GUJARAT ENERGY TRANSMISSION CORPORATION LTD

(Formerly known as G.E. BOARD)

HEAD OFFICE: SARDAR PATEL VIDYUT BHAVAN RACE COURSE, VADODARA – 390 007

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Ref. No.: CE(ENGG)/Equip/I/e-2393/BHEL/100 &315 MVA/ 43

Date: 19th January 2015

To,
M/s Bharat Heavy Electricals Ltd.
C/4 & C/5 BHEL Township, Gayatrinagar,
Gotri, Vadodara - 390021

Sub: Supply of 220/66 kV, 100 MVA Power Transformer & 400/220/33 kV, 315 MVA Power Transformer – Submission of QAP.

Ref : (1) LOA No. CE (P)/Proc/II/ E2393 / BHEL / LOA dtd.15.07.14
(2) Your letter no. RE13EVDR020 & 21 dtd.12.01.15

Dear Sir,

With reference to the above, the Quality assurance Plan (QAP) submitted vide letter under ref (2) is technically scrutinized and found in order.

SN	Particulars	Document No	Remarks
220/66 kV, 100 MVA Power Transformer & 400/220/33 kV, 315 MVA Power Transformer			
01	QAP	QP/PT/1117 R1 (sheet 1 to 9)	Approved with comment

Please note that all routine / acceptance test shall be carried out / performed in line with technical specification requirement.

This approval, however, does not absolve you from the warranty of the equipment or from rectifying the defects due to faulty design or use of incorrect materials.
This is without any prejudice to the terms and conditions of the order.

Yours faithfully,
For, Gujarat Energy Transmission Corporation Ltd.

(B B Chauhan)
CHIEF ENGINEER (Engineering/Project)

Copy to: CE (Project) GETCO HO BARODA

Received on 27/01/15
(S.P. Tiwale) 27/01/15

BHEL/CQX/ 007/0006	BHARAT HEAVY ELECTRICALS LIMTED, JHANSI				
	QUALITY ASSURANCE PLAN FOR CUSTOMER M/s GETCO	QUALITY ASSURANCE PLAN FOR POWER TRANSFORMER WO. NO. 71158A17100, 7x100MVA, 220/66KV	MATERIAL INSPECTION/ IN-PROCESS INSPECTION/ FINAL INSPECTION	SUB VENDORS/ VENDORS/ CONTRACTORS WORK	QP No. QP/PT/ 1117 Rev. No. 01 Date: 08/01/15 Page: 1 of 9

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
1	Winding Conductor (PICC)/ (CTC)/ Lead wires	1. Visual & dimensional check of bare conductor. Thickness & width of bare conductor, covered width & thickness	One sample per type per lot	IEC60317 part 27/ IS13730 part 27	1. Bare conductor Width/ Thickness(mm) Tolerance(in mm) 3.15 0.03 3.15 to 6.3 0.05 6.30 to 12.50 0.07 12.50 to 16 0.10 Insulated conductor Paper cover (in mm) Tolerance (In %) 0.25 to 0.50 10 0.51 to 1.30 7.5 >1.30 5	P	V	W	CHP at supplier works
		2. Resistivity at 20°C		IS13730	2. 0.017241Ω mm²/m max.	P	V	--	
		3. Insulation for bunched conductor a) No. of conductors b) Thickness & width of bare conductor, covered width & thickness c) Voltage test between strands		IS13730	3. As per approved drawing	P	V	W	CHP at supplier works
		4. Tensile strength & elongation test		IS13730	4. 30% min for thk. up to 2.5mm 32% min for thk. 2.5 to 5.6mm	P	V	--	
		5. Proof stress(for proof stress conductor) if applicable		IS13730	5. As per design requirement	P	V	--	
		6. Radius of corner of bare conductor		IS13730	6. As per standard	P	V	W	CHP at supplier works
2.	Kraft insulating paper	1. Visual check & measurement of thickness 2. Density 3. Substance 4. Moisture content 5. Tensile index MD 6. Tensile index CD 7. Electric strength in air 8. Ash content 9. PH of aqueous extract 10. Conductivity of aqueous extract 11. Air permeability 12. Tear index MD 13. Tear index CMD	One sample per type per lot	IEC60554/ IS9335 part 3 sec 5	1. paper to be smooth, unglazed surface & free from dust particles 2. 0.8±0.05g/cm³ 3. As per IEC 60554-3, table 582 4. 8% max. 5. 93Nm/gm min. 6. 34 NM/gm min. 7. NA 8. 1% max. 9. 6 to 8 10. 10 mS/m max. 11. 0.5 to 1.0 µm/Pa.s 12. 5.0 mN m2/g min. 13. 6.0 mN m2/g min.	P	V	--	

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Cat	Particulars	Sign
I	Approved w/o Comment	
II	Approved with Comment	
III	Approved for Information	
IV	Not Approved	

No. 43 dtd. 17-1-15

Legends: M- Manufacturer, C- Contractor, N- Customer, P- Performer, V- Verification, W- Witness

