"> 6.1 Presseure test 6.2 Vaccum test 	100%	CBIP manual 2013	<ol style="list-style-type: none"> 1. Check for proper welding 2. Check for proper welding 3. Free from defect 4. No leakage 5. Paint thickness Outside: 155 micron Inside : 30 micron No peel-off 	P	P	--
22	Radiators	<ol style="list-style-type: none"> 1. DP test on lifting lugs 2. Surface cleaning of header support and bracing details by sand/shot blasting 3. Air pressure test on elements 4. Dimensional check after final welding 5. Air pressure test on radiator assembly 6. Visual check of paint shade, paint film thickness & film adhesion 	one per design 100%	CBIP manual 2013 IEEMA standard	<ol style="list-style-type: none"> 6.1) Twice the normal head + 30 KN/m² for 1 hr. Withstand 6.2) 760 mm of Hg for 1 hr. withstand 1. No welding defect 2. Free from surface defect 3. As per relevant standards /CBIP 4. As per approved drawing 5. 2 kg/cm² for 30 minutes - no leakage 6. As per tech spec, coating thickness more than 70 micron 	P	W	W
23	OLTC	<ol style="list-style-type: none"> 1. Auxiliary circuit insulation test at 2kV for 1min. 2. Function test on OLTC 3. Pressure test on diverter switch oil compartment 4. Mech. Operation test 5. Sequence test 6. Visual & Dimentional check 7. Operational test on Surge relay 	100%	IEC 60214	<ol style="list-style-type: none"> 1. To Withstand for 1 min 2. Satisfactory working as per drawing approved 3. No leakage 4. Satisfactory operation for 1 complete cycle 5. Switching time within permissible limit 6. Free from defects 7. Satisfactory working of trip & reset 	P	P	V

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Components	List of Tests	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Sub Vendor	Manuf-acturer	Customer
24	Cooling Fans	1. Type & Make 2. Power consumption, rating test 3. HV test 4. Insulation resistance value	100%	IS 2312	1. As per approved drawing 2. As per approved drawing 3. 1.3 kV for 1 min or 1.8 kV for 5 sec 4. 10 MΩ min with 500 V DC megger	P	P	V
25	Nitrile Rubber Gasket	1. Dimensions 2. Shore Hardness 3. Tensile Strength 4. Compression set test 5. Elongation at break 6. Accelerated aging in air 7. Accelerated aging in oil	1 sample/ Lot	BS 2751	1. Within tolerance 2. 70 ± 5 IRHD 3. 12.5 N/mm ² min 4. 20% max 5. 250% min 6. Max change in harness - 10 IRHD 7. Change in weight - 5 to 8.5% Change in thickness - 4% max Change in width & length - 0.2% max	P	P	--
26	Bushing CT	1. Dimensions 2. Verification of terminal marking & polarity 3. Overvoltage inter-turn test 4. Determination of error 5. HV Test	100%	IS 2705	1. As per approved drawing 2. As per IS 2705 3. Rated current withstand for 1 min 4. As per IS 2705 5. 3 kVAC for 1 min withstand	P	P	--
27	Remote Temperature detector	1. HV test 2. Calliberation accuracy check 3. IR value	100%	--	1. 500 V AC for 1 min withstand 2. ± 1% of FSD 3. 10 MΩ min with 500 V DC megger	P	P	--
28	Oil pump	1. No load test 2. HV test 3. Oil pressure test 4. Locked rotor test	100%	--	1. Satisfactory performance & no load losses within limit 2. 2 kV AC for 1 min withstand 3. 5 Kg/cm ² at 90° C for 30 mins withstand 4. Satisfactory operation of protection	P	P	--

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Process	Sampling rate	Reference / Standard	Acceptable Value	Category of Responsibility*		
					Sub Vendor	Manufacturer	Customer
B	In Process Inspection No of turns / disc						
1	Lamination for core						
	Visual check	One sample of each type	--	Prime CRGO and Free from defect	--	P	V
	Dimensional check	One sample of each type	--	As per design drawings	--	P	V
	Check for burr	One sample of each type	--	Less than 20µm	--	P	V
	Edge bow	One sample of each type	IS 3024	As per IS 3024	--	P	V
2	Core Building						
	Visual check	100%	--	Free from defect	--	P	W
	Total stack height	100%	As per design drawings	within specified tolerance of design	--	P	W
	Core Diameter	100%	As per design drawings	within specified tolerance of design	--	P	W
	Leg Centre & Leg length	100%	As per design drawings	within specified tolerance of design	--	P	W
	Assembly of limb Insulation & plates	100%	Design drawing	As per design	--	P	V
	Rectangularity of Core Assembly	100%	Design drawing	As per design	--	P	V
	Check for Overlaps & air gap at joints	100%	Design drawing	As per design	--	P	V
	Leaning of Core	100%	Design drawing	No leaning	--	P	V
	Earthing of Core	100%	Design drawing	Proper connection	--	P	V
	Limb Clamping & Binding	100%	Design drawing	As per design drawings	--	P	V
	Insulation test between core & core clamp / frame	100%	As per specification	shall withstand 2 kV for 1 min	--	P	W
	Loss measurement on built up core assembly.	100%	As per specification / GTP	Within limit as per GTP	--	P	W
3	Winding						
	Visual check for drum lable and Conductor Size	100%	As per design drawings	Within limit as per design	--	P	V