Prepared by:-

Checked by:-

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		14. Water absorption 15. Heat stability			14. 10% 15. As per Test report				
3.	CRGO laminations	**Check following documents:** a) Invoice of supplier b) Mill's test certificate c) Packing list d) Bill of lading e) Bill of entry **Check points:** 1. Visual, dimension & thickness 2. Bend/Ductility 3. Surface insulation resistivity check 4. Aging test(type test) 5. Test on stacking factor 6. Test for specific watt loss test	Each lot One sample per lot	IS3024	As per approved design 1. Visual defect free, as per design requirement 2. As per IS 3. Average value 10 Ωcm^2 min. Individual value 5 Ωcm^2 min. 4. 4% max increase in specific measured loss 5. 95.5% min/As per IS 6. As per grade of CRGO used	P --	V P	V C V	witnessed by GETCO and samples shall be Taken in presence of GETCO for Testing in CRDA/NABL Lab
4.	Pre-compressed press board	1. Visual & dimensional check, thickness, width & length 2. Apparent density 3. Compressibility 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 oil 11. Ash content 12. Elongation MD, CD 13. Tensile strength MD, CD	One sample of each size per lot	IEC 60641	1. No surface defects 2. 1 gm/cm³-1.3gm/cm³ 3. 4%-10% 4. 45%-50% 5. 7%-11%, depending upon the thickness 6. 8% max. 7. As per IEC 8. 6-9 9. SmS/m- 10mS/m 10. 30kV/mm-40kV/mm 11. 1% max. 12. MD-3%; CD-4% 13. MD:- 100-110Mpa; CD:- 75-85Mpa		V	V	
5.	Permawood	1. Visual & dimensional check, thickness, width & length 2. Density 3. Moisture content	One sample of each size per lot	IS 3513	1. Shall be free from surface defect 2. 0.8 to 1.3 gm/cm³ 3. 7% max.	P	V	--	

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I	Approved w/o Comment	
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III	Approved for information	
IV	Not Approved	

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		4. Oil absorption at 90°C 5. Electric strength at 90°C 6. Tensile strength 7. Compressive strength test 8. Thickness			4. 5% min. 5. 60kV min. 6. 96MPa min. 7. 170MPa min. 8. As per IS				
6.	Porcelain bushings (Hollow)	1. Visual & dimensional checks 2. Power frequency voltage withstand test	100%	IS 2099	1. As per approved drawing 2. As per IS	P	V	--	
7.	Polyester resin impregnated glass fiber tape	1. Visual check 2. Verification of shelf life 3. Thickness 4. Width 5. Resin content 6. Softening point of resin	One sample per lot	BHEL specification & plant standard AA25716	1. Free from visual defects 2. As per standard 3. As per standard 4. As per standard 5. 29±4 6.235°C max	P	V	--	
8.	Synthetic rubber bonded cork sheet(SRBC)	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 10. Ph value	One sample per lot	BHEL specification & plant standard AA59802	1. Free from surface defects 2. 60-80 IRHD 3. 85% max. 4. NA 5. 1.5N/mm² min. 6. As per standard 7. 25-35% 8. 80% min. 9. As per standard 10. 5-8.5	P	V	--	
9.	Condenser bushing	1. Measurement of dielectric dissipation factor & capacitance 2. Dry power frequency voltage withstand test 3. Measurement of partial discharge 4. Pressure test 5.Creepage distance 6. Visual & dimensional	100%	IEC 60137	1. 0.4%-0.7% 2. As per standard/ approved GTP 3. As per standard/ approved GTP 4. As per standard/ approved GTP 5. As per standard/approved GTP 6. As per approved drawing	P	P V V V V V	W -- -- -- W W	CHP at supplier works CHP at supplier works CHP at supplier works
10.	Buchholz relay	1. Type & make 2. Porosity 3. High voltage 4. Insulation resistance	100%	IS 3637	1. As per approved drawing 2. As per standard 3. As per standard 4. As per standard	P	V	--	

NO. 43 dtd. 17-1-15

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II Approved with Comment 13/1/15
III Approved for Information
IV Not Approved

Legends: M- Manufacturer, C- Contractor, N- Customer, P- Performer, V- Verification, W- Witness.

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Checked by:-

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		5. Element test 6. Gas volume test 7. Loss of oil & surge test			5. As per standard 6. As per standard 7. As per standard				
11.	Bimetallic terminal connector	1. Dimensional 2. Visual check 3. Tensile strength 4. Resistance	100%	IS 5561	1. As per approved drawing 2. Free from defect 3. As per test report 4. As per test report	P	V	--	
12.	Marshalling box	1. Dimension & visual check 2. 2kV test for auxiliary wiring 3. Paint shade & thickness 4. Wiring routine check 5. Functional check	100%	Approved drawing & specificatio n	1. As per approved drawing 2. 1 min. withstand 3. As per approved drawing 4. Firm & aesthetic 5. As per approved drawing	P	V	--	
13.	Remote tap changer control cabinet	1. Dimensional & visual check 2. 2k test for Auxiliary wiring 3. Paint shade & thickness 4. Wiring routing check 5. Functional check 6. Verification of BoQ	100%	Approved drawing & specificatio n	1. As per approved drawing 2. 1 min. withstand 3. As per approved drawing 4. Firm & aesthetic 5. As per approved drawing 6. As per approved drawing	P	V	--	NO. 43 dtd. 17-1-15
14.	Air cell (flexible air separator)	1. Make, visual & dimensions 2. Pressure test at 0.1.5 kg/cm	100%	IS 3400	1. As per approved drawing 2. No leakage for 24hrs	P	V	–	
15.	Roller assembly	1. Visual & dimensions 2. Mechanical properties & chemical composition of raw material used for shaft & roller forging	One sample per melt/ heat treatment batch	--	1. Free from defect 2. As per BHEL plant standard AA10501/ AA10108/ AA19331	P	V	--	
16.	Oil & winding temperature indicator	1. Type & make 2. Calibration 3. 2kV HV test for 1min between all terminal & earth 4. Switch contact operation test	100%	BHEL spec. TR20093/ TR20101/ TR10123	1. As per approved drawing 2. ±1.5% FSD 3. Withstand for 1min. 4. Operation within ±2.5°C	P	V	--	
17.	Pressure relief device	1. Type & make 2. Operating air pressure 3. Switch contact test 4. HV test	100%	IS 2500	1. As per approved drawing 2. No leakage 3.Satifactory operation 4. Withstand for 1 min..	P	V	–	
18.	Magnetic oil level gauge	1. Type & make 2. Dial Calibration for level	100%	--	1. As per approved drawing 2. Check pointer position for all levels	P	V	–	

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S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		3. 2kV HV test for 1min between all terminal & earth 4. Leak test 5. Switch contact operation test			3. Withstand for 1 min. 4. No leakage 5. Operate at min. level indication.				
19.	Valves	1. Type & make 2. ~~Leakage test/ seepage~~ test	100%	BHEL spec. TR20036	1. As per approved drawing 2. ~~No leakage~~	P	V	--	
20.	Transformer oil	Routine test as per IS 335	100%	IS 335	As per standard As per QC-TCP	V	V		specification
21.	Tank & accessories	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 & conservator 5. Visual check of paint shade	100%	CBIP manual	1. Check for proper welding 2. Check for proper welding 3. Free from defect 4. No leakage 5. As per standard	P	V	V	
		6. Tank 6.3 dimensions as per Drg. 6.1 Pressure test 6.2 Vacuum test	One per design	CBIP manual	6.1 As per standard 6.2 As per standard	P	V	W	CHP at supplier works
22.	Radiators	1. DP test on lifting lugs 2. Surface cleaning of header support & 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 & film adhesion	100%	BHEL plant standard no. AA850129	1. No welding defects 2. Free from surface defects 3. As per standard 4. As per approved drawing 5. No leakage 6. As per technical specification				
23	OLTC	1. Auxiliary circuit insulation test at 2kV 2. Function test on OLTC 3. Pressure test on diverter switch oil compartment 4. Mechanical operation test 5. Sequence test 6. Visual & dimensional check 7. Operational test on surge relay	100%	IEC 60214	1. To withstand fro 1min 2. Satisfactory working 3. No leakage 4 Satisfactory operation 5. Switching time within permissible limit 6. Free from defects 7. Satisfactory working of trip & set				
24.	Cooling fans	1. Type & make	100%	IS 2312	1 As per approved drawing	P	V	V	

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S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		2. Power consumption, rating test 3. HV test 4. Insulation resistance value			2. As per approved drawing 3. As per standard 4. As per standard				
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	One sample per lot	BHEL plant standard no. AA59807	1. Within tolerance 2. 75±5 IRHD 3. As per standard 4. 20% max. 5. 250% min. 6. As per standard 7. As per standard	P	V	--	
26.	Bushing CT	1. Dimensions 2. Verification of terminal marking & polarity 3. Over voltage 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 standard 5. As per standard	P	V	--	
27.	Remote temperature detector	1. HV test 2. Calibration accuracy test 3. IR value	100%	BHEL specification TR20094/ TR20095/ TR 20096	1. As per specification 2.As per specification 3. As per specification	P	V	--	
28.	Oil pump	1. No load test 2. HV test 3. oil pressure test 4. Locked rotor test	100%	--	1. Satisfactory performance 2. 2kV AC for 1min withstand 3. 4kg/cm² for 30mins withstand 4. Satisfactory operation of protection	P	V	--	
29.	Laminations for core	1. Visual check 2. Dimensional check 3. Check for burr 4. Edge bow	One sample of each type	IS 3024	1. Prime CRGO & free from defects 2. As per design drawing 3. As per standard 4. As per standard	P	V	--	
30.	Core building	1. Visual check 2. Total stack height 3. Core diameter 4. Leg center & leg length 5. Assembly of limb insulation & plates 6. Rectangularity of core assembly 7. Check for overlaps & air gap at joints	100%	As per drawing/ specification	1. Free from defects 2. Within specified tolerance 3. Within specified tolerance 4. Within specified tolerance 5. As per design 6. As per design 7. As per design	-- -- -- -- -- -- --	P P P P P P P	W W W W V V V	CHP at BHEL CHP at BHEL CHP at BHEL CHP at BHEL CO - CRGO sample is to be taken & sent to NABL Lab.

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No. 43 dtd. 17-1-15

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Checked by:-

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		8. Leaning of core			8. No leaning	--	P	V	
		9. Earthing of core			9. Proper connections	--	P	V	
		10. Limb clamping & binding			10. As per design	--	P	V	
		11. Insulation test between core & core clamp/ frame			11. Shall withstand 2kV for 1min	--	P	W	CHP at BHEL
		12. Loss measurement on built up core assembly			12. Within limit as per GTP	--	P	W	CHP at BHEL
31.	Winding	1. Visual check for drum label & conductor size	100%	Approved drawings/ BHEL specifications/ BHEL plant standards	1. As per standards/ drawings	--	P	V	
		2. Number of turns/ discs			2. As per drawings		P	V	
		3. Dimensional checks a) Outer diameter b) Inner diameter c) Unshrunk height d) Radial thickness			3. As per standards/ drawings		P	V	
		4. Brazing procedure & brazers' qualification			4. As per standards/ drawings			V	
		5. Visual inspection of brazed joints			5. As per standards/ drawings		P	V	
		6. Visual check of transposition			6. As per design		P	V	
		7. Insulation arrangements			7. As per design		P	V	
		8. Lead & coil identification & marking			8. As per design		P	V	
		9. continuity test			9. No breaking of continuity		P	V	
		10. Inter-turn insulation			10. As per design		P	V	
32.	Core coil assembly	1. Visual check for inter coil assembly	100%	--	1. As per design	--	P	W	CHP at BHEL
		2. Lead & coil identification & marking		--	2. As per design		P	W	CHP at BHEL
		3. Brazing. Crimping of joints		--	3. Shall be smooth & no sharp edge		P	W	CHP at BHEL
		4. Visual check for completeness & cleanliness		--	4. Free from dust		P	V	
		5. Ratio test		As per IS 2026/ IEC 60076	5. As per standard		P	V	
		6. Magnetic balance test			6. As per standard		P	V	
		7. Magnetizing current test			7. As per standard		P	V	
		8. Alignment of spacers/ blocks		--	8. Aligned		P	V	
		9. HV test		--	9. 2kV withstand for 1min.		P	W	CHP at BHEL
33.	Connections & checks before tanking	1. OLTC fitting & connection	100%	Mfr. Stds.	1. As per manufacturer standards	--	P	V	
		2. Check for cable sizes		As per design	2. As per design		P	V	
		3. Check for clearance from tank walls			3. As per design		P	V	