Sr. No.	Item/Process	Sampling rate	Reference / Standard	Acceptable Value	Category of Responsibility*		
					Sub Vendor	Manufacturer	Customer
3	Nos of discs	100%	As per approved drawings / Factory drawing	As per Factory drawing	--	P	V
	No of turns / disc						
	Dimensional checks i) Outer diameter ii) Inner diameter iii) Unshrunk height iv) Radial thickness	100%	As per approved drawings / Factory drawing	As per Factory drawing	--	P	V
	Brazing procedure and brazer's qualification	--	Customer approval	As per approval	--	P	V
	Visual inspection of brazed joints	100%	As per brazing procedure	As per approval	--	P	V
	Visual check for transposition	100%	As per design drawings	As per design	--	P	V
	Insulation arrangement	100%	As per design drawings	As per design	--	P	V
	Lead & coil identification & marking	100%	As per design drawings	As per design	--	P	V
	Continuity test	100%	--	No breaking of continuity	--	P	V
	Inter-turn Insulation	100%	As per design drawings	As per design	--	P	V
4	Core Coil Assembly						
	Visual check for intercoil insulation	100%	--	As per design	--	P	W
	Lead & coil identification & marking	100%	--	As per design	--	P	W
	Brazing / Crimping of Joints	100%	--	Shall be smooth and no sharped age	--	P	W
	Visual check for completeness and cleanliness	100%	--	Complete assembly shall be free from dust/ particles	--	P	V
	Ratio test	100%	As per IS 2026 / IEC 60076	Tolerance as per standards	--	P	V
	Magnetic balance test	100%	As per IS 2026 / IEC 60076	Tolerance as per standards	--	P	V
	Magnetizing current test	100%	As per IS 2026 / IEC 60076	Tolerance as per standards	--	P	V
	Alignment of Spacers/Blocks	100%	--	Aligned	--	P	V
	HV test	100%	Mfgs standard	2 kv for 1 min withstand	--	P	W

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Process	Sampling rate	Reference / Standard	Acceptable Value	Category of Responsibility*		
					Sub Vendor	Manufacturer	Customer
5	Connections and checks before tanking						
	OLTC fitting & connections	100%	Manufacturer standard	Manufacturer standard	--	P	---
	Check for cable sizes	100%	As per design drawings	As per design	--	P	V
	Check for clearance from tank walls	100%	As per design drawings	As per design	--	P	V
	Visual checks for crimped joint	100%	--	Shall be smooth and no sharp edge	--	P	V
	Visual checks for bushing CT assembly tightness	100%	--	Assembly tightness	--	P	V
	Ratio test	100%	As per IS 2026 / IEC 60076	Tolerance as per standards	--	P	V
6	Tank						
	Thickness of walls	100%	As per approved drawings	As per approved drawings	--	P	V
	Dimensions	100%	As per approved drawings	As per approved drawings	--	P	V
	Pressure test	100%	As per CBIP	To withstand, permanent deflection shall not exceed as per specification	--	P	W
	Vacuum test	100%	As per CBIP	To withstand, permanent deflection shall not exceed as per specification	--	P	W
7	Ovening, Tanking and Oil filling						
	Drying	100%	Manufacturer standard	Low voltage tan delta and PI values shall be checked periodically and after achieving the satisfactory values the process will be declared complete	--	P	V
	Checks for complete tightness before tanking a) Tightness of all joints / screws b) Application of thread locking adhesive c) Padding of top yoke d) Pressing of active parts e) Fitting of wall shunts & packing	100%	Manufacturer standard	As per design	--	P	V

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Item/Process	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
					Sub Vendor	Manufacturer	Customer
7	Cleanliness of tank before tanking	100%	Manufacturer standard	Shall be clean.	--	P	---
	Tanking of active parts and check for clearance from tank walls	100%	As per design drawings	As per design	--	P	V
	2 kV HV test between (i) Core & end frame (ii) Core & yoke bolts (iii) End frame and yoke bolts	100%	As per specification	To withstand 2 kV for 1 min	--	P	V
	Check for oil quality before impregnation	100%	As per specification	As per specification	--	P	V
	Oil filling & Air release	100%	Manufacturer standard	Manufacturer standard	--	P	---
	Impregnation process	100%	Manufacturer standard	Sufficient impregnation time shall be given before conducting the electrical test on the transformer	--	P	---