Legends: M- Manufacturer, C- Contractor, N- Customer, P- Performer, V- Verification, W- Witness

No. 43 dtd. 17-1-15

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I	Approved w/o Comment	
II	Approved with Comment	16/1/15
III	Approved for Information	
IV	Not Approved	

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32. Core-coil assembly → dimensions of conductors are to be verified

→ one sample is to be taken & sent to NABL Lab for Testing

Checked by:-

W - witnessed by GETCO

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		4. Visual checks for crimped joints		--	4. Shall be smooth & no sharp edge		P	V	
		5. Visual checks for bushing CT assembly tightness		--	5. Proper tightness		P	V	
		6. Ration test		As per IS	6. As per standard.		P	V	
34.	Covening, tanking & oil filling	1. Drying	100%		1. Low value of tanδ	--	P	V	
		2. Checks for complete tightness before tanking			2. As per design		P	V	
		a) Tightness of all joints/ screws		BHEL standards					
		b) Application of thread locking adhesive							
		c) Padding of top yoke							
		d) Pressing of active parts							
		e) Fitting of wall shunts & packing							
		3. Cleanliness of tank before tanking			3. Shall be clean		P		
		4. Tanking of active parts & clearance from tank walls		As per design	4. As per design		P	V	
		5. 2kV HV test between			5. Withstand 2kV for 1 min				
		a) Core & end frame		As per specification					
		b) Core & yoke bolts							
		c) End frame & yoke bolts							
		6. Check for oil quantity before impregnation			6. As per specification		P	V	
		7. Oil filling & air release		BHEL standards	7. As per standard				
		8. Impregnation process			8. As per standard		P	--	
35.	Testing	1. Routine tests	100%	Approved test schedule	1. As per approved test schedule	--	P	W	CHP at BHEL
		2. Type tests			2. As per approved test schedule		P	W	CHP at BHEL
36	Pre shipment checks	1. Pipes & headers	100%	BHEL standards	As per BHE standards	--	P	--	
		2. Radiators							
		3. Verification of completeness of accessories							
		4. Bushings							
		5. Conservator tank							
		6. Transformer oil							
		7. Check nitrogen/dry air pressure after filling							

No. 43 dtd. 17-1-15

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I	Approved w/o Comment	
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III	Approved for Information	
IV	Not Approved	

As per GETCO specification

Legends: M- Manufacturer, C- Contractor, N- Customer, P- Performer, V- Verification, W- Witness

Prepared by:-

Checked by:-

S No.	Item/ Components	List of Tests	Quantum of check/ Sampling	Reference/ Standard	Acceptance norms	Applicable codes M	C	N	Remarks
		8. Measurement of dew point of nitrogen/ dry air before & after filling in tank 9. Check proper blanking of all opening & leakage, if any 10. Provision of impact recorder/ tracking system 11. Check for soundness of packing							

No. 43 dtd. 17-1-15

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Cat	Particulars	Sign.
☐ I	Approved w/o Comment	
☑ II	Approved with Comment	31/1/15
☐ III	Approved for Information	
☐ IV	Not Approved	

भा. एच. इ. लि. आर.ओ.बी. वडोदरा.

Legends: M- Manufacturer, C- Contractor, N- Customer, P- Performer, V- Verification, W- Witness

Prepared by:-

Checked by:-

(vi) Pressure relief valve of adequate size & number/s shall be provided on main tank as well as for OLTC.

(vii) All hardware used shall be ***hot dip galvanised.***

(viii) ***Necessary provision for installation of On Line moisture and gas in oil monitoring system shall be made for satisfactory performance through out the life of transformer.*** **Location and size of the same shall be finalized during detailed engineering.**

(ix) ***Necessary provision shall be made for installation of Nitrogen Injection Fire Prevention cum Extinguishing System. Location and size of the same shall be finalized during detailed engineering.***

1.8 UNDER CARRIAGE

1.8.1 The transformer tank shall be supported on a structure steel base equipped with forged steel single flanged wheels suitable for moving the transformer completely with oil.

1.8.2 Jacking pads shall be provided. It shall be possible to change the direction of the wheels through 90^0 when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse direction. A standard track gauge (Preferably 1676 mm) in both longitudinal and transverse directional shall be chosen.

1.8.3 Pulling eyes shall be provided to facilitate movement of transformer and they shall be suitable brazed in a vertical direction so that bonding does not occur when the pull has a vertical component.

1.9 CORE:

1.9.1 The transformer may be of core or shell type. The core shall be built up with high-grade non-ageing cold-rolled grain oriented silicon steel laminations having high permeability and low hysteresis loss. The core material shall be prime CRGO, which shall be procured directly from manufacturer or through accredited marketing organization of reputation.

1.9.1(a) The thickness of lamination shall be 0.27 mm or less. Surface insulation of laminations shall be rust resistant and have high inter laminar resistance. Insulation shall withstand annealing temperature as high as 850 ^{0}C. Insulation shall be resistant to hot cooling medium. Laminations are not to be punched.

1.9.1(b) Bidder should have in house core cutting facility for proper monitoring & control on quality & also to avoid any possibility of mixing if prime material with defective/second grade material. This should be indicated in variably in the QAP. The purchaser may witness the core-cutting process. In case the in-house core cutting facility is not available, then the same shall be carried out in the presence of the representative of GETCO.

1.9.1(c) The bidder will offer the core for stage inspection and get approval from GETCO during manufacturing stage. The bidder has to produce following documents at the time of inspection for confirmation of use of prime core materials at the time of stage inspection for confirmation of use of prime core materials.

i) Invoice of supplier
ii) Mills of approved test certificates
iii) Packing list
iv) Bill of lading
v) Bill of entry certificate by custom.

To avoid any possibility of mixing of 'Prime material' with any other second grade/ defective material, the imported packed slit coils of CRGO materials shall be opened in the presence of the GETCO representative. Only after the inspection and approval from purchaser, the core material will be cut in-house OR sent to external agency for cutting individual laminations. In case the core is sent to external agency for cutting, the GETCO representative will have full access to visit such agency for the inspection of the cutting of core.

1.9.2 After being sheared, the laminations shall be treated to remove all burrs and shall be re-annealed to remove all residual stresses. The insulation of the lamination shall be inserted to the action of hot transformer oil. Paper and varnish insulation will not be accepted. The nature of insulation should be specified in the bid.

1.9.3 The core shall be rigidly clamped to ensure adequate mechanical strength and to prevent vibration during operation. The clamping structure shall be so constructed that eddy currents will be minimum.

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

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

1.9.6 The transformer shall be designed in such a way that the flux density in the steel core corresponding to the *Rated* voltage and the rated frequency shall be not exceeding **1.727 tesla**.

1.9.7 Core and frame terminal should be brought out on transformer top so as to enable meggering.

1.9.8 The core and the coil assembly shall be so fixed in the tank that shifting will not occur and cause any damage when the transformer is moved shifted, or during a short circuit. **The maximum flux density in any part of core or yoke at 10% continuous over voltage condition shall not exceed 1.9 tesla.**

1.9.9 The complete core and core coil assembly of bolt less core type transformer shall be so assembled that the axis and the plate of outer surface of the coil stack shall not deviate from the vertical plane by more than 25 mm.

1.9.10 In case transformer with variable flux, the voltage variation which would affect flux density at every tap shall be kept in view while designing the transformer.
Transformers shall be designed to withstand the following over fluxing conditions:

a)	110 % of maximum density corresponding to rated voltage	Continuous for all transformers
b)	125 % & 140 % of max. flux density corresponding to rated voltage	for 1 minute and 5 sec. respectively

1.10 WINDING:

1.10.1 The conductor for winding shall be of electrolytic grade copper. The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs can be readily done, without special equipment. The coils shall be supported between adjacent sections by insulating spacers and the barriers, bracings 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 sports in the windings. **The insulation paper shall be of high quality and the value of degree of polymerization shall not be less than 1200 Pv and the necessary test certificate shall be submitted along with the stage inspection report. Provision shall be made in the tank, for taking sample, in future, of paper for testing purpose and location shall be easily accessible and indicated on the transformer tank by affixing special caution plate.**

1.10.2 The insulation of the coils shall be such as to develop the full electrical strength of the windings. All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil, and shall not soften or otherwise be adversely affected under the operating conditions.

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

1.10.4 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 before removal from the treating tank. The copper conductors used in the coil structure shall be best suited to the requirements and all permanent current carrying joints in the windings and the leads shall be welded or brazed.

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

1.28.2 Labeling shall be clear, concise and adequate and shall be of standard size.

1.28.3 Descriptive labels for mounting indoor or inside cubicles and kiosk shall be of material that will ensure permanence of the lettering. Danger notices shall have red lettering on a white background. All plates shall be of material, which will not be corroded.

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

1.29 **INSPECTION:**

(a) The bidder shall carry out a detailed inspection and testing program for manufacturing activities of the various components. An indicative program of inspection of as envisaged by the Engineer is given below. This is not, however, intended to form a comprehensive program as it is bidder's responsibility to draw up and carry out such a program duly approved by the Engineer.

(b) Cost of inspection/tests is to be borne by the bidder.

(c) Additional tests, if required, are to be deemed as included in scope of work.

(d) Stages of inspection and owners participation would be defined and *shall be as per purchaser requirement.* Photographs shall be taken jointly and submitted with inspection report.

(e) The bidder shall guarantee that the goods are new and of high quality and the goods will be free from defects in design.

TANK AND CONSERVATOR:

(a) Certificates of chemical analysis and material tests of plates.

(b) Welder's and weld procedure qualification.

(c) Testing of electrodes for quality of base material.

(d) Inspections of major weld preparation.

(e) Crack detection of major strength weld seam by dye penetration test.

(f) Measurement of film thickness of

i) Oil insoluble varnish.

ii) Zinc chromate paint.

iii) Light gray paint.

(g) Check correct dimensions between wheels, demonstrate twining of wheels through 90^0 and further dimensional check.

(h) Check for physical properties of materials for lifting lugs jacking pad etc. All load bearing welds including lifting lug welds shall be subjected to NDT.