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Test	Description of Test	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*	
						Manufacturer	Customer
C	Routine Tests		100%	IS:2026 / IEC 60076 / specification	As per applicable standard		
	1	Resistance of each winding.				P	W
	2	Turn ratio for all sets of windings on each tap, with percentage error / Voltage				P	W
	3	Polarity and phase relationship (Vector group)				P	W
	4	Impedance between each pair of winding / Impedence Voltage				P	W
	5	Excitation losses at 90, 100 and 110 % rated voltage measured by the average voltmeter method				P	W
	6	Positive phase sequences impedance measurement on three phase transformers				P	W
	7	Regulation at rated load and unity, 0.9, 0.8 lagging P.F.				P	W
	8	Load losses, measured at rated frequency, by applying a primary voltage sufficient to produce rated current in the windings with secondary windings short circuited				P	W
	9	Separate source voltage with stand test.				P	W
	10	Induced over voltage with stand test				P	W
	11	Auxiliary losses (fans. Pumps etc.)				P	W
	12	SFRA test				P	W
	13	Zero Sequence impedance test				P	W
	14	Tests on tap-changer (IEC:214)				P	W
	15	Tan delta & capacitance measurement test for bushings and windings				P	W
16	Tests on transformer oil including DGA on selected sample as per IS:9434/IEC:567, before and after temp rise test and at final stage before dispatch. Corrosive sulphur detection test as per ASTM D1275 subjecting oil for 150°C for 48 hrs.				P	W	

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Test	Description of Test	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*	
						Manufacturer	Customer
C	18	Tank leak test at 5 psi (35 kN/m ²) for 12 hrs with oil & 1 hr with air.	IS:2026 / IEC 60076 / specification	As per applicable standard	P	W	
	19	Magnetic Balance & current test on all winding			P	W	
	20	HV withstand test on auxiliary equipments and wiring			P	W	
	21	Measurement of Insulation Resistance			P	W	
	22	Measurement of acoustic noise level					
	23	Measurement of harmonics of no load current					
	24	Measurement of Partial Discharges of transformer					
	25	Measurement of no load current with 415 V AC supply on LV side.					
	26	Tests on air cell					
	27	ACLD test (For 220 kV class transformer)					
	28	Moisture content in active part measurement test				0.5 % max	P
D	Type Tests		One from Lot or as agreed between Manufacturer and Purchaser.				
	1	Temperature rise test		IS:2026 / IEC 60076	As per standards	P	W
	2	Lightning Impulse Voltage withstand test with chopped wave Switching Impulse Voltage withstand test		IS:2026 / IEC 60076	As per standards	P	W
	3	Vacuum and pressure test on tank		CBIP manual	Permanent deflection within limit as per length of plate used.	W	W
	4	Short circuit withstand capability test (Optional)		IS:2026 / IEC 60076	As per standards		
5	Tests on OLTC		IEC 60214	As per standards	P	W	

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

Sr. No.	Test	Description of Test	Sampling rate	Reference / Standard	Acceptable Value	Category of Reponsibility*		
						Manufacturer	Customer	
E	Special Tests (Optional)							
	1	Degree of protection (IP55) for control cabinets & RTCC panel, OLTC driving mechanism, terminal boxes of PRV, MOG, Buchholz Relay, pump motors, fans etc		IS 13947/IEC 60529: 2001	--	P	W	
	2	Measurement of transferred surge in LV due to Lightning impulse on HV & LV		IS:2026 / IEC 60076	--	P	W	
F	3	Short Time Current withstand test on offered HV and LV terminal connectors for 40 kA for 3 Sec for 220 kV & 132 kV Class and 25 kA for 3 sec for 66 kV & below class		IS:5561	--	P	W	
	Packing & Dispatch - Main tank							
	1	Pipes and headers	100%	Manufacturer's Standard	Manufacturer's Standard	P	--	
	2	Radiators	100%			P	--	
	3	Verification of completeness of accessories	100%			P	--	
	4	Bushings	100%			P	--	
	5	Conservator tank	100%			P	--	
	6	Transformer oil	100%			P	--	
	7	Check Nitrogen / dry air pressure after filling	100%			P	0.15 to 0.2 kg/cm ² above ATM Pr	--
	8	Measurement of dew point of nitrogen or dry air before and after filling in tank before dispatch	100%			P	Manufacturer's Standard	--
	9	Check proper blanking of all openings and leakage, if any	100%			P	Manufacturer's Standard	--
10	Provision of Impact recorder / tracking system	100%	P			Manufacturer's Standard	--	
11	Check for soundness of packing	100%	P			Manufacturer's Standard	--	

* Category of Responsibility: P - Actual Test Performance V - Verify and Accept W - Witness Actual testing, verify and accept