(i) Leakage test of the conservator.

(j) Certification of all test results.

CORE:

(a) Samples testing of core material for checking specific loss, bend properties magnetization characteristics and thickness.

(b) Check on the quality of varnish if used on the stampings.

(c) (i) Measurement of thickness & hardness of varnish on the stampings.

(ii) Solvent resistance test to check that varnish does not react in hot oil.

(iii) Check over all quality of varnish on stamping to ensure uniform shining colour, no bars spots, no over burnt varnish layer and no bubbles on varnished surface.

(d) Check on the amount of burrs.

(e) Bow check on stampings.

(f) Check for the overlapping stampings, Corners of the sheets are to be apart.

(g) Visual and dimensional check during assembly stage.

(h) Check for inter laminar insulation between core sections before & after pressing.

(i) Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core. *The losses shall be actually measured on built up core with dummy turns or can be demonstrated through suitable software to GETCO representative and the report for the same shall be submitted. However, during final inspection the losses shall be actually measured & the same shall be within guaranteed losses.*

(j) Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.

(k) High voltage test (2 KV for one minute) between core and clamps.

(l) Certification of all test results.

INSULATING MATERIAL:

(a) Sample check for physical properties of material.

(b) Check for dielectric strength.

(c) Visual & dimensional checks.

(d) Sample check on insulating paper for pH Value, electric strength.

(e) Check for the reaction of hot oil on insulating materials.

(f) Certification of all tests results.

WINDING:

(a) Sample check on winding conductor for mechanical properties and electrical conductivity.

(b) Visual dimensional checks on conductor for scratches, dent marks etc.

(c) Sample check on insulating paper for pH Value, electric strength.

(d) Check for the reaction of hot oil on insulating paper.
(e) Check for the bonding of the insulating paper on conductor.
(f) Check for absence of short circuit between parallel strands.
(g) Check and ensure that physical condition of all materials taken for winding is satisfactory and free of dust.
(h) Check for brazed joints wherever applicable.
(i) Measurement of voltage to be carried out when core/yoke is completely restacked and all connections ready.
(j) Conductor enamel test for checking of cracks, leakage and pin holes
(k) Conductor flexibility test
(l) Heat Shrinkable test for enameled wire
(m) Certification of all test results

CHECK BEFORE DRYING PROCESS:

(a) Cheek conditions of insulation in the conductor and between the windings.
(b) Cheek insulation resistance between high voltage connection cable and earth others live parts.
(c) Check insulation resistance between low voltage connection and earth & other parts.
(d) Insulation test of core earthing.
(e) Check for proper clean lines and absence of dust etc.
(f) Certification of all test results.

CHECK DURING DRYING PROCESS:

a) Measurement and recording of temperature and drying time during vacuum treatment.
b) Check for completeness of drying.
c) Certification of all test results.

ASSEMBLED TRANSFORMER:

(a) Check completed transformer against approved outline drawing: provision for all fitting, finish level etc.
(b) Taking test on all the assembled transformer
The bidder shall also prepare a comprehensive inspection and testing program for all bought out / sub-contracted items and shall submit the same to the Engineer for approval. Such program shall include the following.
(i) Buchholz relay
(ii) Sudden/rapid pressure rise relay/ PRV
(iii) Axles and wheels.
(iv) Winding temperature indicator for local and remote mounting.
(v) Oil temperature indicators
(vi) Bushing
(vii) Bushing Current Transformer
(viii) Terminal connectors
(ix) Radiators, cooler control and any other item, as desired by purchaser.
c) Test to check effective shielding of the tank
d) Jacking test with oil on all the assembled transformers

e) Dye penetration test shall be carried out after the jacking test

PRE-SHIPMENT CHECKS AT MANUFACTURER'S WORKS:

(a) Check for interchangeability of components of similar transformer for mounting dimensions.
(b) Check for proper packing and preservation of accessories like radiators, bushings, PRV, dehydrating breather, rollers, Buchholz relay, control cubicle, connecting pipes, conservator tank.
(c) Check for proper provision of bracings to arrest the movement of core and winding assembly inside the tank.
(d) Gas tightness test to conform tightness.
(e) Derivation of leakage rate and ensure adequate reserve gas capacity.

INSPECTION AND TESTING AT SITE:

The successful bidder shall carry out a detailed inspection and testing program for field activities, namely covering area right from the receipt of material stage up to commissioning stage. An indicative program of inspection as envisaged by the Engineer is given below.

This is however not intended to form a comprehensive program as it is bidder's responsibility to draw up and carry out such a program duly approved by the Engineer.

1.30 RECEIPT AND STORAGE CHECKS:

(a) Check and record condition of each package, visible part of the transformer etc. for any damage.
(b) Check and record the gas pressure in the transformer tank as well as in the cylinder.
(c) Visual check for welding of core and coils before filling up with oil and also check condition of core and winding in general.

1.30.1 **INSTALLATION CHECKS:**

Test on oil samples taken from main tank top and bottom and cooling system as per IS:335. Sample should be taken only after the oil has been allowed to settle for 24 hours.

1.30.1.1 Check the whole assembly for tightness, general appearance, etc.
1.30.1.2 Oil leakage tests.
1.30.1.3 The bidder shall warrant that oil furnished is in accordance will the specifications given in this specification.
1.30.1.4 Capacitance and tan delta measurement of bushings before fixing / connecting to the winding. Bidder shall furnish these values for site reference.
1.30.1.5 Sweep Frequency Response Analysis (SFRA) test

1.30.2 **COMMISSIONING CHECKS:**

(a) Check the color of silica gel breather.
(b) Check the oil level in the breather housing conservator tank, cooling system, condenser bushing etc.
(c) Check the bushings for conformity of connection to the line etc.
(d) Check for correct operation of all protections and alarms :

(i) Buchholz relay
(ii) Excessive winding temperature
(iii) Low oil flow
(iv) Excessive oil temperature
(v) Low oil level indication

(e) Check for adequate protection on electronic circuit supplying the accessories.
(f) Insulation Resistance measurement for
(i) Control wiring
(ii) Main winding
(g) Check for cleanliness of the transformer and the surrounding.

1.30.3 **TESTING:**

1.30.3.1 The transformer shall be tested in the presence of GETCO's representative; all tests (routine and type tests) shall be witnesses by him. All the tests shall be performed in compliance of IS:2026-1962 (as amended up to date). **All the instruments, meters,** ***instrument transformers*** **etc., used for testing shall be duly calibrated at NABL laboratory and necessary calibration certificate shall be made available during inspection.** ***The instrument transformers shall have ≤0.2 accuracy class. The measurement of losses shall be carried out with 3 (Three) Watt meter method only through digital power analyzer and CTs, PTs and meters used for these measurements shall be of class of accuracy of 0.2.*** The following tests shall be carried out on the transformer.

1.30.3.1(a) ROUTINE TESTS:
All the tests shall be performed in compliance of IS:2026 (as amended up to date) with dielectric tests corresponding to Method 2 shall be carried out on each transformer:

(a) Resistance of each winding.
(b) Turns ratio for all sets of windings on each tap, with percentage error.
(c) Polarity and phase relation-ship.
(d) Impedance between each pair of winding.
(e) Excitation losses at 90, 100 and 110 % rated voltage measured by the average voltmeter method.
(f) Positive phase sequence impedance measurement on three phase transformers.
(g) Regulation at rated load and unity, 0.9, 0.8 lagging P.F.
(h) Load losses, measured at rated frequency, by applying a primary voltage sufficient to produce rated current in the windings with the secondary windings short-circuited.
(i) Separate source voltage withstand test.
(j) **ACLD test**
(k) Auxiliary losses (fans, pump, etc)
(l) SFRA test ***(at factory and at site)***
(m) Zero Sequence impedance test
(n) Tests on tap-changer (IEC:60214)
(o) Tan delta & capacitance test for bushings and windings
(p) 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** ***IEC 62535***

subjecting oil for 150°C for *72* hrs, as specified in Appendix – A (Revised).

(q) Magnetic Circuit test:
After assembly of each core shall be tested at 2 kV between side plates, structural steel works etc. for 1 Minute

(r) Tank leak test at 5 psi (35 kN/m^2) for 12 hrs with oil & 1 hr with air.

(s) Magnetic Balance & current test on all winding

(t) HV withstand test on auxiliary equipments and wiring

(u) Measurement of Insulation Resistance

(v) Measurement of acoustic noise level

(w) Measurement of harmonics of no load current

(x) Measurement of Partial Discharges of transformer

(y) Vacuum test for tank at 25 bar for 1 hr.

(z) Measurement of no load current with 415 V AC supply on LV side.

(aa) Tests on air cell

(bb) Temperature rise as per cl. 1.30.3.1(b)(i) with DGA at initial, after Temp rise test and at final stage before dispatch.

(cc) Lightning impulse test on all windings

(dd) Water content in transformer measurement test (limit – 0.5% of total insulation weight)

(ee) Measurement of transferred surge in LV due to Lighting impulse on HV

(ff) Tests on Fiber Optic system viz. (i) Calibration (ii) functionality and conformance tests along with test report for Probe dielectric test"

(gg) Calibration of temperature indicators and relays.

(hh) CT testing viz. IR, ratio, polarity, excitation etc.

(ii) OLTC Motor current signature

All the routine/acceptance tests shall be carried out on transformer filled with oil to be supplied and fitted with all accessories to be supplied with transformer.

1.30.3.1(b) **TYPE TEST:**

Following type test reports as specified in IS: 2026 (amended up to date) shall be submitted for the offered type rating of transformer, invariably with the technical bid. Bid without type test reports will not be considered for evaluation. The type test reports shall not be older than FIVE years and shall be valid up to expiry of validity of offer.

i) Temperature rise test

The temperature rise test shall be conducted at a tap for the worst combination of loading ***i.e. Load losses measured at minimum voltage tap and no load losses measured at rated voltage. The thermometers used during test shall be digital having calibrated in NABL lab. Calibration certificate shall not be older than one year.***

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as per IS: 9434 (based on IEC 60567) and results will be

interpreted as per IS: 10593 (based on IEC: 60599). *The temperature rise measurements shall be made with the Fiber Optic Thermometers & conventional OTI/WTI. The FOS shall also be operational during temperature tests and demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified, and temperature data for all probes recorded and reported in the test report. Data obtained from FOS and conventional OTI/WTI shall be compared however, both values should satisfy the commitment.*

ii) Impulse test shall be made on three limbs of transformer. The test sequence shall be with chopped wave.
iii) Vacuum and pressure test
iv) Tests on OLTC

Important note for type tests: The type test report shall be submitted for the offered class and rating of transformer. However, the type test report for higher class/rating can be accepted for scrutiny of technical bid but the same test/s shall have to be carried out on the offered class/rating transformer. Bidder shall invariably confirm to carry out the required type test/s, special tests, before commencement of supply, without affecting delivery schedule, free of cost, at NABL approved laboratory, or at suppliers works in presence of ***NABL &*** GETCO representatives, in the event of order.

1.30.3.1(c) **SPECIAL TESTS:**

Following test reports shall be submitted for the offered type rating of transformer & bought outs, invariably with the technical bid.

i) Zero phase sequence impedance measurement.
ii) Degree of protection (IP55) for control cabinets & RTCC panel, OLTC driving mechanism, terminal boxes of PRV, MOG, Buchholz Relay, pump motors, fans, control cubicles for monitoring and NIFPS, etc. RTCC panel shall have IP 54 degree protection
iii) Short Time Current withstand test on offered HV and LV terminal connectors for 40 kA 3 sec.
iv) Measurement of acoustic noise level
v) Measurement of power taken by all auxiliaries
vi) Measurement of harmonic level in no load current
vii) Measurement of transferred surge in LV due to Lighting impulse on HV & IV
viii) ACLD test

If the above tests are carried out at bidder works then the bidder shall have to repeat these tests again on any one unit without affecting delivery schedule at no extra cost to GETCO. The necessary confirmation shall invariably be submitted with the technical bid otherwise the offer shall be evaluated accordingly.

1.30.3.1(d) **CALCULATIONS:**

i) Thermal and Dynamic ability to withstand terminal short circuits
ii) Cooling calculations for ONAN, ONAF & OFAF.
iii) Calculation of offered losses with respect to offered winding and core materials.

1.30.3.2 Radiator, valves and other parts necessary for complete transformer shall be tested for leaks and strength applying to the complete tank filled with oil by air pressure not less than 0.7 atmospheres for a period of 24 hours or not less than 1.0 atmosphere for a period of 6 hours.

1.30.3 **TESTS ON TRANSFORMERS TANK:**

In addition to the routine tests on welds in the tank, the following type tests shall be carried out on one of the transformer tanks **in presence of GETCO representative.**

1.30.3.1 **VACUUM TEST:**

The transformer tanks without oil shall be subjected to a vacuum of 760 mm. of mercury. The permanent deflection of the flat plates after removal of vacuum shall not exceed the values specified below.

Horizontal length of plate (mm)	Permanent deflection (mm)
Below 760	5
760 to 1270	6
1300 to 1780	8
1800 to 2030	10
2050 to 2280	11
2300 to 2540	13
2560 to 3050	16
3075 and above	19

1.30.3.2 **PRESSURE TEST**

The transformer tank along with radiators conservator and other fittings shall be subject to a pressure corresponding to twice the normal head of oil in the transformer or normal pressure plus 0.36 Kg/sq.cm, whichever is lower. The permanent deflection of flat plates after release of excess pressure shall not exceed the figures specified under vacuum test.

During vacuum and pressure test the Sr. no. of transformer punched on jacking pad since fabrication shall be got verified from inspector and recorded in report.

1.30.3.3 **PRESSURE RELIEF TEST**

Pressure Relief Device with its diaphragm in position shall be subject to an increasing oil pressure. This device shall operate before reaching the pressure specified in the pressure test above. Following routine tests shall be performed on PRD

i) Air pressure test
ii) Liquid pressure test
iii) Contact test
iv) Leakage test
v) Dielectric test

1.30.4 **TEST AT SITE**

After erection at site, the transformer shall be subject to the following test

(i) Insulation resistance test
(iii) Ratio and polarity test
(iii) Dielectric test of oil
(iv) Temperature rise test with maximum possible load.
(v) SFRA test

1.30.5 TYPE TESTS ON BOUGHT OUT ITEMS:

1. Bushing (Type test as per IS:2099/IEC:60137) ***Thermal stability, measurement of PD, PF, switching Impulse voltage withstand test, Thermal short time current withstand test etc.***
2. OLTC (Temp Rise of contact, Short circuit current test, Mechanical test & Dielectric test as per IEC:60214 and IP:55 test on driving mechanism box)
3. Buchholz relay (as per IS:3637) & IP-55 on terminal box
4. Air cell (Flexible air separator) – Oil side coating, Air side under coating, Air side outer coating and coated fabric as per IS:3400/BS:903/IS:7016.
5. Oil pump – vacuum test, oil pressure test at 1 kg/cm2 for 24 hrs., Temperature rise test by resistance method, IP-55 for terminal box.
6. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 for terminal box.
7. MOG & terminal box for IP-55 degree of protection
8. ***Tests on fiber optic system- (i) Full wave negative impulse & Negative switching surge tests as per ASTM D-3426 and (ii)PD as per ASTM D-149 tests on fiber optic cable along with EMC testing : Surge testing 4000V (IEEE C37.90.1-2002) on measuring instrument "***
9. ***For any other item required during detailed engineering.***
10. ***Tests on AVR relay – Electrical, Environmental & Mechanical test as per relevant IEC and compatibility with IEC 61850.***

1.31 TESTS ON OLTC:

1.31.1 The various tests (routine and type) as stipulated in the IEC:60214 (as amended up to-date) ***including vacuum helium and gas leak tests*** shall be carried out.

1.31.2 Type test certificate copies of oscillograms as called for in IEC:60214 (as amended up to-date)shall be furnished by the supplier.

1.32 TEST REPORTS:

1.32.1 On completion of all the tests have been completed 3 copies of each test report shall be furnished to the GETCO for his approval prior to the dispatch of equipment. ***Soft copy of test reports for tests results obtained from software shall be submitted for approval and record.***

1.32.2 All the reports of inspections like stage, acceptance, routine & type tests carried out on each transformer including test certificates for bought out items, in bound volume, shall be submitted before dispatch. Also one copy shall be sent along with transformer.

1.33 FURTHER TESTS: