



TECHNICAL SPECIFICATION

FOR

500 MVA, 400/220/33 KV ICT

TECHNICAL SPECIFICATION

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TECHNICAL ANNEXURES

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- I. Quantity and Delivery Schedule.
- II. Maximum Flux Density and Core Weight calculation.
- III. Details of Loss Calculations.
- IV. Guaranteed Technical Particulars.
- V. Additional Schedule of Informations.
- VI. Check list towards Type Test Reports.
- VII. Calibration Status of Testing Instruments/Meters.
- VIII. Check list for Delivery Schedule.
- IX. Abstract of Terms & Conditions (Technical).

- N. B. : 1. Annexure-II to IX are to be filled up in complete shape by the bidders, failing which their tenders are liable for rejection.***
- 2. No approximate value is allowed in respect of any of the parameters, as asked in the above Annexures. The bidders may quote the firm values with tolerances, if asked in respective parameters.***

SECTION - IV.

TECHNICAL SPECIFICATION

1.0 SCOPE:-

- 1.1 This Specification provides for design, engineering, manufacture, assembly, stage inspection, final inspection and testing before dispatch, packing and delivery at destination Sub-station by road transport, **unloading on plinth at site and supervision of erection, testing and commissioning** of 500MVA, 400/220/33KV ICT(Inter Connecting Transformer), complete with all fittings, accessories, associated equipments and spares, required for its satisfactory operation in any of the sub-stations of the State of Odisha.
- 1.2 The scope of supply includes the provision of training for Purchaser's personnel(Limiting to 10 Persons for minimum of 05 days duration) in regard to design, manufacture, assembly, testing, operation and maintenance of offered transformer at his works in the event of order, free of cost to OPTCL.
- 1.3 The transformers shall conform in all respects to high standards of engineering, design, workmanship and the latest revisions of relevant standards at the time of offer and Purchaser shall have the power to reject any work or material which, in his judgment, is not in full accordance therewith. The transformer(s), offered shall be complete with all components, necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of supply, irrespective of whether those are specifically brought out in this Specification and/or the commercial order or not.
- 1.4 This specification also covers following provisions for the transformer,
- a) Dehydrating Breather(s) as per clause no.5.4.1.7 (l)
 - b) Optic fiber temperature sensor as per clause no. 5.4.11 (k)
 - c) Digital RTCC panel as per clause no.5.4.14 (B)
 - d) RIP Bushing as per Cl. No -5.4.15.2
 - e) Oil storage tank as per clause no. 5.4.26
 - f) Oil sampling bottles as per clause no. 5.4.27
 - g) Nitrogen Injection system for protection against Fire & Explosion as per clause no.5.4.28
 - h) On line insulating oil drying system as per clause no. 5.4.29
 - i) On line Dissolved Gas (Multi-gas) and Moisture Analyser as per clause no. 5.4.30
- 1.5 The transformer(s), to be supplied against this specification shall be suitable for satisfactory continuous operation under the following Topographical and Meteorological conditions:-
- | | | |
|----|---|-------|
| a) | Maximum ambient air temperature (°C) - | 50 |
| b) | Minimum ambient air temperature (°C)- | 0 |
| c) | Average daily ambient air temperature (°C)- | 32 |
| d) | Relative humidity (%) - | 100 |
| e) | Average rainfall per annum (cm)- | 150 |
| f) | Maximum altitude above mean Sea level (m)- | 1000 |
| g) | Maximum wind pressure (Kg/m ²)- | 80.84 |
| h) | Isoceraunic level (days/year)- | 70 |
| i) | Seismic withstand factor(g) | 0.3 |
| j) | Wind Velocity-(Wind Zone to IS875) (m/sec) | 50 |

- | | | |
|----|---------------------------------|-----------------|
| k) | Pollution level to IEC815 | Heavy |
| l) | Air-borne contamination, if any | Highly Polluted |

1.6 Transportation

- (i) The supplier shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the transformer. The dimensions of the transformer shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the supplier to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer’s work to OPTCL’s site.
- (ii) The supplier shall carry out the route survey along with the transporter and finalize the detail methodology for transportation of the transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.
- (iii) The main tank of the transformer shall be transported on Hydraulic trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer’s works to the designated site. The supplier shall intimate to Employer about the details of transporter engaged for transportation of the transformer. The requisite details for tracking the transformer during transit shall be provided to Employer. Requirement of Hydraulic trailer is envisaged for the transformer.
- (iv) All metal blanking plates and covers, which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawings/documents.

For details of Transportation, Packing & Forwarding, please refer clause no. 12 of Technical Specification.

2.0 STANDARDS:-

- 2.1 All transformers and associated equipment and accessories shall, except where modified by this Specification, be designed, manufactured and tested in accordance with the latest editions of the relevant International (IEC), Indian (IS) and British (BS) standards. In case of conflict, the order of precedence shall be (1) IEC, (2) IS, (3) Other. Reference to particular standard or recommendation in this Specification does not relieve the Supplier of the necessity of providing goods and services, complying with other relevant standards or recommendations.
- The list of standards, provided in this Specification is not to be considered exhaustive and the supplier shall ensure that equipment supplied under this contract meet the requirements of the relevant standard whether or not it is mentioned here.

IEC	IS	BS/other	Title
60076	2026	171	Auto Transformers

P-1-2011				
P-2-2010				
P-3-2009				
P-4-2001				
-	-	6056		Methods of measurement of transformer and Reactor sound levels
-	-	4360		Weldable structural steel
-	-	61		Threads for light gauge copper tube and fittings
-	-	3600		Steel pipes and tubes for pressure purpose
-	-	4504		Flanges for pipes, valves and fittings
529	13947	EN60529		Enclosures for electrical apparatus (App.C-13947)
214	-	4571		On load tap changers
60137(1995)	2099	223		Bushings for alternating voltages above 1000V
-	3347	-		Dimensions for porcelain transformer bushing for use in lightly polluted atmospheres
223	-	4963		Tests on hollow insulators
60354(1991)	6600	BSCP-0160		Loading guide for transformers
606	-	-		Application guide for power transformers
60296(Amd1-1986)	335	BS-14		Specification for unused mineral insulating oil for Transformers and reactors
34	325	-		Three phase Induction Motors
185	2705	-		Current Transformers
518	-	-		Dimensional standardization of terminals for HV Equipment
616	5578 (11353)	-		Terminal and tapping markings for Power Transformers
-	1886	-		Code of practice for installation and maintenance of Transformers
-	3639	-		Fittings and accessories for power transformers
-	3637	-		Gas operated relays
-	6272	-		Industrial cooling fans
-	4691	-		Degrees of protection provided by enclosures for rotating electrical machines
186	3156			Specification for voltage transformers
617	-	-		Graphical Symbols for drawings
-	2629	729		Galvanising
-	2633	-		Methods of testing uniformity for zinc coated articles
-	5	-		Colours for ready mixed paints and enamels
-	2147	-		Degree of protection provided by enclosures for Low voltage switchgears and control gears
-	3401/1992	-		Silicagel
-	9434	-		Guide for sampling and analysis of dissolved gas in oil filled equipment.
-	12676	-		Oil impregnated paper insulated Bushing

60071, P-1-1993	-	-	Dimension and requirements.
P-2-1996			Insulation Co-ordination
-	375	-	Markings & Arrangements for switchgear Bus bars, Main connections and Auxiliary wiring
-	3638/1996	-	Application Guide for Gas operated Relays.
60214(1989)	8468	-	On-load Tap-changer.
-	8269	-	Methods for switching Impulse Test on High Voltage Insulators.
-	10028/1981	-	Installation of Transformers.
	(Part-2)		
-	10028/1981	-	Maintenance of Transformers.
	(Part-3)		
-	10561/1983	-	Application Guide of Power Transformers.
60542,			
Amd 1-1988	8468/1997	-	Application Guide for On-load Tap-changer.
-	8263	-	Method for Radio Interference Tests on High Voltage Insulators.
-	3202	-	Code of practice for climate proofing of Electrical Equipment.
-	6702/1972	-	Method for determination of Electric strength of Insulating Oils.
-	6103/1971	-	Method of Test for specific Resistance of Elect. Insulating Liquids.
-	6262/1971	-	Method of Test for power factor and Dielectric Constant of Electrical Insulating Liquids.
-	6104/1971	-	Method of Test for Interfacial Tension of oil against water by the Ring Method.
60034,			
P1-22(1972-2000)	-	-	Rotating Electrical Machines.
60044,	-	-	Instrument Transformers.
Amd P1-2000,			
P-6-1992			
60060,	-	-	High Voltage Test Techniques.
P-1-1989,			
Amd P-2-1996			
60085 (1994)	-	-	Thermal Evaluation and classification of Elect. Insulation.
60270 (1981)	-	-	Partial Discharge Measurements.
60404-8-7 (1998)	-	-	Specification for Individual Materials-Cold Rolled Grain oriented Electrical Steel sheet and strip delivered in fully processed state
60529 (Amd 1-1999)	-	-	Degree of protection, provided by enclosures (IP-Code)
60551(Amd 1-1995)	-	-	Determination of Transformer and Reactor Sound Levels.
60567(1992) -	-	-	Guide for sampling Gases and oil from oil- filled Electrical equipment for the analysis of

			free and Dissolved Gases
60599(1999)	-	-	Mineral Oil-Impregnated Electrical Equipment in service-Guide to the Interpretation of Dissolved and Free Gases Analysis.
60722 (1982)	-	-	Guide to the Lightning and Switching Impulse Testing of Power Transformers and Reactors.
60815 (1986)	-	-	Guide for selection of Insulators in respect of polluted conditions.
60947, P-1-7 (1984-2000)	-	-	Low voltage switchgear & control gear.
	-	IEEE C 57.93 1995	IEEE Guides for Installation of Liquid Immersed Power Transformers.
-	-	IEEE Std 80	Guide for safety and AC Sub-station Grounding.
-	-	IEEE Std 979	Guide for Sub-station Fire protection.
-	-	IEEE Std 980	Guide for containment and control of oil spills in Sub-stations.
-	-	CBIP Pub.295/ 2006	Manual on Transformers.
-	-	NFPA	National Fire Protection Association.
-	-	NEMA-- Standard No.1.	
-	-	Indian Electricity Rules-1956.	

2.2 The standards, mentioned above are available from:

Standard:	Name and Address:
IS	Bureau of Indian Standards, Manak Bhawan, 9-Bahadur Sahah Zafar Marg, New Delhi - 110001, India.
IEC	International Electro Technical Commission, Bureau Central dela Commission, Electro Technique International, 1-Ruede Verembe, Geneva, SWITZERLAND.

2.3 Transformer meeting with requirements of other authoritative International Standards that ensure equal or better performance than the standards, mentioned above shall also be considered. When the transformer, offered by the supplier conforms to other standards, salient points of difference between standards adopted and the standards, specified in this specification shall be clearly brought out in the offer. Two copies of such standards with authentic translation in English shall be furnished along-with the offer.

3.0 AUXILIARY POWER SUPPLY:-

Auxiliary electrical equipment shall be suitable for operation on the following supply system.

- (a) Power devices like drive motors of Rating 1KW and above. 415V, 3Phase, 4 Wire, 50 Hz, neutral Grounded AC supply.

- | | | |
|-----|--|---|
| (b) | Lighting, space heaters and KW Meters. | 240V, single phase, 50Hz, neutral Grounded AC supply. |
| (c) | Alarm control and protective Devices. | 220V, DC, 2 Wire. |

Each of the foregoing supplies shall be made available by the purchaser at the terminal point for each transformer for operation of accessories and auxiliary equipment. Supplier's scope includes supply of interconnecting cables, terminal boxes etc. The above supply voltage may vary as below and all devices shall be suitable for continuous operation over entire range of voltages.

- | | | |
|------|--------------|---|
| (i) | AC Supply: - | Voltage $\pm 10\%$
Frequency $\pm 3\%$ |
| (ii) | DC Supply: - | - 15% to + 10% |

4.0 PRINCIPAL PARAMETERS:-
For 500 MVA, 400/220/33 KV ICT

The transformer shall conform to the following specific parameters:-

Sl. No.	Item.	Specification.
1	Type of Power Transformer/Installation.	3 Phase Core type, Auto Inter-connecting transformer suitable for outdoor installation and suitable for bi-directional flow of power
2	Type of Mounting.	On wheels, mounted on rails.
3	Suitable for rated system frequency.	50 Hz ($\pm 3\%$).
4	(a) Maximum system voltage ratio (HV/IV/LV)	420 KV/245 KV/36KV.
	(b) Nominal voltage Ratio (HV/IV/LV)	400KV/220KV/33 KV.
5	No. of Phases.	3 (Three)
6	No. of Windings.	Auto Inter-connecting transformer with tertiary.
7	Type of Cooling.	ONAN/ONAF/ (OFAF or ODAF)

NOTE: - ONAN- Oil Natural Air Natural.
ONAF - Oil Natural Air Forced.
OFAF - Oil Forced Air Forced.
ODAF- Oil Directed Air Forced

8	MVA Rating corresponding to cooling system.	<u>500MVA</u>
	(a) ONAN cooling.	60% - 300 MVA
	(b) ONAF cooling.	80% - 400 MVA
	(c) OFAF / ODAF cooling.	100% - 500 MVA
9	Method of connection.	HV - Star IV - Star LV - Delta.
10	Connection symbol.	Ynao (d11).
11	System Earthing.	Effectively solidly earthed.
12	% Impedance at 75°C	<u>Constant Ohmic impedance Type</u>
	(a) HV - IV	Principal Tap: 12.5 % + 10% (No negative tolerance is allowed)
	(b) HV - LV	Principal Tap:60%(Min.)

	(c) IV - LV	(No negative tolerance is allowed) Principal Tap:45%(Min.) (No negative tolerance is allowed)								
	NOTE: - No reactor either inside or outside the tank shall be used to achieve above % Imp. Value.									
13	Intended regular cyclic overloading of windings. (a) HV and IV (b) Tertiary.	IEC 76-1, Clause 4.2 Suitable for no load operation as well as for loading to its rated capacity with Capacitive or inductive loading or Combination of both(<i>One-third of rated capacity HV winding</i>)								
14	a) Anticipated unbalanced loading. b) Anticipated Continuous loading of windings	< 10% 110% of rated current								
15	Tap changing gear: - (i) Type. (ii) Provided on. (iii) Tap range. (iv) Tap step. (v) Automatic control required? (vi) Remote control panel required? (vii) DC supply. (viii) Supervisory control provision required? (ix) Marshalling kiosk required? (x) No. of Transformers in parallel for which auto control to be suitable. (xi) Rated Current (xii) Rated short circuit current	In Tank, Hi-speed Resistor Type On load. HV end to vary HV (400KV) - 10% to + 10%. 1.25%. Yes. Yes. As per Specification. Yes. Yes. 4 (Maximum). 1200A (min.) 12KA(rms)(min.)								
16	Over voltage operating capability and duration.	125% rated voltage for 60 seconds. 140% rated voltage for 5 seconds. 110% rated voltage continuous								
17	Minimum Air core reactance of HV winding.	20%								
18	Minimum knee point voltage (This will be determined during no load test method that 10% increase in voltage from 110% rated voltage causes the excitation current to increase not by more than 50%).	At 110% of rated voltage.								
19	Maximum Flux Density in any part of the core and yoke at rated MVA, rated voltage [400KV/220KV/33 KV] and rated frequency [50 HZ] [In Tesla]. (The maximum flux density is to be adopted in such a manner that the minimum knee point voltage of 110% as per clause no. 5.4.8 (n) is to be achieved without any deviation)	1.5								
20	Insulation levels:- For windings:- (a) 1.2/50 microsecond wave Shape Lightning Impulse Withstand Voltage(KVP).	<table border="0"> <tr> <td><u>HV</u></td> <td><u>IV</u></td> <td><u>LV</u></td> <td><u>NEUTRAL</u></td> </tr> <tr> <td>1300</td> <td>1050</td> <td>250</td> <td>95</td> </tr> </table>	<u>HV</u>	<u>IV</u>	<u>LV</u>	<u>NEUTRAL</u>	1300	1050	250	95
<u>HV</u>	<u>IV</u>	<u>LV</u>	<u>NEUTRAL</u>							
1300	1050	250	95							

	(b) Switching Impulse Withstand Voltage (KVP).	1050	-	-	-
	(c) Power frequency voltage withstand (KV-rms).	570	460	95	38
21	Type of winding insulation:- (a) HV/IV winding. (b) LV winding.	Graded. Full.			
22	Withstand time for three phase short circuit at Terminals.	5 seconds.			
23	Partial discharge	As per relevant up-to-date IEC			
24	Noise level at rated voltage and frequency.	As per latest NEMA Std. Tr-1.			
25	Permissible Temperature Rise over ambient Temperature. (Both for ONAN, ONAF & OFAF/ODAF Ratings)				
	(i) Of top oil measured by thermometer & Optic Fiber Temperature Sensor	40° C (MAX.)			
	(ii) Of winding measured by resistance Method	45° C (MAX.)			
	(iii) Of winding hot spot temperature rise measured by Optic Fiber Temperature Sensors	54° C (MAX.)			
	(iv) Reference ambient temperature	50° C [MAX.]			
26	Minimum clearances in air (mm):-	Phase to phase.		Phase to ground	
	(a) HV	4000		3500	
	(b) IV	2700		2400	
	(c) LV	1000		650	
27	Terminals.				
	(a) HV winding line end.	420 KV RIP condenser bushing			
	(b) IV winding line end	245 KV RIP condenser bushing			
	(c) HV/IV winding neutral end.	52 KV RIP condenser bushing			
	(d) LV winding.	- Do -			
28 (A)	Current rating Of Bushing	1. 420 KV - 1250 Amp. 2. 245 KV - 2000 Amp. 3. 52 KV - 3150 Amp.			
	(B) The cantilever strength of bushing for 420KV, 245 KV & 52KV - As per relevant IS/IEC.				
29	Maximum Radio Interference Voltage level at 1 MHZ & 1.1 times max. Rms phase to ground Voltage for HV winding.	500 micro volts.			
30	Minimum visual corona extinction voltage (KV- rms).	320 for 420KV 176 for 245 KV class. 105 for 145 KV class.			
31	(a) Number of cooler banks required per Transformer.	Minimum of two.			
	(b) Rating of each bank as % of total loss.	Not greater than 50%.			
	(c) No. of Pumps.	One 100% pump and 100% stand - by Pump in each bank.			
	(d) No. of Fans.	Adequate numbers of fans with one			

		No. stand-by fan in each bank.			
		<u>HV</u>	<u>IV</u>	<u>LV</u>	<u>NEUTRAL</u>
32	Insulation level of bushing.				
	(a) Lightning Impulse withstand (KVP)	1425	1050	305	305
	(b) Switching Impulse Withstand Voltage (KVP).	1050	850	-	-
	(b) 1 Minute Power Frequency withstand Voltage (KV - rms).	695	505	105	105
	(c) Creepage distance (mm). (min.)	10500	6125	1300	1300
	(d) Maximum Tan Delta for bushings at ambient Temp.	< 0.004			
	(Tan delta shall be measured at ambient temperature. No temperature correction factor shall be applied)				
33	Material of HV, IV & LV Conductor.	Copper.			
34	Accommodation on tank for outdoor Neutral C.Ts.	There shall be provision on the main Tank of the Transformer for installation of Outdoor NCT and the required clearances for the same are to be maintained as per this Specification.			
35	(a) Bushing current transformer (for Metering & Restricted E/F protection).				
	(i) Type.	Single phase, ring type, turret mounted.			
	(ii) Current Ratio (A/A).		<u>IV</u>	<u>Neutral</u>	
		<u>HV</u>			
		Core-I 1600/1A	1600/1A	1600/1A	1600/1A
		Core-II 1000/1A	1600/1A	-	-
	(iii) Minimum Knee Point voltage (V). Or Burden and Accuracy class.	Core-I 1600V,TPS	1600V,TPS	1600V,TPS	1600V,TPS
		Core-II 0.2 class 30VA, ISF _≤ 5	0.2 class 30VA, ISF _≤ 5		
	(iv) Secondary resistance (Ohms.)	Core-I 4Ω	4Ω	4Ω	4Ω
		Core-II -	-	-	-
	(v) Maximum Excitation current at minimum Knee Point Voltage	25 mA	25 mA	25 mA	25 mA
	(vi) No. of cores.	Two (identical)			
	(vii) Application.	Core-I REF	REF	REF	REF
		Core-II Metering	Metering	-	-
	(b) Neutral C.T. (To be provided by the bidder):				
	(i) Type.	Separate ring type outdoor mounted			
	(ii) Quantity.	One number.			
	(iii) Voltage class.	52 KV.			
	(iv) No. of cores.	Two (identical).			
	(v) Current ratio (A/A).	1600/1A			
	(vi) Turn ratio.	Identical to turns ratio, provided on HV and IV side.			
	(vii) Knee point voltage.	1600 volts.			
	(viii) Class of Accuracy.	TPS			
	(ix) Maximum secondary winding resistance (Ohms).	4Ω at 75°C.			
	(x) Maximum Excitation current at minimum	25 mA			

Knee Point Voltage
 (xi) Location for mounting. Bracket mounted on tank (with neutral lead for connection for Neutral Bushing to NCT).

NOTE: Any change in the parameters of CT required at the time of detailed engineering will have to be incorporated without any extra cost.

- | | | |
|-----|--|---|
| 36 | (a) Maximum current density for HV, IV & LV Windings at rated load. | 2.8 A/ mm ² |
| | (b) Maximum Tan Delta for winding at ambient Temp. (Tan delta shall be measured at ambient temperature. No temperature correction factor shall be applied) | < 0.005 |
| 37 | Type of oil preservation. | Air cell type. |
| 38 | (i) Minimum Insulation resistance at an ambient Temperature of 30 deg. C with 5KV Megger for 60 seconds duration. | HV-IV /E & LV/E-3000 M-ohms
HV-IV /LV-4000 M-ohms |
| | (ii) Polarization index i.e. ratio of Megger values at 600 sec. to 60 sec. for H.V. to Earth, L.V. to Earth and H.V to L.V | Shall be greater than or equal to 2, as per Cl.No-7.2.13.4 IEEE Standard C57.152-2013 |
| 39. | Zero Sequence Impedance | Shall be 80% or more of the positive Sequence value |
| 40. | Core Assembly | BOLTLESS TYPE |
| 41. | No. of pressure relief devices to be provided. | Adequate Nos. |

5.0 GENERAL TECHNICAL REQUIREMENTS: -

5.1 Duty Requirements.

5.1.1 The transformer will be used for bi-directional flow of rated power.

5.1.2 The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 5 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

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

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e. $Z_s = 0$).

5.1.3 The transformer shall be capable of being loaded in accordance with IS: 6600 upto loads of 150 %. There shall be no limitation imposed by bushings, tap changer etc.

5.1.4 The transformer shall be capable of being operated without danger on any tapping at the rated KVA with voltage variation of $\pm 10\%$ corresponding to the voltage of that tapping.

5.1.5 Radio interference and Noise level:

- (i) The transformers shall be designed with particular attention to suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuits.
- (ii) The noise level, when energized at normal voltage and frequency with fans and

pumps running shall not exceed, when measured under standard conditions, the values, specified in NEMA, TR-1.

The transformer noise levels shall be measured as a routine test and in accordance with IEC-60551:1981.

- 5.1.6 Transformer shall be capable of operating under the natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by preset contacts of winding temperature indicator and initially as ONAF up to specified load and then as OFAF / ODAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 degree centigrade. Also stopping of one or two cooling fans should not have any effect on the cooling system. Transformers fitted with two coolers each capable of dissipating 50 percent of the loss at continuous maximum rating shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers, associated with one cooler, without the calculated winding hot spot temperature exceeding 115 degree centigrade at continuous maximum rating.
- 5.1.7 The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. The manufacturer shall ensure that there is no electrostatic charging tendency in the design. In general, oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers.
- 5.1.8 Transformer shall accept, without injurious heating, combined voltage and frequency fluctuation, which produces the following over fluxing condition:
- i) 125% for 1 minute The base voltage and frequency refer to those mentioned in Clause 4.0 (3& 4).
 - 140% for 5 seconds.
 - ii) Over fluxing withstand characteristics up to 170% shall be submitted along with the bid.
- 5.1.9 The tenderers shall recommend if any Surge Arresters and surge capacitors are required to be connected to tertiary terminals to protect the tertiary winding against transfer surges during fault and its transient conditions when the tertiary winding is unloaded. If so, full specifications of above equipment and the manner in which the same are required to be connected shall be given in the tender.
- 5.1.10 In case, no surge protection devices are required, tenderer should comment, is solid Earthing of one terminal of unloaded tertiary winding would be in order. The arrangement of earthing of terminals of unloaded tertiary winding is to be shown.
- 5.1.11 Autotransformers shall be capable of withstanding the stresses that would develop because of inductive or capacitive loading on tertiary winding. The transformer shall be designed to withstand a DC current of 10A per phase without injurious heating, noise and vibration.
- 5.1.12 Tertiary Windings:**
- i) The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching. All the windings shall be capable of withstanding these stresses that may be caused by such switching.
 - ii) The tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.
 - iii) The tertiary winding shall be suitable for connection to Transformer for auxiliary supply.
 - iv) The rated capacity of tertiary winding is 167 MVA reactive and 5 MVA active.

5.1.13 Dynamic Short Circuit Test Requirement:- Bidder / manufacture should have successfully carried out Dynamic Short Circuit Test on 3-Phase 315 MVA, 400/220/33 KV Auto Transformer or Higher capacity Transformer(both MVA and Voltage rating) as on date of opening of techno-commercial bid and shall enclose the relevant test report/certificate along with the bid.

In case the bidder has not successfully tested Dynamic Short Circuit Test on 3-Phase 315 MVA, 400/220/33 KV Auto Transformer or Higher capacity Transformer (both MVA and Voltage rating) as on date of opening of techno-commercial bid, then they shall conduct the same successfully & submit the report before opening of price bid[Undertaking to be submitted by the bidder as per the format at **Annexure-XVIII, Section-III**]

5.2.0 TRANSFORMER LOSSES:-

5.2.1 The bidder shall indicate values of No load losses (iron losses), load losses (copper losses) and auxiliary losses in his bid, which shall be firm.

5.2.2 **Loss figure for evaluation of bid:-**

For total cost evaluation for comparison, capitalized cost of losses shall be calculated at the following rates per one-kilo watt of loss:

- | | |
|---------------------------|--------------------------|
| i) No load losses- | Rs 2,66,016.00/KW |
| ii) Load (Copper) losses- | Rs1,59,610.00/KW |
| iii) Auxiliary losses- | Rs1,59,610.00/KW |

For fraction of a KW, capitalized cost of losses should be calculated on pro-rata basis.

The lowest figure of loss for the transformer, quoted by any Bidder shall be taken as basis and that quoted by the particular Bidder shall be used to arrive at the differential bid price to be applied for the bid. The transformer losses, guaranteed in the bid are to be supported by design calculations along with documentary evidences.

5.2.3 **Liquidated damage for excessive losses:-**

On testing, if it is found that actual losses are more than the values, quoted in the bid, undisputed liquidated damages shall be recovered from the supplier at the following rates: -

- | | |
|---|--------------------------|
| (i) For each KW of excess in 'No Load losses... | Rs.5,32,032.00/KW |
| (ii) For each KW of excess in 'Load losses'
and "auxiliary losses" | Rs.3,19,220.00/KW |

For fractional Kilowatt, penalties shall be applied on prorata basis. No bonus shall be payable for losses, which are less than those, stated in the Bid.

The purchaser reserves the right to reject the transformer, if on testing, the losses exceed the declared losses beyond tolerance limits as per I.S. or the temperature rise in oil and/or winding exceed the values, specified in technical particulars or impedance value differs from the guaranteed value including tolerance as per this specification and if any of the test results do not match with the values, given in the guaranteed technical particulars and as per technical specification. The purchaser reserves the right to retain the rejected transformer and take it into service until the supplier replaces it, at no extra cost to the purchaser by a new transformer. Alternatively, the supplier shall repair or replace the transformer in a reasonable period, as decided by the purchaser to purchaser's satisfaction at no extra cost to the purchaser.

5.2.4 In case of failure of the transformer, the supplier shall take back the faulty transformer from its plinth for repair at their own cost (or replace the transformer with a new transformer) and deliver, at their own cost, unload at the destination sub-station

transformer plinth within three months period from the date of intimation of defects to the satisfaction of the owner, at free of cost. If the delivery after repair/replacement will not be completed within three months, then the supplier shall pay penalty @ 0.5% of the contract price for each calendar week of delay from the end of three months period from the date of intimation of defects. Also, the Purchaser reserves the right for forfeiture of the total Composite Bank Guarantee and all the Securities, available with OPTCL, in case the Supplier fails to pay the penalty by one month before the expiry of the guarantee period. Also, this will be taken as adverse in all future tenders.

5.3 **CLEARANCE :-**

The overall dimensions of the transformer shall allow for sufficient clearances for installation in a 420/245/145 KV switchyard with bay width of 27000/18000/10500 mm and beam height of 22/15/11 m.

5.4 **CONSTRUCTIONAL DETAILS:**

The features and constructional details of Auto transformer shall be in accordance with the requirements, stated hereunder:-

5.4.1 **TANK AND TANK ACCESSORIES:**

5.4.1.1 **TANK :-**

- (a) The transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage.
The construction shall employ weldable, low carbon, tested quality structural steel of an approved grade to BS: 4360 / IS: 2062. The transformer tank shall have rectangular shape. The minimum thickness of side, base and tank cover shall be 16mm, 20mm and 20mm respectively.
- (b) The tank of the transformer shall be complete with all accessories and shall be designed so as to allow complete transformer in the tank and filled with oil, to be lifted by crane or jacks, transported by road or rail without over-straining any joint and without causing subsequent leakage of oil.
- (c) All seams and those joints, not required to be opened at site shall be factory-welded and wherever possible they shall be double welded. After completion of tank construction and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. Also radiographic tests shall be carried out on 5% of total weld length. The requirement of post-weld heat treatment for tank/stress relieving parts shall be based on recommendations of BS: 5500, Table 4.4.3.1 / IS: 10801. Welding shall conform to BS-5135 / IS-9595.
- (d) All necessary precautions shall be taken to prevent ingress of moisture between flange plates, around gaskets and O-rings, at insulator/flange interfaces etc. due to high humidity.
- (e) Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.
- (f) The tank shall be of proven design either bell type with bolted/welded joint or conventional type with welded/bolted cover. Bell type tank construction shall be provided with the joint at about 500 mm. above the bottom of the tank. In case the joint is welded, it shall be provided with flanges, suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.
- (g) The main tank body excluding tap-changing compartments, radiators and coolers shall

be capable of withstanding vacuums i.e. 100.64 KN/m² of gauge pressure, 760 mm of Hg.

- (h) The tank shall be designed to withstand:-
 - (i) Mechanical shocks during transportation.
 - (ii) Vacuum filling of oil.
 - (iii) Continuous internal pressure of 35 KN/m² over normal hydrostatic pressure of oil.
 - (iv) Short circuit forces.
- (l) Wherever possible, the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have minimum inside diameter of 15 mm except for short branch pipes, which may be 6 mm minimum inside diameter.
- (j) All joints other than those, which may have to be broken, shall be welded, when required, they shall be double-welded. All bolted joints to the tank shall be fitted with suitable oil-tight gaskets, which shall give a satisfactory service under the operating conditions and guaranteed temperature-rise conditions. Special attention shall be given to the methods of making hot oil tight joints between the tank and the cover as also between the cover and the bushing and all other outlets to ensure that the joints can be remade satisfactorily at site and with ease with the help of semi-skilled labour. If gasket is compressible, metallic stops shall be provided to prevent over compression.
- (k) Adequate space shall be provided at the bottom of the tank for collection of sediments.
- (l) The base of each tank shall be so designed that it shall be possible to move the complete unit by skidding in any direction without injury when using plates or rails.
- (m) Tank shields shall be such that no magnetic fields shall exist outside the tank. They shall be of magnetically permeable material. If required, impermeable shields shall be provided at the coil ends. Tank shield shall not resonate when excited at the natural frequency of the equipment. Bidder may confirm use of tank shields in the schedule of additional information.
- (n) Suitable guides shall be provided in the tank for positioning the core and coil assembly.
- (o) The tank shall be designed such that it can be mounted on the plinth directly.
- (p) When the transformers are provided with separately mounted radiators, flexible joints shall be provided in the main oil pipes, connecting the transformer tank to the radiator banks to reduce vibration and facilitate erection and dismantling.
- (q) The transformer tank, fittings, radiators and all accessories shall be designed to withstand seismic acceleration, as specified.
- (r) All connections, bolted to the tank shall be fitted with suitable gas oil resistant gaskets, made of such a material that no serious deterioration occurs under service conditions. Gaskets of nitrile rubber or equivalent shall be used to ensure perfect oil tightness. All gaskets shall be of closed design (without open ends) and shall be of one piece only. Rubber gaskets, used for flange connections of the various oil compartments shall be laid in grooves or in groove-equivalent retainers on both sides of the gaskets throughout their total length. Care shall be taken to secure uniformly distributed mechanical pressure over the gaskets and retainers throughout the total length. Gaskets of neoprene and/or any kind of impregnated/ bonded cork or cork only which can easily be damaged by over-pressing are not acceptable. Use of hemp as gasket material is also not acceptable.
The properties of the gaskets / O-ring shall comply with the requirements of IS-11149. The gaskets to be used shall not be older than one year. Gaskets / O-rings shall be replaced every time whenever the joints are opened.

- (s) **Tank hotspot**- under extreme conditions, the maximum temperature on any metal part shall not exceed 130°C.

5.4.1.2 **LIFTING AND HAULAGE FACILITIES:-**

Tank shall be provided with:

- (a) Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.
- (b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks.
- (c) Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.
- (d) Suitable haulage holes shall be provided.
- (e) Provision of 04 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during detailed engineering.
- (f) Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

5.4.1.3 **FOUNDATIONS, CABLE DUCTING ETC.:-**

The Supplier will have to liaise with the Purchaser or its authorised contractor immediately after Design approval to finalize the detailed design of the following:-

- Transformer main tank foundations.
- Cooler bank foundations.
- Marshalling kiosk/control cabinet location and foundation.
- Cable ducting requirements.
- Adequate bunding design for the complete containment of all oil spills.
- Any other civil/electrical requirements for the installation of the transformer.

5.4.1.4 **TANK COVER:**

- (a) The tank cover shall be of adequate strength, shall not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. At least two adequately sized inspection openings, one at each end of the tank shall be provided for easy access to the internal connections of bushings, winding connections and earthing links. The inspection covers shall not weigh more than 25 Kg. The inspection cover shall be provided with lifting handles.
- (b) The tank and cover shall be designed in such a manner so as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting. The design of the tank cover should not present a safety hazard to personnel working on top of the unit.
- (c) It must be possible to remove any bushing without removing the tank cover.
- (d) One pocket shall be provided for stem type thermometer in addition to those for the Bulbs of the oil temperature and winding temperature indicators. These pockets shall be located in the position of the maximum oil temperature and it must be possible to remove any bulb without lowering the oil level in the tank. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.
- (e) Bushings, turrets, covers of inspection opening, thermometer pockets etc. shall be

designed to prevent ingress of water into or leakage of oil from the tank.

- (f) All bolted connections shall be fitted with weather proof, hot oil resistant gasket in between for complete oil tightness. If gasket is compressible, metallic stops shall be provided to prevent over-compression.
- (g) The top part of the tank cover shall be sloped to prevent retention of rain water and shall not distort when lifted.
- (h) The tank cover and all covers for mounting, cleaning, man-holes, hand holes and inspection openings on tank etc. shall be earthed by suitable grounding conductors of the flexible type, having a cross-section of minimum 95 mm². Appropriate earthing studs with bolts and washers, made of stainless steel shall be provided.
- (i) **Currents flowing in tank cover and bushing turrets** - To allow for the effect of possible induced and capacitive surge current, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

5.4.1.5 **AXLES AND WHEELS:**

- (a) The transformer shall be designed with flanged bi-directional wheels and axles of a suitable size to carry the full weight of the transformer, oil and accessories. These shall be so designed as not to deflect excessively to interfere with the movement of the transformer. Wheels, axles and bearings shall be fully corrosion - resistant and complete with fittings to facilitate lubrication.
- (b) Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of the transformer.
- (c) The wheels are required to swivel and they shall be arranged so that they can be turned through an angle of 90 degrees when the tank is jacked up to clear of rails. Means shall be provided for locking the swivel movements in positions parallel to and at right angles to the longitudinal axis of the tank.
- (d) The rail track gauge shall be 5'6" (1676 mm) along longer axis as well as along shorter axis.
- (e) Foundation layout details will be furnished by the supplier during detailed Engineering.

5.4.1.6. **ANTI-EARTHQUAKE CLAMPING DEVICE :-**

To prevent transformer movement during earthquake, clamping device shall be provided for fixing the transformer to the foundation. The Bidder shall supply necessary bolts for embedding in the concrete foundation. The arrangements shall be such that the transformer can be fixed to or unfastened from these bolts, as desired. The fixing of the transformer to the foundation shall be designed to withstand seismic events to the extent that a static co-efficient of 0.3g. applied in the direction of least resistance to that loading, will not cause the transformer or clamping devices as well as bolts to be over-stressed. Special steps must be taken to prevent mal-operation of Buchholz relay in such conditions.

The details of the device used and its adequacy, suitability and design calculations to withstand seismic load shall be brought out in the additional information schedule.

5.4.1.7 **CONSERVATOR VESSELS, OIL GAUGES AND BREATHERS:-**

- (a) A conservator, complete with sump and drain valve shall be provided in such a position, so as not to obstruct the electrical connections to the transformer having a capacity between highest and lowest visible levels of 7½% of the total cold oil volume in the Transformer and the cooling equipment from minimum ambient temperature to 100 Degree C. The minimum indicated oil level shall be with the feed pipe from the main tank

covered with not less than 15 mm depth of oil and the indicated range of oil level shall be minimum to maximum.

- (b) If the sump is formed by extending the feeding pipe inside the conservator vessel, this extension shall be for at least 25 mm. The conservator shall be designed so that it can be completely drained by means of the drain valve provided, when mounted as in service.
- (c) The conservator tank shall be bolted on to its support of mounting to allow for its removal for cleaning/repair. It shall be bolted onto the main tank to allow for its removal for cleaning/repair.
- (d) The conservator for main tank shall be fitted with a magnetic oil level gauge with low oil level, electrically insulated alarm contacts. The indicator shall have the minimum and maximum levels, indicated along with the normal level at an oil temperature of 25° C. The temperature markings shall preferably be integral with the level-indicating device. The gauge should be readable from the transformer base level. Sight glasses of oil level indicators shall be of laminated security glass. Sight glasses of transparent plastics will not be accepted.
- (e) Taps or valves shall not be fitted to oil gauge.
- (f) The oil connection from the transformer tank to the conservator vessel shall be arranged at a rising angle of 3 to 9 degrees to the horizontal up to the Buchholz Relay and shall consist of 80 mm inside diameter pipes as per IS: 3639.
- (g) A valve shall be provided at the conservator to cut off the oil supply to the transformer, after providing a straight run of pipe for at least a length of five times the internal diameter of the pipe on the tank side of the gas and oil-actuated relay and at least three times the internal diameter of the pipe on the conservator side of the gas and oil-actuated relay.
- (h) The conservator tank shall be equipped with a nitrile rubber diaphragm or bag filled with dry air, which isolates the transformer oil space from the ambient air. The bag shall work satisfactorily and without damage at all anticipated oil temperatures.
- (i) Provision shall be made for monitoring the integrity of rubber bag and giving an electrical alarm when the bag is damaged.
- (j) The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stenciled on its underside with the words **“Caution: Air cell fitted”**. Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **“Main conservator is fitted with an air cell”**.
- (k) The conservator for the OLTC/diverter switch can be either an integral, but completely separated part of the main conservator or a separate oil tank. It shall have a prismatic or magnetic oil level gauge.

(l) Dehydrating Silicagel Filter Breather

Conservator of Main Tank and OLTC shall be fitted with a dehydrating silicagel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breather & Connecting pipes shall be securely clamped and supported to the transformer or other structure supplied by the supplier, in such a manner so as to eliminate undesirable vibration and noise. No valve is to be placed between breather & conservator. Minimum quantity of silica gel will be 1Kg for every 3500 Litres of oil in the tank. The design shall be such that:

- a) Passage of air is through silicagel.

- b) Silicagel is isolated from atmosphere by an oil seal.
- c) Moisture absorption indicated by a change in colour of the crystals.
- d) Breather is mounted approximately 1200 mm above rail top level.
- e) To minimise the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Supplier shall provide flexible connection pipes to be used during replacement of any silicagel breather.
- f) To minimise the ingress of moisture, two in series of identical size shall be connected to OLTC Conservator. Supplier shall provide flexible connection pipes to be used during replacement of any silicagel breather.

5.4.1.8 PIPING WORKS FOR CONSERVATOR

- (a) Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.
- (b) The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. Gas-venting pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.
- (c) This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees.
- (d) A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.
- (e) The feed pipe diameter for the main conservator shall be not less than 80mm.
- (f) Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

5.4.2 VALVES AND LOCATION: -

5.4.2.1 General: -

- (a) Blank flanges, plates or captive screw caps shall be fitted to all valves and pipe ends, not normally connected in service.
- (b) The omission of any, or the provision of alternative arrangements to the listed requirements, which alter the functional nature of the valve system, will not be accepted.
- (c) All valves up to and including 100 mm shall be of Gun Metal. Larger valves may be of Gun Metal or may have cast iron bodies with Gun Metal fittings. They shall be of the full way type with internal screw and shall be opened by turning counter clockwise when facing the hand wheel. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.
- (d) Means shall be provided for padlocking the valves in the open and closed positions. Provision is not required for locking individual radiator valves.
- (e) Every valve shall be provided with an indicator to show clearly the position of the valve.
- (f) All valves shall be provided with flanges having machined faces.
- (g) All valves shall be suitable for continuous operation with transformer oil at 100° C.
- (h) Suitable valves shall be provided to take sample of oil from OLTC chamber during operation of the transformer.
- (i) Oil sampling valves shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- (j) Each transformer shall be fitted with the valves, identified in the following Sub-sections as a minimum requirement.
- (k) Inside surface of all cast iron valves coming in contact with oil shall be applied with one

coat of oil resisting/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS: 2932. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS: 2074 followed by two coats of fully glossy finishing paint.

5.4.2.2 **MAIN TANK:-**

- (a) One filter valve located near to the top of the tank.
- (b) One filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against(a). Where design permits, this valve may be combined with item (c).
- (c) One drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained off oil as far as practicable. This valve shall also be provided with an approved oil sampling device.
- (d) Two oil valves for taking oil samples from the top and bottom of the tank. The top-oil sampling point shall be brought down to be accessible from ground level.
- (e) A flanged valve suitably positioned near the top of the main tank for the connection by the Purchaser of a 'Hydran' monitor.
- (f) A flange for the vacuum control switch tank will be provided on the tank cover.

5.4.2.3 **CONSERVATOR:-**

- (a) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank.
- (b) One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil. It shall also be fitted with an oil-filling hole with cap.

5.4.2.4 **TAP CHANGER/DIVERTER SWITCH :-**

Filter and drain valve where selector switches are contained in a separate tank.

5.4.2.5 **RADIATORS AND COOLER BANKS:-**

Valves of adequate size as per 'CBIP Manual on Transformers (Publication No. 317)' at each point of connection to the tank shall be provided.

5.4.2.6 Air release plug(s) of adequate size shall be provided.

N.B.: However, type, size, additional locations if required shall be finalized during detailed engineering, which shall be provided at no extra cost to OPTCL.

5.4.3 **JOINTS AND GASKETS:-**

- (a) All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.
- (b) Nitrile base cork or equivalent shall be used for gaskets. Oil resistant synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork or similar material or where metal inserts are provided to limit compression.
- (c) Gaskets shall be consistent with the provision of a good seal and full details of all gaskets sealing arrangement shall be shown on the drawings.

5.4.4(A) **PRESSURE RELIEF DEVICE:-**

- (a) An approved pressure relief device of sufficient size shall be provided for rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment. It shall positively operate, at a pressure of 7+/-1PSi (48+/- 6.8KN/Sq.mm) and automatically reset when pressure falls below this value. There will be no leakage of

oil after resetting of PRD. Means shall be provided to prevent the ingress of rain or dust. Pressure relief devices of the type mounted below normal oil level shall be of the resetting type once the dangerous pressure has been reduced to prevent unnecessary release of oil.

- (b) Contacts shall be provided for alarm and trip and initiation on operation of the device. Baffles shall be provided when necessary to safely control the direction in which oil or gas is ejected.
- (c) Unless otherwise approved, the relief device shall be mounted on the main tank and if on the cover, shall be fitted with a skirt projecting 25 mm. inside the tank to prevent gas accumulation.
- (d) Loss of oil on operation of the relief device shall be contained within the transformer oil retaining area.
- (e) The bidders shall furnish constructional, design details of pressure relief device(s) and calculations along with the bids to prove that the size and setting of pressure relief device(s) is adequate, considering the rating of the transformer, the quantity of oil in the Transformer and the insulating oil will not catch fire in case of any short/ground fault inside the transformer.
- (f) The terminal box/boxes of PRD should conform to degree of protection as per IP-55 of IEC- 60529.
- (g) One set of potential free contacts (**with plug & socket type arrangement suitable for 2.5sq.mm control cable**) per device shall be provided for alarm/tripping. Following routine tests shall be conducted on PRD:
 - a) Air pressure test
 - b) Liquid pressure test
 - c) Leakage test
 - d) Contact operation test
 - e) Dielectric test on contact terminals

5.4.4(B) **SUDDEN PRESSURE RELAY:-**

Adequate number of Sudden Pressure relay with alarm/trip contacts (**Terminal connection plug & socket type arrangement suitable for 2.5 sq.mm control cable**) shall be provided on tank of transformer. Operating features, size and quantity shall be reviewed during design review.

5.4.5 **EARTHING TERMINALS:**

(i) Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanized steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

(ii) Two earthing terminals suitable for connection to 75 x 12 mm galvanized steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

(iii) Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

5.4.6 **CORROSION PROTECTION:**

5.4.6.1 **General:**

- (a) Bidders shall state clearly the corrosion protection, applied to aluminum and aluminum-alloy parts.
- (b) Bidders shall draw attention to all exposed points in their equipment at which aluminum or aluminum- alloy parts are in contact with or in close proximity to other metals and shall state clearly the protection employed at each point to exclude air and moisture.
- (c) A full description of the corrosion prevention system, proposed by the Bidder shall be given and this is subject to acceptance by the purchaser. This description shall include details of surface preparation, rust inhibition, and paint thickness, treatment of fasteners and painting of surfaces in contact with oil.

5.4.6.2 The minimum standards acceptable to the purchaser are:-

(a) Hot Rolled Steel:

- (i) Grit blasting to grade sa 2.5 of ISO 8501-1.
- (ii) Epoxy-base zinc primer. Coating thickness 25 micrometer.
- (iii) Zinc spraying of tank bottom. Thickness 100 micrometer.
- (iv) Epoxy-based micaceous iron-oxide paint. Coating thickness 40 micrometer.
- (v) Alkyd or phenolic-based micaceous iron-oxide paint. Coating thickness-40 micrometer.

(b) Radiators and Fasteners larger than 12 mm:-

- (i) Hot dip galvanized to IS: 2633.
- (ii) Cleaning and surface preparation followed by paint treatment as specified above.

(c) Smaller fasteners, cable clips:-

Use of non-ferrous material, stainless steel or appropriate plated components.

5.4.7 **RATING, DIAGRAM AND VALVE PLATES:-**

The following plates or an approved combined plate shall be fixed to each transformer Tank at an average height of 1500 mm above the ground level:-

- (a) A rating plate bearing the data, specified in IEC 76 Part - I. This plate shall also include: -
 - (i) The short circuit current rating.
 - (ii) Time factor for each winding measured.
 - (iii) Measured no load current and no load losses at rated voltage and rated frequency.
 - (iv) Measured load losses at 75° C (Normal tap only).
 - (v) D.C. resistance of each winding at 75° C.
- (b) A diagram plate showing in an approved manner, the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 76 Part-I with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct physical relationship of the terminals.
- (c) A plate showing the location and function of all valves and air-release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.
- (d) Current transformers Rating Plate.
- (e) Diagram plate, indicating the oil levels in the conservators dependent on the oil temperature.
- (f) Loading plan plate, showing transport dimensions and masses. This plate shall also warn the erection staff not to remove any cover, before filling the tank with oil to such a level where the windings are not exposed to the atmosphere. This shall be fixed directly on to the transformer tank and shall not be removed for transport.
- (g) Identification plates, alpha-numerical number in an approved manner, for all fans,

marshaling cabinets, breathers, valves, cocks, accessories etc. (minimum size: 110mm x 50mm) rigidly fastened by rivets on corrosion proof base plates. In addition, the function (description) of the related devices shall be clearly indicated on these plates. The alphanumeric numbers on the identification plates shall be of such a size as to be clearly legible from the floor level.

- (h) Plates, showing all control, measuring and monitoring circuits and terminal blocks. These plates shall be rigidly fixed at the inner side of the hinged door of the concerned marshaling kiosk.
- (i) Plates, showing the control circuit/ block diagram of the OLTC. These plates shall be rigidly fixed at the inner side of the hinged door of the motor drive cubicle.

Outdoor arranged plates are to be of polished stainless steel of top quality only (back ground clear, engraving black, depth of engraving 0.5mm) stainless steel, capable of withstanding the rigours of continuous outdoor service at site. Plates, arranged inside control and marshaling cubicles may be of material in accordance with manufacturer's standard, e.g. glass -fibre reinforced synthetic resin (subject for approval). All plates other than those located on tank cover shall be easily and clearly legible from ground level.

5.4.8. **CORE:** -

- (a) The core shall be constructed from high grade non-ageing cold rolled super grain oriented silicon steel laminations, known as HIB steel as trade name having high permeability and low hysteresis loss. B-H and specific loss curve shall be furnished in support of these materials. Laminations of one particular thickness i.e. 0.23mm or 0.27mm or better (quoted grade and type) shall be used. Laminations of different grade(s) and different thickness(s) are not allowed to be used in any manner or under any circumstance.
- (b) After being sheared, the lamination shall be treated to remove all burrs and shall be reannealed to remove all residual stress. The insulation of the lamination, which is to be stated in the tender, shall be inert to the action of the hot transformer oil and pressure.
- (c) The design of the magnetic circuit shall be such as to achieve minimum possible active and reactive core losses during the entire life of the transformer.
- (d) The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations, which may cause local heating. The joints of limbs and yokes shall be designed and constructed to keep the no-load losses and the hot spot temperature in the magnetic core as well as the noise level as low as possible.
- (e) The core and winding shall be capable of withstanding the shock during transport, installation, service and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions and reduce vibrations to a minimum for all operating conditions. Care shall also be taken to secure uniformly distributed mechanical pressure over all the laminations to prevent setting of the core and to limit noise and vibration to a minimum under service conditions.
- (f) The Transformer shall be of **BOLTLESS** core design. The Bidders will furnish documentary evidence with proof of their experience and performance in such type of design.
- (g) All steel sections, used for supporting the core shall be thoroughly sandblasted after cutting, drilling and welding. Any non-magnetic or high resistance alloy shall be of established quality.
- (h) When bell type construction is offered, suitable projecting guides shall be provided on

core assembly to facilitate removal of tank. The supporting framework of core shall be so designed so as to avoid presence of pockets, which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

- (i) The core shall be provided with lugs suitable for lifting the complete core and coil assembly of the transformer.
- (j) The core and coil shall be so fixed in the tank that shifting will not occur when the Transformer is moved or during a short circuit.
- (k) Oil ducts shall be provided where necessary to ensure adequate cooling. The winding structure and major insulation shall not obstruct the free flow of oil through such ducts. Where the magnetic circuit is divided into pockets by cooling ducts parallel to the planes of laminations or by insulating material above 0.25 mm thick, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between pockets.
- (l) **The temperature gradient between the core and surrounding oil shall be maintained less than 20°C.** The manufacturer shall demonstrate this either through a test (procedure to be mutually agreed) OR by a calculation.
- (m) The transformer shall be designed in such a way that the maximum flux density in any part of the core and yoke at rated M.V.A, rated frequency and rated voltage shall not exceed 1.5 Tesla. The tenderer shall establish this by calculation as per given format. Core hot spot temperature shall be determined as per Cl. No – 3.21 of CBIP manual(Publication No – 317).
- (n) **Minimum knee point voltage is 110% of rated voltage. Accordingly, the operating flux density for design should be carefully chosen within the stipulated value to achieve the above minimum knee point voltage. The tenderer shall quote the practical achievable no load current at different percentages of rated voltage as per Guaranteed Technical Particulars along with a linear graph confirming the above said knee point voltage which will be verified during no load test method that 10% increase in voltage from 110% rated voltage causes the excitation current to increase not by more than 50%.**
- (o) The tenderer will offer the core for inspection and approval by the Purchaser during manufacturing stage. Tenderer's notice for this purpose shall be accompanied with the following documents towards use of prime core.
 - (i) Invoice of the supplier.
 - (ii) Mill's test certificates.
 - (iii) Packing list.
 - (iv) Bill of lading.
 - (v) Bill of entry certificates by customs.
- (p) Core material shall be directly procured either from the manufacturer or through their accredited marketing organizations of repute and not through any agent. All the core import documents must be in the name of the transformer manufacturer / the accredited marketing organization.
- (q) The bidder should preferably have in-house core-cutting facility for proper monitoring and control on quality and also to avoid any possibility of mixing of prime material with defective/ second grade material. However, the core-cutting operation may be witnessed by OPTCL's representatives at the works of the manufacturer and specific loss, other tests will be conducted on samples of core materials, selected at random by OPTCL's representative.

The following procedure is to be adopted for those manufacturers who have no in-house core-cutting facility:

- (1) In the offer, against tender for transformers, the bidder should mention names of at least three manufacturers of Transformer core material who have at least 5 (five) years experience in manufacturing of Transformer grade core. The Transformer

- manufacturer (TM) can purchase the core from such manufacturer(s) for which approval will be accorded by OPTCL.
- (2) The bidder should specify the grade, thickness of core material in the offer along with submission of all graphs/ documents, relating to the grade of core material, offered by them.
 - (3) The documents, as mentioned against Sl. 'O' should be submitted to OPTCL, once the core materials are landed in any of the Indian ports and same should be offered to OPTCL for inspection. The representative, deputed by OPTCL for such inspection will record the following information:-
 - a) Purchase order No. & Date.
 - b) No. of packed coils with package Nos.
 - c) Gross weight.
 - d) Net weight
 - e) Port of loading.
 - f) Port of discharge.
 - g) Name of the ocean vessel.
 - h) Grade and thickness of core material.
 - i) Any other information, as mentioned on the body of packed coils.
 - (4) The bidder in its offer will mention the names of at least three Sub-vendors, to whom they intend to assign their core cutting. Such sub-vendors should have been approved by other Electricity Boards/ Electrical utilities and are accredited by some International recognized certification body like ISO: 9000 etc., to ensure that a minimum quality parameters and tolerances are maintained. The experience, the details of core-cutting facilities, finishing and testing facilities etc., as available with such sub-vendors should be clearly outlined in the bid.
 - (5) On award of contract, the TM is to assign the core-cutting to such sub-vendor(s) for which approval is to be given by OPTCL
 - (6) After the packed core coils are received by the OPTCL's approved sub-vendors, the TM is to offer the same to OPTCL for deputing representative(s) to first note down the details as per Sl (3) above and witness the cutting of cores and relevant tests on core samples.
 - (7) The TM will offer the core materials for inspection during assembly stage and witnessing the stage inspection and relevant tests.
 - (r) Further, the Bidder is required to furnish the copies of import documents (as mentioned at Sl.'o' above) along with the tender offer in support of their direct import of core materials in the recent past.
 - (s) **Tenderer shall furnish along with the bid the calculation towards Air-core reactance of H.V. winding and maximum peak value of magnetizing in- rush current and shall justify that the transformer will not trip due to this during initial charging and subsequent charging. The formula & basis for calculation of air core reactance is to be justified during design review.**

5.4.8.1 EARTHING OF CORE CLAMPING STRUCTURE :

The top main core clamping structure shall be connected to the tank body by a copper strip. The bottom clamping structure shall be earthed by one or more of the following methods: -

- (a) By connection through vertical tie-rods to the top structure.
- (b) By direct-metal-to metal contact with the tank base maintained by the weight of the core and windings.
- (c) By a connection to the top structure on the same side of the core as the main earth connection to the tank.
- (d) By any other better earthing method.

5.4.8.2. **EARTHING OF MAGNETIC CIRCUITS:**

- (a) The core shall be earthed to the core clamping structure at one point only, through a removable external link of minimum size of 80 sq. mm copper suitably located and protected in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates etc. to be tested at voltages up to 2.0KV(rms). The removable link shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the outside of tank cover.
- (b) In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

5.4.8.3 **SIZE OF EARTHING CONNECTIONS:-**

To be proposed by the manufacturer for the Purchaser's approval.

5.4.9. **WINDINGS:-**

- (a) The supplier shall ensure that the windings of all EHV class transformers are made in dust proof, conditioned atmosphere. **He shall furnish the facilities, available in this regard at his works along with the bid.**
- (b) The windings for system rated voltages of 400 KV & 220 KV shall have graded insulation, as defined in IEC-76 and IS-2026. The winding for 33 KV shall be fully insulated.
- (c) All neutral points shall be insulated to withstand the applied test voltage as per above standards.
- (d) The neutral ends of star connected three phase windings shall be connected at points, which are accessible from manholes in the cover and brought out via one bushing.
- (e) The conductors for the windings and connecting leads shall be of electrolytic grade copper, free from scales and burrs and shall have properly rounded corners to reduce electrostatic flux concentration.
- (f) The current density, adopted for all the windings shall not exceed 2.8 Ampere/sq.mm at rated load. The total net cross-sectional area of the strip conductors for calculating the current density for each winding shall be obtained after deducting the copper area, lost due to rounding up of the sharp edges of the rectangular conductors.
- (g) The copper conductors, used in the coil structure shall be best suitable to the requirements and all permanent current carrying joints of the windings and the leads shall be welded or braced or crimped.
- (h) The coils shall be supported between adjacent sections by insulating spacers and the barriers, bracings and other insulation, which shall be arranged to ensure a free circulation of the oil and to reduce hot spots in the windings. The stacks of windings shall receive adequate shrinkage treatment before final assembly. **If necessary, Adjustable devices shall be provided for taking up any possible shrinkage of coils in services.**
- (i) The transformer shall be designed to withstand Lightning impulse, switching Impulse and power frequency test voltages as specified in IEC 76 and IS: 2026.
- (j) The windings shall be capable of withstanding axial and radial forces during fault conditions as per clause No.5.1.2. of this specification. **The detailed calculation towards the above should be furnished along with the bid.**
- (k) The short circuit temperature rise should not exceed the limits, fixed as per IS: 2026. **The calculation towards the above for 400 KV, 220 KV and 33 KV windings shall be furnished along with the bid.**

- (l) The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse or be catalytic and chemically active in the hot transformer oil during service. The dielectric strength of winding insulation shall conform to the values, given in IS: 2026, as amended up to date. **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 transformer tank for taking sample of paper for testing purpose in future and the location shall be easily accessible and indicated in the transformer tank by affixing special caution plate.**
- (m) The coil clamping arrangement and the finished dimensions of any oil duct shall be such as will not impede the free circulation of oil through the ducts.
- (n) No strip conductor wound on edge shall have a width exceeding six times its thickness.
- (o) The conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.
- (p) The windings and leads of all transformers shall be able to withstand the shocks, which may occur through rough handling and vibration during transport, switching and other transient service conditions including external short circuit. Adequate barriers shall be provided between windings and core and between windings. All leads or bars from the windings to the terminal boxes and bushings shall be rigidly supported. Stresses on coils and connections must be avoided.
- (q) The windings shall be located in a manner, which will ensure that they remain electro-magnetically balanced and their magnetic centres remain co-incident under all conditions of operations.
- (r) Tappings shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.
- (s) The coils should be made up, shaped and braced to provide for expansion and contraction due to temperature changes.
- (t) Coil clamping rings, if provided, shall be of steel or of suitable insulating material.
- (u) All threaded connections shall be provided with locking facilities. All leads from the winding to the terminal board and bushing shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used, where practicable.
- (v) The assembled core and windings shall be vacuum dried and suitably impregnated before removal from the treating tank.
- (w) Where coil-clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the transformer as the main earth connection. However, same shall be proposed by the manufacturer for the Purchaser's approval.
- (x) Washers in contact with non-ferrous parts, which carry current, shall be of phosphorous bronze.
- (y) The tertiary winding shall be suitable for connection of reactors or capacitors, which would be subjected to frequent switching. All the three windings shall be capable of withstanding stresses that may be caused by such switching. The Bidder shall furnish the details to prove his claim.
- (z) The rating of the tertiary shall be one third of the total rating of the transformer. The tertiary winding shall be suitable for delivering its full rated power at any cooling of the Auto Transformer. Sufficient number of radial ducts shall be provided on tertiary winding for effective cooling. The tertiary winding shall withstand short circuit faults of the transformer upto the prescribed fault levels on HV & IV sides. The short circuit MVA capacity of the tertiary winding shall be 25 % extra over the calculated and designed

short circuit MVA. **Detailed short circuit calculations of the transformer shall be furnished along with the offer.**

- (aa) The tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.
- (bb) The current density of the conductor used for tertiary winding shall not exceed the current density, specified for the main winding's conductor.
- (cc) The design of the transformer shall ensure that the amplitude of surges, transferred from the HV or IV windings to the LV windings is effectively controlled well below the maximum limit, admissible with the BIL of the LV winding, which should be supported with calculations. The said stipulated limit shall be verified through RSO method or any other equivalent technical method to authenticate the submitted calculations during final testing .
- (dd) The tenderer should have in house availability of vapour phase Drying (VPD) plant for proper drying of the insulation. In case VPD facility is not available, the bidder will prove that the method of drying adopted by them is equivalent or better than VPD in terms of level of dryness and other benefits of VPD.
- (ee) The air-core reactance of HV winding of Transformer shall not be less than 20%.
- (ff) The transformer shall be designed to withstand a DC current of 10A per phase without Injurious heating.
- (gg) Tan delta value for windings shall be less than 0.005. Tan delta shall be measured at ambient temperature. No temperature correction factor shall be applied.

5.4.10. **GAS AND OIL-ACTUATED RELAYS:-**

- (a) Each transformer shall be fitted with gas and oil-actuated relay equipment having alarm contacts, which close on collection of gas or low oil level, and tripping contacts which close following oil surge conditions. Separate relays shall be provided for on load tap changer.
- (b) Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.
- (b) Each relay shall be fitted with a calibrated glass window for indication of gas volume.
- (d) To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point, approximately 1400 mm above ground level. Where it shall be terminated by a cock, which shall have provision for locking to prevent unauthorized operation.
- (e) The design of the relay mounting arrangements, the associated pipe work and the cooling plant shall be such that mal-operation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps whether by manual or automatic control under all operating temperatures.
- (f) The pipe work shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is to be tied into or connected through the pressure relief vent. Sharp bends in the pipe work shall be avoided. For this reason, bushing turrets, if fitted shall have vent pipes, which will route any gas collection through the relay.
- (g) A machined surface shall be provided on the top of each relay to facilitate the setting of the relays and to check the mounting angle in the expansion pipe and the cross level of the relay.
- (h) A straight run of pipe work shall be provided for a length of five times the internal diameter of the pipe on the conservator side of the gas and oil-actuated relay.
- (i) The surge float contacts shall close at a rate of steady oil flow between the following

limits. As far as possible, the limits shall also be met when the relay is subjected to oil surge conditions, produced by rapid opening of a lever operated gate valve.

- (j) The relays shall be so located as to be easily accessible from the top of the tank. Oil Pipe Connection I.D. (mm) Operational Limits for Relay.

[Rising angles of 1° to 9°.]

25	700-1300
50	750 - 1400
75	900 - 1600

- (k) The gas collection contacts shall operate within the angle limits, specified for test:
- (l) When a transformer is provided with two conservators, the gas and oil - actuated relays shall be arranged as follows:
- (i) If the two conservators are connected to the transformer by a common oil pipe, one relay shall be installed in the common pipe.
 - (ii) If the two conservators are piped separately to the transformer, two relays shall be installed, one in each pipe connection.
- (m) The clearance between oil pipe work and live metal shall be not less than the minimum clearances as per standard practice.

5.4.11. **TEMPERATURE INDICATING DEVICES AND ALARMS:-**

The Transformer shall be provided with approved devices for indicating the oil temperature and hot spot winding temperature of each winding. The devices shall have a dial type indicator and in addition, a pointer to register the highest temperature reached and re-setting device. Each temperature device shall have three separate contacts fitted, one of which shall be used to control the cooling plant motors, one to give an alarm and one to trip the associated circuit breakers.

(a) **Oil Temperature Indicator (OTI)**

The thermometer for top oil temperature indication should be of 150mm dial type. A temperature-sensing element, suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be $\pm 1.5\%$ or better. The temperature indicator dials shall have linear graduations to clearly read at least every 2 deg. C.

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

A device for measuring the hot spot temperature of each of the HV/IV/LV windings shall be provided. It shall comprise of the following:-

- i) Temperature sensing element.
- ii) Image Coil.
- iii) Auxiliary CTS, if required to match the image coil, shall be provided and mounted in the cooler control cabinet. For autotransformers, an additional CT is required in the lead to the primary terminal to give a true image of the temperature in the common/secondary winding. The current transformers shall be of class 1, and the rated primary current shall correspond to the rated current of the related transformer winding. The effective resulting rated secondary current shall be 2A. Matching units between current transformers and thermal replicas shall not be provided.
- iv) 150 mm diameter local indicating instrument with maximum reading pointer, mounted in cooler control cabinet and with two adjustable electrically independent ungrounded contacts (besides that required for control of cooling equipment), one for high winding temperature alarm and one for trip. The temperature indicator dials shall have linear graduations to clearly read at least 2 deg. C
- v) Calibration device.

- vi) In addition to the above, the following indication equipment shall be provided for each winding for remote indication.
- 1) Conventional Remote winding temperature indicator & Remote Oil temperature indicator: - It shall be suitable for flush mounting on RTCC panel. The difference between local and remote indication at any given time shall not exceed 1 deg. C.
 - 2) Remote Optic Fiber temp. Indicators.
 - 3) Auxiliary supply, if required, in RTCC panel, for above, shall be 220V DC only.
 - 4) The drawing showing details of above shall be submitted to the purchaser.
 - 5) Accuracy class of WTI & OTI shall be +/- 1.5% or better.
 - 6) Any special cable(s), required for shielding purpose for connection between cooler control cabinet and remote winding temperature indicator control circuit shall be in Bidder's scope.
- (c) The winding temperature indicators shall be housed in the cooler control cabinet/marshalling kiosk. The tripping contacts of the winding temperature indicators shall be adjustable to close between 80°C and 150°C and to re-open when the temperature has fallen by not more than 10°C.
- (d) The alarm contacts and the contacts used to control the cooling plant motors on the above devices shall be adjustable to close between 50°C and 100°C and to re-open when the temperature has fallen by a desired amount between 10° C and 15° C.
- (e) All contacts shall be adjustable to a scale and must be accessible on removal of the relay cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 and 250 Volts AC or DC and of making 500 VA between the limits of 110 and 250 V DC. Cooler motor control contacts shall be suitable for operating the cooler contactors direct, or if necessary, through an interposing relay.
- (f) The temperature indicators in the marshalling kiosk shall be so designed that it is possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.
- (g) The working parts of the instrument shall be made visible by the provision of cut-away dials and glass-fronted covers. All setting and error adjustment devices shall be easily accessible.
- (h) Connections shall be brought from the device to terminal boards, placed inside the marshalling cubicle.
- (i) Terminals, links and a 63 mm moving iron ammeter shall be provided in the marshalling kiosk for each WTI for: -
- (i) Checking the output of the current transformer.
 - (ii) Testing the current transformer and thermal image characteristics.
 - (iii) Disconnecting the bulb heaters from the current transformer secondary circuit to enable the instrument to be used as an oil temperature indicator.
- (j) Sight glasses of temperature indicators shall be of laminated security glass. Sight glasses of transparent plastics will not be accepted.
- k) In addition to the above, **'OPTIC FIBER TEMPERATURE SYSTEM'** of proven quality and performance in Indian Utilities shall be provided in each transformer for measurement of temperature of windings, oil and core. Bidders are required to state in their offers regarding performance of such Optic Fiber Temperature System along with the names of the end-users in India. The end-user's certificates for such system will be furnished by the Bidders along with their Tender offers.

Following is the criteria for temperature measurement of oil, windings and core by using

Fiber Optic Sensors: -

1. System shall be with fiber optic sensors with proven and rugged technology. The probes shall be directly installed in each winding of both HV & IV of Auto transformer to measure the winding hot spot, top oil and core temperature. There will be **minimum eight probes** inside the transformer, out of which one probe should be installed in top of the transformer for the detection of top oil temperature.
2. The remaining Fiber Optic probes; one each shall be installed in each phase winding (both HV & IV) at the hottest spot of each of the phase windings and the remaining one probe in hottest spot of the core. The locations of the probes shall be proposed by the Manufacturer and locations, to be finalized by agreement with the purchaser.
3. Probes shall be able to be completely immersed in hot transformer oil; they shall withstand exposure to hot kerosene vapour during the transformer insulation drying process. The probes shall meet the requirement to eliminate the possibility of partial discharge in high electrical stress areas in the transformer.
4. Temperature range of the system should be -30deg.C to $+200\text{deg.C}$ and accuracy of $\pm 2\text{deg.C}$ with no recalibration required.
5. Probes shall be all silica, double PFA Teflon jacketed; Kevlar cabled fiber with perforated outer jacket to allow complete oil filling; and white Teflon protective Helix wrap having improved visibility and mechanical strength.
6. A microprocessor based monitoring and recording unit shall be a part of the system, having 8(eight) channels. System should include analog outputs for each measurement channel. Temperature resolution of the analog outputs shall be ± 0.1 deg. C and the system shall offer user programmable temperature alarm outputs with 6 relays, alarm lights and controller system status indicators. All inputs and outputs of the system shall meet the requirements of surge test of IEEE C37.90.1-1989 in which a 3000V surge is applied to all the inputs and outputs without permanent damage to the instrument.
7. The system shall be capable of retaining temperature data of a minimum of 90 days at one (1) reading/minute and should retain max temperature of each channel until reset.
8. **The transformer manufacturer should submit data showing that the probes are located in the hottest point of the winding and oil, while submitting drawings for approval.**
9. The Fiber Optic cables are to be brought out of the main tank through tank wall penetrator feed through plate. The Feed through plate shall be welded on to the Tank. The external fiber optic extension cable shall then be run to main control cabinet, routed inside the conduits with large bend radius. Protective cover shall be provided for the Tank Wall Feed through Plate.
10. The controller / measuring system having at least 8 channels shall be housed in cooler control cubicle or in a separate enclosure having degree of protection IP56 class, mounted on the transformer tank. The position shall be clearly indicated in the GA drawings.
11. Temperature Rise Test Measurement shall be made with the FO Thermometers. The

Optic Fiber Temperature System shall be operational during temperature rise tests and be demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified and temperature data for all probes (hourly readings) recorded and reported in the test report. The hot spot temperature rise of the windings above ambient temperature shall not exceed 54 deg. C (for ONAN, ONAF & OFAF/ODAF ratings) and the top oil temperature rise above ambient temperature shall not exceed 40 deg. C (for ONAN, ONAF & OFAF/ODAF ratings) as per this specification.

12. For remote indications on RTCC panel, output of 4to 20mA shall be made available. Digital Temperature Indicators shall be provided in the RTCC Panel for indications of temperatures in each of the windings, top oil and core from the Optic Fiber Temperature Sensor Controller Unit. This shall also be demonstrated during temperature rise test.
13. The output of FO system shall be suitable for PC interface with USB port. All required software shall be provided.
14. Any other accessories required for satisfactory operation of fiber optic sensor temperature measurement system shall be provided.
15. All type test reports as per relevant standard shall be submitted with the technical bid.
16. Services of FO system supplier during manufacturing, testing, commissioning and after sales service even beyond guarantee period shall have to be arranged and provided by the bidder.

5.4.12. **COOLING EQUIPMENT AND ITS CONTROLS:**

5.4.12.1. Cooling Equipment:

- (a) The Cooler shall be designed using 2 x 50 % radiator banks.
- (b) Each radiator bank shall have its own cooling fans, oil pumps, oil flow indicators, shut off valves at the top & bottom, lifting lugs, top and bottom oil filling valves, air release plug, a drain valve and thermometer pocket, fitted with captive screw cap on the inlet and outlet oil pipes.
- (c) One stand by fan of at least 20% capacity shall also be provided and identified with each radiator bank.
- (d) Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration.
- (e) The exhaust airflow from cooling fan shall not be directed towards the main tank in any case.
- (f) Cooling fans for each radiator bank shall be located so as to prevent ingress of rainwater.
- (g) It shall be possible to remove the blower complete with motor without disturbing or dismantling the cooler structure framework.
- (h) The blades of cooling fans shall be of galvanised steel or cast aluminum alloy unless otherwise approved. Thickness of galvanization shall be minimum 55 microns.
- (i) Blower casings shall be made of galvanised steel of thickness not less than 2 mm or aluminum alloy and shall be suitably stiffened by angles or tees.
- (j) Galvanised wire guards with mesh not exceeding 12.5 mm shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts can not be touched by

- test fingers to IEC - 529:1976 (BSEN60529). Direction of rotation shall be indicated.
- (k) Two (2), 100% oil immersed in line axial flow motor pumps (out of which one pump shall be stand by) shall be provided with each radiator bank. The pumps shall be assembled on common shaft and housed in a common casing. The motor windings shall be immersed in a part of the circulating oil to obviate the need of packing glands and lubrications of the pump and motor bearings by external means. The stand by pump shall be connected in parallel at the same level. **CENTRIFUGAL TYPE OIL PUMPS MUST NOT BE PROVIDED AND OFFER WITH SUCH PUMPS SHALL NOT BE CONSIDERED.** The manufacturer will have to show either by certified type test results or type tests, witnessed by the purchaser that switching on of all the oil pumps into services, simultaneously, does not operate the Buchholz relay. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil under failure of main oil pump, the changeover from main to stand by oil pump shall be automatic.
 - (l) It shall be possible to remove the motor and pump from the oil circuit without having to take the transformer out of service and without having to disturb the pump foundation fixing.
 - (m) The pump shall be capable of dealing with the maximum output and head, which may occur in service and head which may occur in service and with the varying head due to changes in the viscosity of oil. Guards shall be provided over all exposed couplings and shafts.
 - (n) An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.
 - (o) Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase and 50 Hz power supply and shall conform to IS: 325. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure - equivalent to IP: 55 as per IS: 4691.
 - (p) Each cooling fan and oil pump motor shall be provided with starter thermal overload and short circuit protection.
 - (q) Valves shall be provided across the pump and oil flow indicator to avoid oil drain & long outage during maintenance/replacement of pump & oil flow indicator.
 - (r) **Each radiator shall be provided with the following items: -**
 - One shut off valve at the top.
 - One shut-off valve at the bottom.
 - Air release device at the top.
 - Lifting lugs to lift entire cooling assembly.
 - Air release device and oil plug on oil pipe connections.
 - Loose blanking plates for blanking off the main oil connections.
 - Visual oil flow indicators, fitted with the electrical contacts to close when oil is not flowing. Contacts are to be connected in the cooler fail alarm circuit.**Each radiator bank shall be provided with the following items: -**
 - Main and sampling device at the bottom.
 - Expansion joints, one each on top and bottom cooler pipe connections.
 - A thermometer pocket fitted with captive screw cap, in the inlet and in the out let oil pipes.

N. B.: - The omission of any or the provision of alternative arrangements to the above requirements will not be accepted.

(s) **OIL PIPES AND FLANGES :**

- All oil piping, necessary for connecting of each transformer to its conservator, cooler

- banks and oil pumps etc. shall be supplied under this contract.
- The oil piping shall be of approved material with machined flanged joints.
- Copper pipe work is to comply with BS.61.
- Dimensions of steel pipes shall be in accordance with BS. 3600: 1973 and the drilling of all pipe flanges shall comply with BS: 4504:1969.
- An approved expansion piece shall be provided in each oil pipe connection between the transformer and each oil cooler bank.
- All necessary pipe supports, foundation bolts and all other attachments are to be provided.
- It shall be possible to drain any section of pipe work independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

5.4.12.2. COOLING EQUIPMENT CONTROL (ONAN/ONAF/OFAF or ODAF COOLING):-

- (a) Automatic operation control (switching in and out) of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The supplier shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF to OFAF/ODAF. The setting shall be such that hunting i.e., frequent start operations for small temperature differential do not occur.
- (b) Suitable manual control facility for cooler fans and oil pumps with manual/automatic select or switches and push buttons shall be provided.

5.4.12.3. INDICATING DEVICES:-

Following lamp indications shall be provided in cooler control cabinet.

- Fan 'ON' Fan 'OFF'.
- Pump 'ON' and Pump 'OFF'.
- Cooling system 'On Automatic Control'.
- Cooling system 'On Manual'.
- No flow/Reverse flow of oil in oil pump.
- Selector switch in 'auto' or 'manual' for each fan and pump.
- 415 volts cooler supply auto changeover.
- Cooler supply failure for each supply.
- Oil pump failure for each pump.
- Cooling fan failure for each fan.
- Control supply failure for main and stand by.
- No flow/reverse flow of oil in oil pump.
- One potential free initiating contact for all the above indications shall be wired independently to the terminal blocks of cooler control cabinet exclusively for purchaser's use.
- A 12-window annunciator shall be provided in the RTCC panel for visual and audible signaling of important functions of cooling equipment and tap changer.

5.4.12.4. COOLER CONTROL CABINET:

- (a) Each transformer unit shall be provided with a cooler control cabinet.
- (b) The cooler control cabinet shall have all necessary devices, meant for cooler control and local temperature indicators. All the contacts of various protective devices, mounted on the transformer shall also be wired up to the terminal board in the cooler control cabinet. All the secondary terminals of the bushing CTs shall also be wired up to the terminal board at the cooler control cabinet.
- (c) The cooler control cabinet shall have two (2) sections. One section shall have the control equipment, exclusively meant for cooler control. The other section shall house

the temperature indicators, auxiliary CTs. and the terminal boards, meant for termination of various alarm and trip contacts as well as various bushing CT Secondaries. Alternatively, the two sections may be provided as two separate panels, depending on the standard practices of the supplier.

- (d) The temperature indicators shall be so mounted that the dials are not more than 1600 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

5.4.12.5. **TERMINAL BLOCK:**

- (a) The terminal blocks('ELMEX' Make, Type – OAT 6 or its equivalent), to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with block and barriers, moulded integrally. Such block shall have washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring.
- (b) All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. The terminal blocks shall be 1100 V grade and have 10 Amps continuous rating moulded piece, complete with insulated barriers, non-disconnecting stud type terminals, washers, nuts and lock nuts. Terminal block design shall include a white fibre-marking strip with clear plastic, slipon/clipon terminal cover. Markings on the terminal strips shall correspond to wire number and terminal numbers on the wiring diagrams.
- (c) Terminal blocks for current transformer's secondary leads shall be provided with test links and isolating facilities. Also current transformer secondary leads shall be provided with short-circuiting and earthing facilities.
- (d) At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.
- (e) Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors on each side.
 - (i) For all circuits except current transformer circuits, minimum of two nos. 2.5 sq.mm copper.
 - (ii) For all CT circuits, minimum of two nos. 4 sq. mm. copper.
- (f) There shall be a minimum edge-to-edge clearance of 250 mm. between the first row of terminal block and the associated cable gland plate. Also the clearance between two rows of terminal blocks shall be minimum of 150 mm.
- (g) Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run parallel and in close proximity long each side of the wiring duct to be provided for convenient attachment of internal panel wiring. The side of the terminal block, opposite the wiring duct shall be reserved for the owner's external cable connection. All adjacent terminal blocks shall also share this field-wiring corridor. A steel strip shall be connected between adjacent terminal block rows at 450 mm intervals for support of incoming cables.
- (h) The number and sizes of the purchaser's multi-core incoming cable will be furnished to the Bidder after placement of the order.

5.4.12.6 **LABELS.**

- a) Labels shall be provided for all the apparatus such as relays, switches, fuses etc., contained in control cabinets/marshalling box.
- b) Description labels for mounting indoor or inside control cabinets/marshalling box shall be of such material that will ensure permanence of lettering. A matt of satin finish shall

be provided to avoid dazzle from reflected light. Labels, mounted on dark surfaces shall have white lettering on a black background. All plates shall be of a material, which will not get corroded.

- c) Labeling shall be clear, concise and adequate.
- d) Labels shall be supplied as far as possible in the following four standard sizes
 - (i) Label for fuses and links shall measure approximately 28mm. to 45mm by 13mm. to 19mm. and lettering of 3mm to 6mm. shall be used according to the amount of inscription required. The lettering shall have strokes of approximately 1mm. width.
 - (ii) Labels for relays, contactors, thermal devices and similar apparatus shall measure 65mm. by 20mm. and shall have lettering as specified in (i) above.
 - (iii) Labels for controllers and changeover switches shall measure 70mm by 30mm and where practicable have 20 mm lettering with 1.5 mm strokes.
 - (iv) The labels for the doors of junction boxes, marshalling boxes and similar equipment shall measure 125 mm x 50 mm and have 13 mm, lettering with 1.5 mm wide strokes.
- (e) The labels for mounting outdoor shall be weather and corrosion proof. The letters/diagrams thereon shall be framed by etching or other such process, which will ensure permanence of the lettering/markings.
- (f) Labels shall be attached to panels with brass screws or with steel screws which have received rust preventive treatment.

5.4.13 **VOLTAGE SELECTION AND CONTROL** :

5.4.13.1. **On load tap changers:**

5.4.13.1.1 **General:**

- (a) The OLTC shall be of In Tank, Hi Speed Resistor type.
- (b) OLTC gear shall be motor-operated for local as well as remote electrical operation. An external hand wheel/handle shall be provided for local manual operation.
- (c) On-load tap-changer shall be sourced from reputed manufacturer and it should be type tested as per relevant IEC-60214 and test methods shall be in full conformance to the procedures, indicated in IEC-60214.
- (d) The details of the method of diversion of the load current during tap-changing, the mechanical construction of the gear and control features of OLTC gear shall be submitted with the bid. Information regarding the service experience on the gear and a list of important users shall be furnished. The tap-changer shall change the effective transformation ratio without producing phase displacement.
- (e) The current diverting contacts shall be housed in a separate oil chamber, not communicating with the oil in the main tank of the transformer. On load tap changer shall have maximum rated through current to meet the normal rated load as well as over-load as per standards. The OLTC should also be suitable for an occasional switching at 200% of the OLTC rating as per IEC-60214 which shall be validated with by the type test. The OLTC shall have BIL rating and short circuit withstand current as per relevant IEC standards.
- (f) All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.
- (g) Tap positions shall be numbered consecutively ranging from one upwards. Tap one being the highest voltage ratio.
- (h) Current rating and voltage steps shall be as specified.
- (i) On-load tap changers shall comply with IEC 214:1976 and BS: 4571:1970 and shall be suitable for power flow in both the directions. **Only designs, which have been type tested in accordance with these standards will be accepted. All the type test certificates**

as per the above standards shall be submitted along with the tender bid.

- (j) Current making and breaking switches, associated with the tap selectors shall be contained in a tank in which the head of oil is maintained by means, completely independent of that on the transformer itself.
- (k) Details of maintaining oil separation, oil levels, oil draining/filling/sampling, detection of oil surges and provision of alarm and trip contacts will be dependent on the design of tap-changer and be to the approval of the purchaser. However, a suitable pressure relief device shall be provided for all on-load tap changer compartments. It should be possible to inspect the diverter switch contacts without having to lower the oil in the transformer. Contact tips should be replaceable.
- (l) Transformer on load tap changers shall be equipped with a fixed resistor network, capable of providing discrete voltage steps for input to the supervisory system.
- (m) The Bidder shall indicate the safeguards in order to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.
- (n) Any 'DROP DOWN' tanks, associated with the tap changing apparatus shall be fitted with guide rods to control the movements during lifting or lowering.
- (o) All relays and operating devices shall operate correctly at any voltage between the limits specified.
- (p) The OLTC shall be suitably protected through oil surge relay (OSR). This surge relay shall be tested for an oil flow velocity of 1.20 +/-0.20m/s.

5.4.13.1.2. **MECHANISMS:**

- (a) The drive mechanism chamber shall be mounted on the tank in an accessible position. It should be adequately ventilated and provided with anti-condensation metal clad heaters with thermostatic control. All components inside shall be protected against corrosion, deterioration due to condensation, fungi etc. The door shall be pad-lockable.
- (b) The tap change mechanism shall be designed in such a way that when a tap change has been initiated, it will be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement, not being completed, an approved means shall be provided to safeguard the transformer and its auxiliary equipment.
- (c) Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any condition. For on-load tap change equipment, these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment. Limit switches may be connected in the control circuit of the operating motor, provided that a mechanical de-clutching mechanism is incorporated.
- (d) Thermal devices or other approved means shall be provided to protect the motor and control circuit.
- (e) A permanently legible lubrication chart shall be provided and fitted inside the tap-changing chamber.

5.4.13.1.3 **TAP CHANGE CONTROL PHILOSOPHY:-**

5.4.13.1.3.1 **General:**

The following operating conditions are applicable to the on-load tap changer controls:-

- (a) It must not be possible to operate the electric drive when the manual operating gear is in use.
- (b) It must not be possible for two electric control points to be in operation at the same

time.

- (c) Operation from a control switch shall cause one tap movement only unless the control switch is returned to the off position between successive operations. Subsequent tap changes shall be initiated only by a new or repeat command.
- (d) It shall not be possible for any transformer operating in parallel with one or more other transformers in a group to be more than one tap out of step with the other transformers in the group. On load tap changers shall be equipped with a time delayed INCOMPLETE STEP alarm, consisting of a normally open contact which closes if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.
- (e) All electrical control switches and local manual operating gear shall be clearly labelled in an approved manner to indicate the direction of tap changing i.e., raise and lower tap number.

5.4.13.1.3.2. **Manual Control:**

- (a) The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man, standing at ground level.
- (b) The manual control shall be considered as back up to the motor operated control and shall be inter locked with the motor to block motor start up during manual operation. The manual operating mechanism shall be labeled to show the direction of operation for raising the terminal voltage and vice-versa.
- (c) Manual tap position indicator which shall be complete with the following:-
 - (i) Mechanical tap position indicator which shall be clearly visible from near the transformer.
 - (ii) A mechanical operation counter.
 - (iii) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

5.4.13.1.3.3. **Local and Remote Control:**

Equipment for local, manual and electrical operation shall be provided in an outdoor cubicle. Electrical remote control equipment shall also be supplied on the tap changer. The following control facilities shall be provided: -

- (a) 'Local - Remote' Selector Switch, mounted in the local OLTC, control cabinet. When the selector switch is in 'local' position, it shall be possible to operate the 'raise-lower' control switches, specified in (b) below. Remote control of the raise-lower functions shall be inhibited. When the selector switch is in 'remote' position, the local OLTC control cabinet mounted 'raise-lower' switch, specified in clause (b) below shall be inoperative. Remote control of the raise/lower function shall be possible from the remote control panel. The 'local-remote' selector switch shall have at least two spare contacts per position, which are closed in that position, but open in the other position.
- (b) A 'raise-lower' control switch/push button shall be provided in the local OLTC control cabinet. This switch shall be operative only when 'local-remote' selector switch is in 'local' position.
- (c) An 'ON-OFF' tap changer control switch shall be provided in the local OLTC control cabinet of the transformer. The tap changer shall be in operative in the 'OFF' position. The 'OFF-ON' switch shall have at least one spare contact per position, which is closed in that position, but open in the other position.

1.4.13.1.4. **Control Circuits:-**

The control circuits shall comply with following conditions:-

- (a) An interlock to cut off electrical control automatically upon recourse being taken to the manual control.
- (b) Re-enforcement of the initiating impulse for a tap changer, ensuring a positive completion, once initiated to the next (higher or lower) tap.
- (c) "Step-by-step" operation ensuring only one tap change from each tap changing impulse and a lockout of the mechanism if the control switch (or push button) remains in the "operation" position.
- (d) An interlock to cut out electrical control when it tends to operate the gear beyond either of the extreme tap positions.
- (e) An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for the new position.
- (f) Tap change in progress indication shall be provided by means of an indicating lamp at the purchaser's control panel. Necessary contacts for this and for remote tap position indicator at purchaser's control panel shall be provided by the Bidder.
- (g) Protective apparatus, considered essential by the Bidder according to specialties of the gear.

5.4.13.1.5. Indications: -

Apparatus of an approved type shall be provided on each transformer:-

- (a) To give indication mechanically at the transformer and electrically at the remote control point of the number of the tapping in use.
- (b) To give electrical indication, separate from that specified above, of tap position at the remote supervisory point. Suitable tap position transducer to be incorporated for indication.
- (c) To give indication at the remote control point and at the supervisory control point that a tap change is in progress, this indication to continue until the tap change is complete.
- (d) To give indication at the remote control point and at the supervisory control point when transformers operating in parallel are out of step.
- (e) To indicate at the tap change mechanism the number of operations, completed by the equipment. A six digit counter should be provided for this.

5.4.13.2. LOCAL CONTROL CABINET: -

The local OLTC control cabinet shall house all necessary devices, meant for OLTC control and indication. It shall be complete with the following: -

- (a) A circuit breaker/contactors with thermal overload devices for controlling the A.C. auxiliary supply to the OLTC motor.
- (b) Cubicle light with door switch.
- (c) Space heaters to prevent condensation.
- (d) Padlocking arrangement for hinged door of cabinet.
- (e) Cable terminal glands for power and control cables to the OLTC gear.

5.4.13.3. AUXILIARY SUPPLY FOR OLTC CONTROL AND POWER CIRCUIT :-

Auxiliary supplies as indicated in the specification will be provided by the purchaser at any one place. All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch, housed in the marshalling Kiosk. The design feature for the transfer switch shall include the following: -

- (a) Provision for the selection of one of the feeders as normal source and the other as standby.
- (b) Upon failure of normal source, the loads shall be automatically transferred after an adjustable time delay to the stand by source.

- (c) Indication for failure of the normal source and for transfer to standby source and also for failure to transfer shall be provided locally as well as at the remote control panel.
- (d) Automatic re-transfers to normal source with an adjustable time delay following re-energisation of the normal source.
- (e) Both the transfer and the re-transfer shall be dead transfers and AC feeders shall not be paralleled at any time.
- (f) Necessary isolating switches, MCBs and other components for the above power supply transfer arrangement shall be provided by the supplier.

5.4.14(A). **SUPERVISORY CONTROL:-**

5.4.14.1 **General:-**

- (a) Tap change control equipment shall be suitable for supervisory control and indication with make before break multi-way switch-having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches, which may be required in remote tap position indication.
- (b) Transformer on-load tap changer shall be equipped with a fixed resistor network, capable of providing discrete voltage steps for input to the supervisory system.
- (c) Transformer tap change control will be effected from the sub-station control room with facilities for remote control from the supervisory control centre. Provision for such supervisory control shall be included in this contract.
- (d) The supervisory facilities, outlined in the following sub-clauses will be required and control circuit design must make provision for these.

5.4.14.2. **CONTROLS:-**

- (a) Tap change control remote/supervisory select/deselect:-
N.B.:- Selection of supervisory control shall render voltage control non-automatic.
- (b) Tap position Raise/lower.

5.4.14.3 **INDICATIONS AND ALARMS:-**

- (a) Tap change remote/supervisory indication.
- (b) Tap position indication through appropriate transducer.
- (c) Tap change out of step alarm.
- (d) Tap changer auto/non-auto indication.
- (e) Independent/master/follower indication.
- (f) Tap change in progress indication.
- (g) AVR reference voltage failure alarm.
- (h) Tap changing incomplete (TCINCL).
- (i) Tap changer supply failure alarm.
- (j) Cooling equipment running indication.
- (k) Cooling equipment failure alarm.
- (l) All contacts for supervisory alarms and indications shall be potential free.

5.4.14(B) **Digital RTCC Panel (With 3 nos. Digital RTCC relays and provision for mounting another spare relay)**

- (i) It shall be possible to remotely control and monitor OLTC from Digital RTCC panel. The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**). **The relay shall be of reputed make and shall be in successful operation for at-least 2 years for transformer OLTC application.**

- (ii) Digital RTCC relay should be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and can be easily configurable. If it is supplied as a draw out type module, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors.
- (iii) The digital RTCC Panel shall be provided with digital RTCC relay, Raise/Lower push buttons, Manual/ Automatic mode selector switch and Master / Follower/ Independent/ Off mode selector switch for control of OLTC. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.
- (iv) **In Manual Mode:** In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.
- (v) **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

(vi) Master / Follower/ Independent/ Off mode

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other transformer banks/three phase transformer in the follower mode by operating the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

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

- (vii) **Raise/Lower:** The remote OLTC scheme offered shall have provision to raise or lower taps only for the complete bank of three 1-phase transformers. Individual single phase OLTC operation shall not be possible from the remote control panel.
- (viii) The Digital RTCC relay shall incorporate all the control facilities specified in this specification. The Digital RTCC relay shall be provided for controlling all three phases of a transformer bank. Each Digital RTCC relay shall have integration feature for parallel operation of at least 7 nos. 3-ph transformers or 21nos, 1-ph transformers working in parallel. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.
- (ix) Communication between the Digital RTCC relays in order to execute the commands for parallel operation shall be implemented using hardware and communication protocol, suitable up to a maximum length of 1km.

- (x) Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterise & control OLTC. Any software required for this purpose shall be supplied. The software supplied will not have restriction in loading of multiple computers for downloading and analysing the data. The vendor shall provide necessary provision for SCADA integration with the existing/ future SCADA system. Software shall indicate the current overview of all measured parameters of the connected transformer on-line in real time.
- (xi) It shall be possible to communicate/integrate with all digital RTCC relays of different make located at different locations in the substation by making hardwire and using IEC 61850 communication link. The integration of existing conventional RTCC panel with Digital RTCC panel of different make shall also be possible.
- (xii) The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employers future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.
- (xiii) Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.
- (xiv) "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.
- (xv) Following minimum indications/alarms shall be provided in Digital RTCC panel either through relay display panel or through LEDs:
 - a. INCOMPLETE STEP alarm
 - b. OLTC motor overload protection alarm
 - c. Supply to DM Motor fail alarm
 - d. OLTC IN PROGRESS alarm
 - e. OLTC upper/lower limits reached alarm
 - f. 415V Main AC supply Fail alarm
 - g. 415V Standby AC supply Fail alarm
 - h. Local / Remote Selector switch positions in DM Box
OLTC Tap position indications
for transformer
 - i. 'Independent-combined-remote selector switch positions of CMB

5.4.15. TERMINAL AND CONNECTION ARRANGEMENTS:

5.4.15.1 RATING:

Current rating shall be 1.5 times the rated current of the transformer.

5.4.15.2. OUTDOOR BUSHINGS:

a) Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

b) Bushing for voltage of 52 kV and above shall be RIP bushing with composite polymer insulator. 36 kV bushing shall be solid porcelain or oil communicating type.

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

d) Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

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

f) Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

g) Composite polymer insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be decided during finalization of QAP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test).

h) Clamps and fittings shall be of hot dip galvanized /stainless steel.

i) Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

j) No arcing horns shall be provided on the bushings.

k) RIP bushings shall be specially packed to avoid any damage during transit & suitable for long storage with non-returnable packing wooden boxes with hinged type cover, without any gaps between wooden planks. Packing box opening cover with nails/ screws type packing

arrangement shall not be acceptable. Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawings / documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

l) The terminal marking and their physical position shall be as per IEC: 60076.

m) Tan Delta measurement at variable frequency (in range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing at transformer manufacturing works as routine test before dispatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing. If the bushing Tan Delta goes beyond 0.005 or increase is more than 0.001 within the guarantee period with respect to the pre-commissioning values, the contractor shall arrange to replace the defective bushing by new one. No temperature correction factor shall be applicable for Tan Delta.

5.4.15.3. **TERMINAL CONNECTORS:**

- (a) Bushing terminals shall be provided with terminal connectors of approved type and size for connection to external parts. Terminal connectors, offered must have been successfully type tested as per IS: 5561.
- (b)
 - (i) All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off. The aluminum alloy castings, if used, shall conform to designation A6 of IS: 617.
 - (ii) No part of clamp shall be less than 10 mm. thick.
 - (iii) All ferrous parts shall be hot dip galvanized conforming to IS: 2633. Spring washers and H.T. bolts shall be dectrogalvanised conforming to IS: 1573.
 - (iv) For bimetallic clamp, copper alloy linear of minimum thickness of 2 mm. shall be cast integral with aluminum body.
 - (v) Flexible connectors shall be made from tinned copper sheets.
 - (vi) Size of terminal/conductor for which the clamp is suitable and rated current under site conditions shall be embossed/punched on each component of the clamp, except hardware.
 - (vii) All current carrying parts shall be designed and manufactured to have minimum contact resistance.
 - (viii) The short time rating of terminal connector shall not be less than the short time rating of respective bushing.
 - (ix) Terminal connectors shall be subject to all type, routine and acceptance tests as per IS: 5561 (latest).
 - (x) Malleable cast iron for terminal connectors or any of its parts and accessories shall not be acceptable.
 - (xi) Bolts and Nuts used shall be of stainless steel or galvanized/passivated mild steel.

5.4.15.4. **BUSHING CURRENT TRANSFORMERS:**

- (a) Current transformers shall comply with IEC-60044-1.
- (b) It shall be possible to remove turret mounted C.Ts from the transformer tank without removing the tank cover. Necessary precaution shall be taken to minimise the eddy currents and local heat generated in the turret.

- (c) All secondary leads shall be brought to a terminal box near bushing. These terminals shall be wired out to cooler control cabinet using separate cables for each core.
- (d) Bushing C.T. parameters, indicated in the Specification are tentative and liable to change within reasonable limits. The Bidder shall obtain purchaser's approval before proceeding with design of Bushing C.Ts.
- (e) The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.
- (f) Additional CTS shall be provided, as may be required for winding temperature indicators for each winding and OLTC for parallel operation of the transformers. CT characteristics shall have to match with purchaser's protected relays, meters and instruments.

5.4.15.5. **TERMINAL MARKING:**

Transformer terminals are to be provided with phase markings to the requirements of IEC- 616 and are subject to the agreement of the purchaser. Transformer terminals shall be silver/tin-plated copper.

5.4.15.6 **NEUTRAL EARTHING:**

The neutral terminals shall be brought to ground level by a brass or tinned copper grounding bar of approved size which shall be supported from the tank with porcelain insulators and connected to purchaser's local earth grid. The supplier must liaise with the purchaser or its approved contractor to finalize the details of installation of this earthing and mounting of the outdoor neutral C.T. on this.

5.4.16. **SPECIFICATION FOR CONTROL CABINETS:**

- (a) Control cabinets shall be of the free standing floor mounting type.
- (b) Control cabinet of the operating mechanism shall be made out of 3 mm thick sheet steel or 10 mm thick aluminium plate or casting. Hinged door shall be provided with pad locking arrangement. Sloping rain hood shall be provided to cover all sides. 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protection of at least IP-55 as per IS: 2147.
- (c) Bus bars shall be of tinned copper of adequate cross-section to carry the normal current without exceeding the permissible temperature rise over an ambient temperature of 50 degree centigrade outside the cubicle. The buses shall be braced to withstand forces corresponding to short circuit current of 25KA.
- (d) Motors rated 1 KW and above being controlled from the control cabinet would be suitable for operation on a 415V, 3 Phase, 50 HZ system. Fractional KW motors would be suitable for operation on a 240V, 1- Phase, 50 HZ supply system.
- (e) Isolating switches shall be group operated units (3 pole for use on 3-MCBS phase supply systems and 2 pole for single phase supply systems) quick make quick break type, capable of breaking safely and without deterioration, the rated current of the associated circuit. Switch handle shall have provision for locking in both fully open and fully closed positions.
- (f) Push button shall be rated for not less than 6 Amps. 415V A.C. or 2 Amps, 220/110V D.C. and shall be flush mounted on the cabinet door and provided with appropriate nameplates. Red, Green and Amber indicating lamps shall be flush mounted.
- (g) For motors upto 5 KW, contactors shall be direct-on-line, air break, single throw type and shall be suitable for making and breaking the stalled current of the associated motor which shall be assumed equal to 6.5 times the full load current of the motor at 0.2 p.f. For motors above 5 KW, automatic star delta type starters shall be provided. 3 Pole contactors shall be furnished for 3 Phase motors and 2 Pole contactors for single

phase motors. Reversing contactors shall be provided with electrical interlocks between forward and reverse contactors. If possible, mechanical interlocks shall also be provided. Contactors shall be suitable for uninterrupted duty and shall be of duty category class AC4 as defined in IS: 2959. The main contacts of the contactors shall be silver plated and the insulation class for the coils shall be class E or better. The dropout voltage of the contactors shall not exceed 70% of the rated voltage.

- (h) Contactors shall be provided with a three element positive acting, ambient temperature compensated, time lagged, hand reset type, thermal overload relay with adjustable setting. Hand reset button shall be flush with the front door of the cabinet and suitable for resetting with starter compartment door closed.
- (i) Single phase preventer relay shall be provided for 3 Phase motors to provide positive protection against single phasing.
- (j) Mini starters shall be provided with no volt coils, whenever required.
- (k) Purchaser's power cables will be of 1100/650 Volts grade stranded aluminum conductor PVC insulated, PVC sheathed, single steel wire armoured and PVC jacketed. All necessary cable terminating accessories such as glands, crimp type tinned copper lugs etc. for power as well as control cables shall be included in Bidder's scope of supply. Suitable brass cable glands shall be provided for cable entry.
- (l) Wiring for all control circuits shall be carried out with 1100/650 Volts grade PVC insulated tinned copper stranded conductors of sizes not smaller than 2.5 sq.mm. At least 20% spare terminal blocks for control wire termination shall be provided on each panel. The terminal blocks shall be of non-disconnecting stand type. All terminals shall be provided with ferrules, indelibly marked or numbered and these identifications shall correspond to the designations on the relevant wiring diagrams. The terminals shall be rated for adequate capacity which shall not be less than 10Amps.
- (m) Separate terminal blocks shall be provided for terminating circuits of various voltage classes. CT loads shall be terminated on a separate block and shall have provision for short circuiting the CT secondary terminals.
- (n) Control cabinet shall be provided with 240V, 1 Phase, 50 HZ, 20 W fluorescent light fixture and a suitably rated 240 V, 1 Phase, 5 Amps, 3 Pin socket for hand lamps.
- (o) Strip heaters shall be provided inside each cabinet complete with thermostat (preferably differential type) to prevent moisture condensation. Heaters shall be controlled by suitably rated double pole miniature circuit breakers.
- (p) Signal lamps, provided shall be of neon screw type with series resistors, enclosed in bakelite body. Each signal lamp shall be provided with a fuse, integrally mounted in the lamp body.
- (q) Electric measuring instruments shall be of moving iron type. Ammeters for measuring current upto 30 Amps shall be directly connected while those for measuring above 30 Amps shall be connected through suitable CTs. Ammeters shall be provided with selector switches.
- (r) Items inside the cabinet, made of organic material shall be coated with a fungus resistant varnish.

5.4.17(A) **INSULATING OIL:-**

- (a) The quality of the oil, supplied with the transformer shall conform to IEC-60296 (Mineral oil class 1) and IS: 335 with latest amendment, if any. The percentage of Napthanic content in the oil will be more than 40 % & Paraffinic content will be less than 56%. No oil shall be supplied or used at any stage of manufacture or test without a certificate, acceptable to the Purchaser that it has a PCB content of less than 2 mg/kg. The oil samples will be drawn as follows:-

- (i) Prior to filling.
- (ii) Before and after heat run test.
- (iii) Before energizing.

All tests as per relevant IEC & ISS shall be conducted on all samples.

- (b) Sufficient quantity of oil, necessary for first filling of all tanks, coolers and radiators at the proper level shall be supplied in returnable containers. The **10% extra** oil for topping up shall be supplied in non-returnable containers, suitable for outdoor storage.
- (c) The supplier shall despatch the transformer, filled with oil or in an atmosphere of Nitrogen. In the former case, the Bidder shall take care of the weight limitation on transport and handling facility at site. In the latter case, necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adapter valve shall be provided. **The transformer shall also be fitted with at least two nos. impact recorders during transportation. These impact recorders are on returnable basis.**
- (d) The Bidders shall ensure that the oil supplied is in accordance with the latest editions of the following specifications with amendments, if any.

<u>Sl. No.</u>	<u>Characteristics</u>	<u>Requirement.</u>	<u>Method of Test.</u>
1.	Appearance	The oil shall be clear and transparent & free from suspended matter or sediments.	A representative sample of oil shall be examined in a 100mm thick layer at 27 Deg C temperature.
2.	Density at 29.5 deg.C (Max)	0.89 g/cu.cm.	IS: 1448(Pt-16), 1977 (as per Note-1 of IS-335)
3.	Kinematic viscosity Max at, a) 27 deg.C (max.)	27Cst.	IS: 1448(Pt-25), 1976
4.	Interfacial tension at 27 deg.C (min.)	0.04 N/m	IS: 6104, 1971
5.	Flashpoint penskey Marten (closed) (min.)	140 deg.C	IS: 1448(Pt-21), 1970
6.	Pour point (max.)	-6 deg.C	IS: 1448(Pt-10), 1970
7.	Neutralization value a) Total acidity, (max.) b) Inorganic acidity/Alkalinity (Remarks:- Alcoholic Potassium Hydroxide solution of 0.02N should be used in place of 0.1N indicated in test method)	0.03 mg KOH/G Nil	IS: 1448(Pt-2), 1967 IS: 1448(Pt-2), 1967
8.	Corrosive Sulphur	Non-corrosive	IS: 335 (Annexure 'B')
9.	Electric strength (break down voltage), min. a) New unfiltered oil. b) After filtration.	30 KV (rms) 70 KV (rms)	IS: 6792, 1972.
10.	Di-Electric dissipation factor (tan delta) at 90 deg.C (max.)	0.002	IS: 6262, 1971(See Note of IS-335)
11.	Specific resistance (resistivity) a) at 90 deg.C (min.) b) at 27 deg.C (min.)	35 x 10 ¹² Ohm-cm. 1500 x 10 ¹² Ohm-cm.	IS: 6103, 1971 (See Note -2 of IS-335)
12.	Oxidation stability.		IS-335, Annexure-C

	a)	Neutralization value after oxidation (max.)	0.4 mg KOH/g.	
	b)	Total Sludge after oxidation (max.).	0.10% by weight.	
13.		Presence of Oxidation inhibitor	The oil shall contain anti oxidant inhibitors.	IS: 335 (Appendix 'D')
14.		Water content (max.)	a) Untreated and unfiltered oil- 50 ppm. b) Before commissioning- 10 ppm.	IS: 13567, 1992
15.		Aging characteristics after accelerated ageing(Open beaker method with copper catalyst), As per IS: 12177, 1987, Method-A		
	a)	Resistivity(Min).		
		i) 27 deg.C	2.5 x (10) ¹² Ohm-cm.	
		ii) 90 deg.C	0.2 x (10) ¹² Ohm-cm.	
	b)	Tan delta at 90 deg.C	0.2 (max.).	
	c)	Total acidity.	0.05 mg KOH/gm (max.)	
	d)	Sludge content by weight.	0.05% (max.)	
16.	a)	Napthenic content	More than 40%	Spectroscopic method
	b)	Paraffinic content	Less than 56%	or any other prescribed method.

(e) Particles in the oil:

The particle analysis shall be carried out in an oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength".

(f) Moisture content in solid insulation:

Dummy insulation test block shall be inserted in the active part of transformer at factory and same shall be used to detect the volume of moisture content. Before application of vacuum and oil filling in the transformer, it will be ensured that moisture content in the dummy insulation test block is less than 0.5%. Measurement shall be carried out as per IEC.

The Test certificates to conform the quality of the oil shall be submitted by the supplier. The purchaser at his discretion may depute his representative for witnessing the tests at the works of the supplier or its sub-vendor. The purchaser's representative may recommend for testing of sample oil at CPRI/ERDA including ensuring the percentage of naphthenic and paraffinic content in the offered oil. The cost for such testing shall be borne by the supplier. The purchaser at his discretion may also get the supplied oil, tested at Govt. approved laboratory for determination of quality, naphthenic and paraffinic contents as per specification.

5.4.17(B) Oil Filling:-

(i) Procedures for site drying, oil purification, oil filling etc. shall be done as per Field Quality Plan (FQP).

(ii) The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours for 400kV and 48 Hours for 220kV and below transformer. The vacuum shall be measured on the top of the Transformer tank and should be less than 1mbar.

(iii) Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relay.

(iv) The minimum safe level of oil filling (if different from the Buchholz level) to which the Transformer shall be oil filled under vacuum, shall be indicated in the manual.

(v) The Ultra High Vacuum type oil treatment plant of suitable capacity (minimum 6000 litres per hour) suitable for treatment of oil in EHV class Transformer shall be used in order to achieve properties of treated oil. The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

- a. Removal of moisture from 100 ppm to 3 ppm (max.)
- b. Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
- c. Improvement of dielectric strength break down voltage from 20 to 70 KV
- d. Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
- e. Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
- f. Processing temperature shall be automatically controlled and have an adjustable range from 40°C to 80°C.

5.4.18 **CLEANING, PAINTING AND TROPICALISATION:-**

- (a) All steel surfaces except galvanized surfaces or where otherwise specified, shall be shot blasted to remove all rust, scale and foreign matters from the surface. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. The surfaces shall then be chemically cleaned and surface treated by phosphating and dried in accordance with IS-6005 - "Code of practice for phosphating of iron and steel". Immediately after phosphating, the surfaces shall be given two coats of high quality zinc chromate primer.
- (b) The interior surfaces of mechanism chambers, boxes and kiosks, after preparation, cleaning and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating, followed by two coats of phenolic based finishing paint to white colour, followed by a final coat of anti-condensation white paint of a type and make to the approval of the Purchaser. A minimum overall paint film thickness of 200 microns shall be maintained throughout.
- (c) All steel work and metal work, after preparation and priming shall be painted with one coat zinc chromate primer, one coat of phenolic based under coating and two coats of micaceous iron oxide paint to an overall thickness of 200 microns to hard gloss finishing Light Grey Shade No. 697 of IS:5. Each successive coat of paint shall be of slightly different shade to enable inspection.
The finished surface shall present a pleasing appearance free from dents or unevenness surfaces.
- (d) It is the responsibility of the supplier to ensure that the quality of paints used shall withstand the tropical heat and extremes of weather conditions. The paint shall not peel-off, wrinkle, be removed by wind, storm and handling on site and the surface finish shall neither rust nor fade during the service life of the equipment.
- (e) After erection at site, the interior surfaces of mechanism chambers and kiosks shall be thoroughly examined and any deteriorated or mechanically damaged surfaces of such shall be made good to the full specification, described above.
- (f) After erection at site, all surfaces of steel works and metal works shall be thoroughly washed down and examined. Any deteriorated or otherwise faulty paint work shall be removed down to bare metal and made good to the full specification described above, then painted one further coat of phenolic based under coating and one coat phenolic based hard gloss finishing paint to provide an overall minimum paint film thickness of 200 microns.
- (g) All paint work shall be left clean and perfect on completion of the site works.

5.4.19. **BOLTS AND NUTS:-**

- (a) All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate Indian Standards for metric threads, or the technical equivalent.
- (b) Except for small wiring, current carrying terminal bolts or studs for mechanical reasons shall not be less than 6 mm in diameter.
- (c) All nuts and pins shall be adequately locked.
- (d) Wherever possible, bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position
- (e) All bolts, nuts and washers, placed in outdoor positions shall be treated to prevent corrosion, by hot dip galvanizing. Bolts and Nuts below M12 (12mm.) size shall be of stainless steel. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals
- (f) Where bolts are used on external horizontal surfaces and where water can collect, methods of preventing the ingress of moisture to the threads shall be provided.
- (g) Each bolt or stud shall project at least one thread, but not more than three threads through the nut, except when otherwise approved for terminal board studs or relay stems. If bolts or nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.
- (h) The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.
- (i) Taper washers shall be provided where necessary.
- (j) Protective washers of suitable material shall be provided front and back on the securing screws.

5.4.20. **WIRING AND CABLING:-**

5.4.20.1 (a) Cable box/sealing end shall be suitable for following types of cable.

- i) 415 Volt Power 1100 Volt grade PVC Insulated aluminum conductor cable with armour.
- ii) Control. 1100 Volt grade PVC insulated 7/0.737 mm stranded copper conductor cable with armour.
- (b) Compression type cable connector shall be provided for termination of power and control cables.
- (c) All controls, alarms, indicating and relaying devices, provided with the transformer shall be wired up to the terminal blocks inside the local control cabinets (both cooler and OLTC control cabinets)
- (d) All devices and terminal blocks with the cooler control cabinet shall be clearly identified by symbols, corresponding to those used on applicable schematic or wiring diagrams.

5.4.20.2 **EXCLUSION IN SCOPE OF CABLING:**

Following cabling works are specifically excluded from the scope of the supplier. However, interconnection drawings for the same are to be submitted by the supplier

- (a) Cabling between Remote OLTC panel to cooler control cabinet.
- (b) Cabling between Remote OLTC panel to local OLTC cabinet.
- (c) Cabling between Remote OLTC to supplier's panel.
- (d) Cabling between cooler control cabinet to supplier's panel.
- (e) Cabling between local OLTC cabinet to supplier's panel.

5.4.21. FITTINGS:

The following fittings shall be provided with each transformer, covered in this specification.

- (a) Conservator for main tank with oil filling hole and cap, air-cell, vacuum application valve, vacuum equalizing valve, isolating valves, drain valve, shut off valve, magnetic oil level gauge with low level alarm contacts, dehydrating air breather .
- (b) Conservator for OLTC with drain valve, surge relay (oil flow operated), vacuum application valve, vacuum equalizing valve, magnetic type oil level gauge with low level alarm contacts, oil-level indicator and silica gel breathers.
- (c) Oil preservation equipment.
- (d) Pressure relief devices with alarm/trip contacts.
- (e) Sudden pressure relief relay with alarm contacts.
- (f) (i) Buchholz relay, double float/reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts (Rating 1 Amp. 220V DC) test cock, gas collection box and gas check valve at ground level.
(ii) Separate Oil surge relay with above features to be provided for OLTC chamber.
- (g) Air release plug.
- (h) Inspection openings and covers.
- (i) RIP Bushing with metal parts and gaskets to suit the termination arrangement.
- (j) Winding temperature indicators for local and remote mounting. One RWTI with a four-point selector switch shall be provided.
- (k) Top Oil temperature indicator with maximum pointer along with two sets of contactors.
- (l) Cover lifting eyes, transformer-lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
- (m) Protected type mercury or alcohol in glass thermometer.
- (n) Bottom and top filter valves with threaded male adoptors, bottom sampling valve and drain valve.
- (o) Rating and diagram plates on transformers and auxiliary apparatus.
- (p) Earthing terminals.
- (q) Flanged bi-directional wheels.
- (r) Cooler Control Cabinet with pad locks.
- (s) On load tap changing gear, OLTC DM Box, marshalling box / Cooler control cabinet, Fibre optic sensor box and Digital RTCC Panel as applicable.
- (t) Drain valve plugs shall be provided in order that each section of pipe work can be drained independently.
- (u) Insulating Oil.
- (v) Terminal marking plate.
- (w) Jacking pads/lugs
- (x) Lifting bollards.
- (y) Haulage lugs.
- (z) Cover lifting lugs.
- (z) Valve schedule plate.
- (aa) Bushing CT
- (bb) Cooling fans
- (cc) Motor pumps
- (dd) Marshaling Box
- (ee) Digital RTCC Panel
- (ff) Bushing Terminal Clamps & Connectors

- (gg) Oil flow indicator
- (hh) Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition.
- (ii) Flow sensitive conservator isolation valve.
- (jj) Nitrogen Injection Type Fire Prevention and extinguishing system.
- (kk) Valves, as indicated at Cl.No.5.4.2 of this Specification
- (ll) Wiring up to marshaling box with PVC SWA PVC copper cables, 1100Volts grade.
- (mm) Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.
- (nn) Online insulating oil drying system.
- (oo) Online dissolved gas(Multi gas) & moisture analyzer
- (pp) Optic Fiber Temperature Sensor System as per this Technical Specification.

Note: - The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of the above rated transformers are deemed to be included.

5.4.22. LIMITS OF TEMPERATURE RISE :-

The temperature rise on any part of equipment shall not exceed the maximum temperature rise specified below under the conditions specified in test clauses. The permissible temperature rise indicated is for a maximum ambient temperature of 50 degree C. If the maximum ambient temperature rises, permissible values shall be reduced accordingly. For actual maximum temperature at the location of installation, refer perfect synopsis.

Sl. No.	Nature of the part or of the liquid.	Maximum value of:	
		Temperature.	Temperature rise at a Maximum ambient air Temp. not exceeding 50 degree C.
1	Contacts in air, silver-faced copper, Copper alloy or aluminium alloy (see Notes (i) & (ii). Bare copper or tinned aluminium alloy.	95 75	40/45 25
2	Contacts in oil: Silver-faced copper, copper alloy or Aluminium alloy [see note- (i)].	90 80	40 30
3	Terminals to be connected to external Conductors by screws or bolts silver faced (see note (iii)).	105	55
4	Metal parts acting as springs.	(See note iv).	(See note iv).
5	Metal parts in contact with insulation of the following classes: Class Y: (for non-impregnated Materials). Class A: (for materials immersed in oil or impregnated). Class E: in air In oil Class B: in air In oil Class F: in air	90 100 120 100 130 100 155	40 50 70 50 80 50 105

	In oil	100	50
	Enamel: oil base	100	50
	Synthetic, in air	120	70
	Synthetic, in oil	100	50
6	Any part of metal or of insulating Material in contact with oil, except Contacts.	100	50
7	Oil	90	40

- Notes: (i) When applying the temperature rise of 45° C, care should be taken to ensure that no damage is caused to the surrounding insulating materials.
- (ii) The quality of the silver facing shall be such that a layer of silver remains at the points of contact after the mechanical endurance test. Otherwise, the contacts shall be regarded as 'bare'.
- (iii) The values of temperature and temperature rise are valid whether or not the conductor connected to the terminals is silver-faced.
- (iv) The temperature shall not reach a value where the elasticity of the material is impaired. For pure copper, this implies a temperature limit of 75°C.

5.4.23. **MOTORS & MCBS:**

- (a) All motors shall comply with IS: 325 and IEC 34 and dimensions with IEC-72. They shall be capable of operating continuously under actual service conditions without exceeding the specified temperature rises, determined by resistance, at any frequency between the voltage and frequency fluctuation, stated in this specification.
- (b) All miniature circuit breakers shall be provided with auxiliary contacts for remote indication of circuit breaker operation. Means shall be provided to prevent the miniature circuit breakers, being inadvertently switched to the 'OFF' Position. Miniature circuit breakers shall be mounted in such a manner so as to give easily visible indication of breaker position and shall be grouped and spaced according to their function in order to facilitate identification and easy replacement.

5.4.24. **SPECIAL TOOLS AND TACKLES:-**

One Set of hand tools of 'Taparia' or 'GEDORE' Make, packed in a carry bag/box, broadly comprising of double ended spanners (Open jaws, cranked ring, tubular with Tommy bar, of different sizes as used in the Transformer –one set), adjustable wrenches (of different sizes as used in the Transformer –one set), gasket punches (of different sizes as used in the Transformer –one set), pliers (flat nose, round nose and side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle(one),adjustable hacksaw(one), cold chisel(one), Bushing Handling & lifting tools with Nylon Rope/belt, Chain Block(2 Nos.) and D-shackle shall be supplied for each Transformer.

5.4.25. **LIST OF MANDATORY SPARES FOR THE ENTIRE LOT OF TRANSFORMER**

- (a) The supplier shall provide the mandatory spares, detailed below and shall, where considered necessary, provide a list of recommended spare parts together with their individual prices. The purchaser may order all or any of the spare parts, listed at the time of contract award and the spare parts, so required by the purchaser, shall be supplied as part of this contract. Additional spares may be ordered at any time during the contract at the rates, stated in the purchase order.

<u>Sl.No.</u>	<u>Description.</u>	<u>Quantity.</u>
1	HV Bushing(RIP) with metal parts and gaskets.	1 no

2	IV Bushing(RIP) with metal parts and gaskets	1 no
3	Tertiary Bushing(RIP) with metal parts and gaskets.	1 no
4.	Neutral Bushing(RIP) with metal parts and gaskets.	1 no
5	Local and remote winding temperature indicators with contacts.	1 set
6	Oil temperature indicator with contacts.	1 set
7	Pressure relief device.	1 no
8	Magnetic oil level gauge with low oil level alarm contacts	1 No
9	Oil flow indicator with contacts.	1 No
10	Cooler pump with motor.	1 no
11	Cooler fans with motor.	1 No
12	Buchholz relay.	1 No
13	<u>Tap position indicator (Local and remote).</u>	<u>1 No.</u>
14	<u>Expansion joint (complete replacement for transformer).</u>	<u>1 Set.</u>
15	Oil sampling bottle.	3 Nos.

N.B.:-

- (a) The Supplier shall ensure that sufficient spare parts and consumable items are available for his own use during commissioning of the transformer. The spares, provided with the transformer shall not be used by the supplier without the written consent of the Purchaser and any spares, used during the commissioning of the transformer shall be replaced by the supplier at his own expense.
- (b) The Supplier shall provide a list in the schedule, of additional recommended spare parts together with their individual prices. The Purchaser may order at a later date, at a price, indicated on the schedule, such additional spare parts, listed at the time of contract award.
- (c) Spares shall be available during the life of the equipment and the Supplier shall give 12 months notice of his or any Sub-Suppliers, intention to cease manufacture of any component used in the equipment.
- (d) Any spare apparatus, parts and tools shall be subject to the same Specification, tests and conditions as similar material, supplied under this contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts, supplied with the transformer and must be suitably marked and numbered for identification and prepared for storage by greasing and painting to prevent deterioration.
- (e) All spare apparatus or materials, containing electrical insulation shall be packed and delivered in cases, suitable for storing such parts or material over a period of years without deterioration. Such cases shall have to be affixed to both the underside and topside of the lid a list detailing its contents. The case will remain as the property of the Purchaser.

5.4.26 OIL STORAGE TANK:

(i) **General**

This specification covers supply of Oil Storage Tank of 25 cubic meter capacity along with complete accessories.

(ii) **Standard**

The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS: 803 or other internationally acceptable standards.

(iii) **Specifications**

Transformer oil storage tanks shall be towable & rested on pneumatic types of adequate quality & size. The tank shall be to cylindrical shape & mounted horizontally and made of mild steel plate of adequate thickness. Size of the storage tank shall be follows:

Diameter : 2.5 meter

Capacity : 25 cubic meters

The tank shall be designed for storage of oil at a temperature of 100°C.

- (iv) The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 meters above road top.
- (v) The tank shall have adequate number of jacking pads so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.
- (vi) The tank shall be also fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. Bidder shall indicate the engine capacity in horse power to pull one tank completely fitted with oil. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Four nos. of suitable rubber hoses with couplers and unions each not less than 10 meters long shall also be provided.
- (vii) The internal & external surfaces to be painted shall be shot or sand blasted to remove all rust and scale of foreign adhering matter or grease. All steel surfaces in contact with insulating oil shall have to be painted with two coats of heat & oil resistant anti-corrosive paint.

All steel surfaces exposed to weather shall be given primary coat zinc chromate, second coat of oil & weather resistant paint of a colour distinct from primary and final two coats of glossy oil & weather resistant light grey paint in accordance with shade no. 697 of IS: 5. All paint shall be carefully selected to withstand heat & extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. The minimum thickness of outside painting of tank shall be 20 microns per coat the total thickness shall be within 70 to 100 microns.

- (viii) The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers suitable for rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electrical motor driven and shall have a discharge of not less than 6 kLph with a discharge head of 8 Mtr. The pump motor and the control cabinet shall be enclosed in cubicle with IP55 enclosure.

5.4.27 OIL SAMPLING BOTTLE:

- (i) Oil sampling bottle suitable for collecting oil sample from transformer for dissolved gas analysis shall be supplied. Bottles shall be robust enough so that no damage occurs during frequent transportation of samples.

- (ii) Oil sampling bottle shall be made of Stainless Steel having capacity of ONE litre.
- (iii) Oil sampling bottle shall be capable of being sealed gas tight and shall be fitted with cocks on both ends.
- (iv) The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
- (v) An impermeable oil proof transparent plastic or rubber tube of about 5 mm diameter and of sufficient length shall also be provide with each bottle along with suitable connectors to fit the tube on to the oil sampling valves of the equipment and the oil collecting bottle respectively.

5.4.28 NITROGEN INJECTION TYPE FIRE PREVENTION & EXTINGUISHING SYSTEM:-

5.4.28.1 General:- Scope of work is to design, supply, erection, testing and commissioning of Nitrogen Injection system for protection against the transformer explosion and fire for 400 KV Transformers including all required civil works of oil sump, foundations, any other required for satisfactory working of system. The NIFPS shall be guaranteed as per clause no. 18 of GTCC.

Each oil filled transformer shall be provided with a dedicated Nitrogen Injection system for prevention against the transformer explosion which shall use nitrogen as quenching medium. The system shall prevent transformer oil tank explosion and possible fire in case of internal / external cause. In the event of fire by external causes such as bushing fire, OLTC fires, fire from surrounding equipment etc., it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water or carbon dioxide. Fire shall be extinguished within reasonable time (not more than 3 minutes so as not to harm the transformer) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection. The offered NIFPS system should have been in successful operation in Indian installations for at least last five years for protection of transformers of 220 KV and higher voltage class. The list of past supplies in India along with performance certificate from Central or State Government Power sector utilities, using the above system shall be submitted along with the bid offer.

Nitrogen Injection system should be a dedicated system for each oil filled transformer. It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the firewall (if fire fighting wall exists). The FEC shall be connected to the top of transformer / reactor oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer / reactor tank / or existing oil pit) from its bottom through oil pipes. The FEC should house a pressurized nitrogen cylinder (s) which is connected to the oil tank of transformer /reactor oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to FEC and from TCIV to signal box. Detectors placed on the top of transformer / reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

5.4.28.2 Activation of the system

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below

flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

Mal-functioning of the Nitrogen injection system could lead to interruption in power supply. The supplier shall ensure that the probabilities of chances of malfunctioning of the Nitrogen injection system are practically zero. To achieve this objective, the supplier shall plan out scheme of activating signals which should not be too complicated to make the system inoperative in case of actual need. The system shall be provided with automatic controls to prevent the explosion of transformers. Besides automatic control, remote electrical push button control at Control box and local manual control in the cubicle shall also be provided. The following electrical-signals shall be used for activating the system under prevention mode/fire extinguishing mode.

5.4.28.2.a Auto Mode

For prevention:

- Differential relay operation.
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)
- Tripping of all circuit breakers (on HV & LV/IV side) associated transformer / reactor is the pre-requisite for activation of system.

For extinguishing

- Fire Detector
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay).

Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system.

5.4.28.2.b Manual Mode (Local / Remote)

Tripping of all circuit breakers (on HV & LV / IV side) associated with transformer / reactor is the pre-requisite for activation of system.

5.4.28.2.c Manual Mode (Mechanical)

- Tripping of all circuit breakers (on HV & LV / IV side) associated with transformer / reactor is the pre-requisite for activation of system.

The system shall be designed to be operated manually in case of failure of power supply to the system.

5.4.28.3 Operation

On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

- Electrical isolation of transformer shall be an essential pre-condition for activating the system, to avoid nitrogen injection in energized transformer.
- The system shall have provision of testing on live transformers to ensure healthiness at all times.
- The system shall have mechanical locking arrangement for nitrogen release system as well as oil drain to avoid unnecessary operation during maintenance and /or testing of the transformer and / or system.
- The system shall have provision to monitor nitrogen injection pressure as well as cylinder pressure.
- Pressure monitoring switch for back up protection for nitrogen release as redundancy to first signal of oil draining commencement for nitrogen release shall preferably be provided.
- System shall have individual mechanical release devices and provision for oil drain and nitrogen release to operate manually in case of operation DC supply failure.
- Nitrogen release scheme shall be designed in such a way that the nitrogen gas shall not enter the energized transformer tank even in case of passing / leakage of valve.
- Individual system component / equipment should operate on station DC voltage. AC-DC / DC-DC converter shall not be used for reliable operation.
- All outdoor panels / equipment shall be of IP-55 protection class.

5.4.28.4 System components:-

Nitrogen Injection system shall broadly consist of the following components. However, all other components which are necessary for fast, reliable and effective working of the system shall be deemed to be included in the scope of supply.

5.4.28.4.a CUBICLE (FEC):-

The Cubicle Frame shall be made of CRCA sheet of 3 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5). It shall have hinged / hinged split doors fitted with high quality tamper proof lock. The doors, removable covers and panels shall be gasketed all round with neoprene gaskets. The degree of protection shall be IP55. The following items shall be provided in the Cubicle.

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer / reactors.
- Panel lighting (LED Type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.
 - Space heater.

5.4.28.4.b Under Ground Oil Storage Tank:-

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non Corrosive, water proof, epoxy coated (from Inside) mild steel

(minimum thickness 6 mm) to store drained-out oil on operation of NIFPS. The tank shall be painted from outside as per Clause no. 5.4.8. The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipes and physical connections from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made up of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalized during detailed engineering.

5.4.28.4.c Control box:-

Control box is to be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

- System Oil.
- TCIV open.
- Oil drain valve closed.
- Gas inlet valve closed
- TCIV closed
- Detector trip
- Buchholz relay trip
- Oil drain valve open
- Extinction in progress
- Cylinder pressure low
- Differential relay trip
- PRV / RPRR /OSR trip
- Transformer / reactor trip
- System out of service
- Fault in cable connecting fault detector
- Fault in cable connecting differential relay
- Fault in cable connecting Buchholz relay
- Fault in cable connecting PRV / RPRR / OSR
- Fault in cable connecting transformer reactor trip
- Fault in cable connecting TCIV
- Auto / Manual / Off
- Extinction release on / off
- Lamp test
- Visual / Audio alarm for AC supply fail
- Visual / Audio alarm for DC supply fail

As far as possible, the control box should be so devised that all the transformers and reactors or group thereof should be controlled from single spot.

5.4.28.4.d Transformer Conservator Isolation Valve:-

Transformer conservator isolation valve (TCIV) is to be fitted in the conservator pipe line, between conservator and buchholz relay, which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling,

locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator.

The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer / reactor.

Locking plates shall be provided for pad locking.

5.4.28.4.e Detectors:-

The system shall be complete with adequate number of detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

5.4.28.4.f Signal box:-

It shall be mounted away from transformer / reactor main tank, preferably near the transformer marshaling box, for terminating cable connections from TCIV & detectors and for further connection to the control box. The degree of protection shall be IP55.

5.4.28.4.g Cables:-

Fire survival cables (capable to withstand 750° C.) of 4 core x 1.5 sq. mm size for connection of detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-2-1 or relevant Indian standards.

Fire Retardant Low Smoke(FRLS) cable of adequate size shall be used for connection of signal box / marshaling box near transformer / reactor and FEC mounted near transformer/ reactor with control box mounted in control room.

Fire Retardant Low Smoke (FRLS) cable of 4 core x 1.5 sq. mm size shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshaling box to transformer conservator isolation valve connection on transformer / reactor. Separate cables for AC supply & DC supply shall be used.

5.4.28.4.h Pipes:-

Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

5.4.28.4.i Other items to be supplied:-

- a) Oil drain and nitrogen injection openings with gate valves on transformer / reactor tank at suitable locations.
- b) Flanges between Buchholz relay and conservator tank for fixing TCIV.
- c) Detector brackets on transformer / reactor tank top cover.
- d) Spare potential free contacts activating the system i.e. in differential relay, Bucholz relay. Pressure Relief Device / RPRR , Circuit breaker of transformer / reactor.
- e) Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.
- f) Cabling for detectors mounted on transformer / reactor top cover.
- g) Inter cabling between signal box, control box and FEC.
- h) Butterfly valves / Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.
- i) Supports, signal box etc. which are to be painted with enameled paint.
- j) Any other item required for satisfactory operation of system.

5.4.28.5 Power supply:-

For Control Box: As per substation DC voltage.

For FEC Auxiliary: 230 V AC

5.4.28.6 Modification on the transformer:-

No modification on the transformer shall be allowed which affects its performance (i.e. efficiency, losses, heat dissipation ability etc.) safety, life etc. or its any other useful parameter. This requirement shall be of paramount importance and shall form the essence of the contract.

However, in any case, performance of transformer should not be affected in any manner by having Nitrogen Injection Fire Prevention Cum Extinguishing System (NIFPES) and the Contractor / Sub-Contractor shall give an undertaking to this effect. All pipes should be washed / rinsed with transformer oil. If any damage is done to the transformer and / or any connected equipment during installation, commissioning, full recovery therefore shall be effected from the Contractor / Sub-Contractor, of NIFPES system.

It shall be solely the responsibility of Contractor / Sub-Contractor to install, carry out pre-commissioning tests & commission NIFPES at the mentioned Sub-Station in this specification, to the entire satisfaction of the OPTCL.

5.4.28.7 Interlocks:-

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PRV shall get closed only if all the connected breakers are open.

5.4.28.8 Tests:-

Supplier has to carry out the type test as per relevant IS/IEC. Specifically IP 55 on FEC or have to produce the report from NABL approved Lab.

Reports of all routine test conducted as per relevant IS/IEC standards in respect of various bought out items including test reports for degree of protection for FEC / control box / signal box shall be submitted by the supplier.

The supplier shall demonstrate the entire functional tests, associated with the following as Factory Acceptance Tests:

- FEC, Control Box
- Fire Detector
- Transformer Conservator Isolation Valve

The performance test of the complete system shall be carried out after erection of the system with transformer at site.

Detailed layout drawings, equipment drawing along with 4 sets of Operation and Maintenance manual along with soft copies (In CDs) shall be submitted by the supplier along with the consignment.

The guaranteed technical particulars for the offered system are indicated in Ann-IV. Any other particulars, considered necessary in addition to those listed in that Section may be furnished by the Bidder.

5.4.29 ON LINE INSULATING OIL DRYING SYSTEM (Cartridge type):-

Each Transformer shall be provided with an on-line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be,

- i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).
- ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.
- iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.
In case, drying system is transported with oil, the oil shall conform to OPTCL specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.
- iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.
- v. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.
- vi. The equipment shall be capable of transferring data to substation automation system conforming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the supplier for integration with automation system.
The equipment shall be supplied with Operation Manual (2 sets for every unit), Software (if any), and Compact disc giving operation procedure, Maintenance Manual & Trouble shooting instructions.

5.4.30 ON LINE DISSOLVED GAS (MULTI-GAS) AND MOISTURE ANALYSER:-

- a. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including in built display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.
- b. The equipment shall detect, measure and analyse the following gases.

Gases & Moisture Parameters	Typical Detection Range
H ₂	5 – 5,000 ppm
CH ₂	5 – 5,000 ppm
C ₂ H ₆	5 – 5,000 ppm
C ₂ H ₄	3 – 5,000 ppm
C ₂ H ₂	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO ₂	20 – 30,000 ppm
H ₂ O	2 – 100 % RS should have facility for measurement of

	moisture in oil in ppm
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- c. The analyser should measure (not calculate) all above gases and should have 100 % sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the supplier for integration with automation system. The necessary type test report for such confirmations shall be submitted during detailed engineering.
- d. Equipment shall have facility to give SMS to at least three users where never any fault gas violates the predefined limit.
- e. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.
- f. Online DGA shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV /HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55⁰C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer’s Warranty.
- g. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analyses. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable) shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) up-to warrantee period shall be included in the scope of supply.
- h. The equipment must have an automatic Calibration facility at fixed interval. For calibration if anything required including cylinder must be mounted with the Equipment.
- i. The technical feature of the equipment shall be as under

Accuracy	± 10%
Repeatability	± 3% to 10% depending upon gases
Oil temperature range	- 20 ⁰ C to + 120 ⁰ C
External Temp. Range	-20 ⁰ C to + 55 ⁰ C (External temp range of 55 ⁰ C is important and should not be compromised due to Indian ambient & operating conditions).
Humidity range	10 to 95%
Operating Voltage	250 Vac; 50 Hz (± 20% variation)

Communications	USB & IEC 61850 compliant
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j) Software for fault indication and fault diagnostics shall include following :

Fault indication:

- IEEE, IEC or user configurable levels of dissolved gases
- Rate of change trending

Fault Diagnosis:

- Key gases
- Ratios (Rogers, IEC. etc.)
- Duval's Triangle

k) The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall also form a part of supply.

- i) Software
- ii) Operation Manual (2 set for every unit)
- iii) Software manual and
- iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

l) The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

5.5 **CENTRE OF GRAVITY:**

The center of gravity of assembled transformer shall be as low and as near the vertical center line as possible. The transformer shall be stable with and without oil. The location of the center of gravity, relative to track shall be clearly marked in the outline drawing, accompanying bid.

6.0 **INSPECTION AND TESTING:-**

6.1 **TESTING FACILITIES:-**

- a) Bidders shall submit along with the bid, the details of testing facilities, available at their works for carrying out all the routine and type tests, as specified.
- b) In case, the test facilities for any particular test are not available at the bidder's works, this shall be clearly brought out in the additional information schedule and proposed arrangement of carrying out that test shall be clearly indicated.
- c) All the measuring systems, used for the tests have certified, traceable accuracy and are subjected to periodic calibration, according to the rules of 4.11 of ISO 9001[Ref-Cl.No.10 (Tests) of IEC-60076-1]
- d) OPTCL at its discretion may use their own testing equipment(s) or third party testing equipment(s) such as Power Analyzer, D.C. Resistance meter etc. during Routine test/Type test of the Transformers at the Bidder's Works. The test results of OPTCL/Third party instrument will be accepted for the purpose of the contract. During testing & inspection, of the Transformer, it shall be ensured to the Inspecting Officers that there must be direct connections from the secondary of the unit auxiliary testing transformer and from the secondaries of the testing instrument transformers to the power analyzer without any termination or any other parallel connection, what so ever. The measuring instruments with connections should be positioned in such a manner that there shall be easy access to the above instruments / equipment at the time of

testing by Inspecting Officers.

6.2 **GENERAL:-**

Inspection and testing shall be carried out on the transformer as detailed here and generally in accordance with IEC 76 and IS: 2026. The Purchaser shall have the right to reject a transformer, if test results do not comply with the standards/values, specified and information /data, given in the schedules. For the purpose of determining when type tests are required, a transformer is considered to be representative of others only if it is fully identical in design, rating and construction.

Before and after acceptance testing, samples of oil shall be taken from the transformer and analyzed for dissolved gases, using the procedures, specified in IEC Publications 567 and 599. Results of the analysis of gases, dissolved in the oil shall be immediately submitted to the Purchaser and included in the Acceptance Test Report. On completion of acceptance testing, the Supplier shall provide the Purchaser with seven copies of the complete test reports.

Full details of the proposed methods of testing including connection diagrams shall be submitted by the Supplier for approval at least one month before testing. All tests will be witnessed by the Purchaser.

The Purchaser shall have full access at all times to the works and all other places of manufacture of the transformers. The Supplier shall report to the Purchaser monthly or other period, as agreed between the two on manufacturing progress. The Supplier shall give the Purchaser on award of contract a complete manufacturing inspection program to allow the Purchaser, at its discretion, to inspect at all stages of transformer manufacture.

6.3 **STAGE INSPECTION: -**

Stage inspection on core, windings, tank, OLTC and all other accessories etc. will be carried out by the Supplier in the presence of OPTCL's representative on free of cost to OPTCL before tanking of the core and windings. All the measurements will be taken on the above components, so as to ensure their compliance to the above Specification and the Guaranteed Technical Particulars. The possible routine tests like measurement of D.C. resistance, no load current and no load loss, determination of Knee Point Voltage, determination of core hot spot temperature[As per Cl. No – 3.21, Section-BB of CBIP Manual, Publication No -317 and as specified at Cl. No. 9.2.2.(i) of this spec], specific core loss, tank tests etc. will be conducted during stage inspection. For determination of number of turns in the windings, the manufacturer shall provide dummy core, so as to accommodate the LV winding and determining the ratio between the unknown No. of turns (winding) and known No. of turns, wrapped around the LV winding. The purchaser's representative at his discretion may choose small strips of core for testing at CPRI/ERDA. Also, a small piece of conductor for each type of winding and core material shall be made available to the purchaser's representative. Apart from the above, the purchaser at his discretion reserves the right to carry out the stage inspection at other stages also, for which advance intimation shall be given and all necessary co-operation shall be rendered by the manufacturer.

The Supplier shall give at least 3 weeks notice in advance for deputing Inspecting Officer(s) to their works. Type Tests and routine tests on the transformer shall be conducted only if the stage inspection report and the pre-tanking tests are found to be in order as per this Specification.

6.4 **FINAL INSPECTION& TESTING:-**

Before offering for final inspection, type tests and routine tests, the Supplier shall furnish the factory test results (except dielectric tests) of the offered transformer(s) along with list of equipments/meters/instruments, to be used, during testing (both routine and type tests) as per Annex of this Specification along with calibration certificates of measuring instruments. The Purchaser may direct the Supplier for use of better equipments/meters during inspection/testing. The calibration of all the meters/instruments to be used during testing should have been done in Government approved laboratory.

6.4.1 **TYPE TESTS & SPECIAL TESTS:-**

The followings shall be regarded as type tests and shall be carried out in presence of Purchaser's representative on one unit out of the lot at the discretion of the purchaser. The charges for conducting each type test shall be quoted in the relevant price schedule.

(a) **Temperature Rise Test:-**

Test of temperature rise (IEC Publ. 76.2): This test shall be carried out on the tap giving the worst combination of loading on the transformer windings. The transformer shall be tested by feeding the tested losses or quoted losses, whichever is higher. The supplier, before carrying out such tests, shall submit detailed calculations, showing the alternatives possible on various taps and for the three different ratings ONAN/ONAF/OFAF(or ODAF) of the transformer and shall recommend the combination that results in highest temperature rise for the test. Temperature rise shall be measured at ONAN, ONAF & OFAF(or ODAF) ratings. Gas chromatographic analysis on oil shall be carried out before and after the temperature rise test and the results recorded in the test report. Sampling shall be in accordance with IEC 60567. For evaluation of the gas analysis in temperature rise test, the procedure shall be as per IS: 9434 (based on IEC: 60567) and the results will be interpreted as per IS: 10593 (based on IEC-60599). These results shall be treated as reference during future maintenance of Transformers. The calibration of OTI and WTI shall be done by transformer manufacturer and these calibrated OTI; WTI shall be used during testing of the transformer. The Sr.No.of WTI and OTI should be recorded during testing of the Transformer and only these OTI & WTI shall be supplied with the Transformer. The Optic Fiber Temperature Sensor System shall be operational during temperature tests and be demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified and temperature data for all probes (hourly readings) recorded and reported in the test report. The final hot spot temperature rise of the windings above ambient temperature after completion of last one hour before taking shut-down for hot resistance measurement shall not exceed 54 deg. C [for ONAN, ONAF & OFAF (or ODAF) ratings] and the top oil temperature rise above ambient temperature shall not exceed 40 deg. C [for ONAN , ONAF & OFAF(or ODAF) ratings ratings].

(b) **Measurement of Zero Sequence Impedance:-**

Measurement of open circuit and short circuit zero sequence impedances of the primary and secondary windings.

(c) **Auxiliary Power Consumption:-**

Measurement of power taken by fan and oil pump motors.

(d) Vacuum Test:-

One transformer tank of each size shall be subjected to full vacuum and tested at an internal pressure of 3.33 KN/Sq.m. (25 Torr) for one hour. The permanent deflection of

plates after the vacuum has been released shall not exceed the values, specified below and the performance of the transformers shall not be affected in any way.

<u>Horizontal length of flat plate (mm.)</u>	<u>Permanent deflection (mm.)</u>
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

The purchaser at his discretion may opt for vacuum test for the tanks of all the transformers, by paying extra cost to the supplier at their quoted price(s).

(e) Pressure Test:-

One transformer tank of each size together with its radiators, conservator vessel and other fittings shall be subjected to a pressure, corresponding to twice the normal head of oil or to the normal pressure plus 35KN/Sq.m. whichever is lower. The applied pressure shall be measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after excess pressure has been released shall not exceed the values, specified in (d).

The purchaser at his discretion may opt for pressure test for the tanks of all the transformers, by paying extra cost to the supplier at their quoted price(s).

(f) IP-55 Test:-

One cooler control cabinet and OLTC cabinet for each type of transformer shall be tested for IP-55 protection in accordance with IS-2147/IEC-529.

Test reports towards all type tests as per IEC-214:1976 and BS: 4571:1970 for the offered OLTC along with approved drawings to be submitted. Purchaser at his discretion may insist on repetition of some or all the applicable type tests as per above IEC & BS.

N.B.:- 1) Any other test as per IS / IEC with amendments if any, shall also be carried out with no extra cost to OPTCL.

2) The transformer offered or higher capacity (Both MVA & voltage rating) should have been tested as per the above type tests [6.4.1(a) to (f)] and chopped Lightning Impulse tests, as prescribed in this specification in presence of authorized representative(s) of Government Utilities. The bidder shall furnish four sets of such type & special test reports including Lightning Impulse Test Report (chopped Impulse) (indicating therein the type and design details) along-with the offer without which the tender may be rejected. These tests should have been conducted not before five years from the date of opening of bid.

3) Test reports towards all type tests as per IEC-214: 1976 and BS: 4571:1970 for the offered OLTC along with approved drawings are to be submitted. Purchaser at his discretion may insist on repetition of some or all the applicable type tests as per above IEC & BS, at supplier's cost, if any discrepancy/deviation/deficiency is noticed in the type test reports.

4) If it is desired by the Purchaser that the 'Short Circuit Test' at CPRI, Bangalore/Bhopal or any other test lab. needs to be conducted on any unit, randomly selected for 'Short Circuit Test', the firm will make all necessary arrangements for above Test and expenditure on above will be reimbursed by OPTCL on actual basis.

6.4.2. **ROUTINE TESTS:-**

The followings shall be regarded as routine tests and shall be conducted on each transformer in the presence of purchaser's representative. No extra cost shall be paid for these tests.

- (a) **Measurement of winding D.C. resistance.**
- (b) **Voltage- ratio measurement and check of vector group.**
- (c) **Measurement of capacitance and dielectric dissipation factor.** (Before and after the series of dielectric tests). The capacitance test shall be carried out with the help of ampere turn bridge method on fully assembled transformer (filled with oil) to determine capacitance and tan delta between winding and earth as under:
 - i) HV and IV winding with LV winding and tank earthed.
 - ii) LV winding with IV and HV winding and tank earthed.
 - iii) HV, IV and LV windings with tank earthed.
- (d) **Measurement of Polarisation Index :-**This measurement shall be made with ten minute and one minute IR tests and should be repeated after all other tests.
- (e) **Impulse Test:**
 - (i) Full Wave Impulse Voltage withstand Test: - The test voltage shall be applied to each line. The applied voltage shall be the relevant lightning impulse voltage, specified in the schedule of requirements. This test shall be applied to each HV, IV & LV Phase terminal.
 - (ii) Chopped wave impulse voltage withstand test: - The test voltage shall be applied to each line terminal. The applied voltage shall be 110% of the specified relevant lightning impulse voltage, as per IEC-60076;Part-III, 2013. This test shall be applied to each HV, IV & LV Phase terminal.
 - (iii) Switching Impulse Tests on each HV phase terminals as per relevant IEC shall be carried out.
 - (iv) An impulse test on transformer neutrals as per IEC-76-3 Clause 12.3.2 shall be carried out.
 - (v) Measurement of transferred surge on LV (tertiary winding) due to HV lightning Impulse and IV lightning Impulse.

Tests (i) and (ii) shall be combined in a single sequence as follows for each line terminal:-

1. One reduced full impulse .
2. One 100% full impulse.
3. One or more reduced chopped impulse(s).
4. Two 100% chopped impulses.
5. Two 100% full impulses.

The sequence for test (iii) & (iv) shall be as follows:-

1. One reduced full impulse at 50-75% of full level.
2. Three 100% full impulses.

In carrying out the above tests, the two extreme taps and another tap to be selected by the purchaser with each of the three phases, being tested on a different tap.

- (f) **Separate source voltage withstand test:-**
The applied voltage shall be the specified/relevant power frequency voltage.
- (g) **Induced over-voltage withstand test:-**
Test shall be carried out as per IEC-76-3, clause 11.4 (Method 2). The firm shall

have to submit the over-potential diagram with details of calculation and explanation along with the offer for inspection.

(h) **Partial discharge test:-**

This test shall be carried out using a broad band instrument during the whole application of long duration induced AC voltage test (ACLD) as per clause no. 12.1 of IS:2026 (Part-3):2009 and IEC 60076-3:2000. The voltage time envelope shall be as described in clause 11.4 of IEC 76-3. The apparent charge (q) shall be in accordance with IEC 60076-3:2000.

(i) **Measurement of Impedance voltage on all taps.**

(j) **Measurement of the load loss** at normal tap and extreme taps. (To be carried out by three wattmeter method with low power factor wattmeters at full rated current). The voltage, current, wattage, power factor and frequency meter reading in individual phases (u, v, w) shall be recorded during testing and shall be reflected in the test report.

(k) **Measurement of no load loss, no load current and determination of knee point voltage:-**

This test is to be carried out with three wattmeter method by using low power factor wattmeters, three power factor meters, phase sequence meters, three low range ammeters and three each of average value and RMS value voltmeters. The test voltage from 10% voltage to 121% voltage shall be applied and currents, voltages (Average value and RMS value), wattmeters, power factor and frequency meter readings in all the three phases are to be recorded during the test. A saturation characteristic curve between the no load voltage (rms) vs. Measured current is to be plotted on the graph sheet, so as to determine the voltage at which increasing voltage by 10% (ten percent), the excitation current shall not increase by more than 50% (fifty percent). The knee point voltage as per specification will be complied if the excitation current at 121% of rated no load voltage shall not exceed by not more than 50% over the excitation current, obtained at 110% of the rated no load voltage. During the no load test, supplier's own generator set shall be used for feeding the above no load voltages at rated frequency. If the applied frequency is greater than the rated frequency, then proportionate voltage as per the rated frequency will be fed during the above no load test and following frequency correction formula along with the formula, stipulated at Clause No 16.5 of IS:2026 (Part-I) shall be used.

$$K = 0.5 [(f/f_1) + (f/f_1)^2]$$

Where f = rated frequency and f₁ = applied frequency.

For Example: - If measured loss = X Watts, correction factor due to r.m.s. and average voltage as per ISS = K₁ and frequency correction factor = K as per above formula, then corrected loss will be calculated as = measured loss • K₁ • K.

If applied frequency is less than the rated frequency, no frequency correction formula will be applied. Rated voltage at that frequency will be fed during the no load test.

N.B.:- 1) If power analyser is to be used for determination of no load loss, no load current, Impedance Voltage, short circuit losses etc., its manual of operation, calibration certificate and the relevant standard for its use shall be produced prior to one month of test offer for studying its feasibility and reliability.

- 2) C.Ts. and P.Ts. of accuracy class 0.2 or better as per IS: 2705 are to be used during determination of no load losses and short circuit losses which involves financial implication. The calibration certificates of these C.Ts. & P.Ts. from independent Government approved laboratory shall be produced along with the traceability while offering for inspection. The accuracy class of reference standard C.T. & P.T. used for determination of the errors of the above C.Ts. & P.Ts. shall be 0.05 or better as per Clause No.2.9 of IS : 1248 (Part-9).
- (l) **Measurement of Harmonic level** (1st to 24th Harmonic) in no-load current in all three phases at 90%, 100% and 110% of no-load voltage. The magnitudes of no load currents for all the three phases at the above excitation levels shall also be recorded and reflected in the test report for measurement of harmonic levels.
- (m) **Measurement of capacitance and dielectric dissipation factor [Repeat @ above).**
- (n) **Measurement of polarisation Index (Repeat (d) above).**
- (o) **Tests on no-load tap-changer (as per IS: 2026. Besides, following tests shall be carried out in accordance with IS: 8468/IEC 214):-**
- i) Mechanical test of diverter switch.
 - ii) Sequence test (switching time).
 - iii) Pressure test of the Tap selector switch oil compartment.
 - iv) Mechanical test of Tap selector with motor drive.
 - v) Operation test of the complete Tap changer.
 - vi) Dielectric test of the Motor Drive Unit.
- (p) **Transformer noise measurement:-**
Noise level measurement in accordance with IEC Publication 551 using a precision sound level meter conforming to IEC Publication 651.
- (q) **Auxiliary circuit tests:-**
All auxiliary circuits shall be subjected to application of 2KV (rms) withstand test voltage. Correct operation of all auxiliary control circuits will be tested.
- (r) **Core earth test:-**
A test voltage of 2KV shall be applied between the core and the earthed structural steel work to prove that the core is earthed through the removable link, at one point only.
- (s) **Oil BDV test.**
- (t) Measurement of Neutral current during load loss test which shall not be more than 2% of the rated current of the transformer.
- (u) **Magnetic balance test.**
- (v) **DGA test before and after all the tests.**
- (w) **Oil Leakage test on transformer tank:-**
All tanks and oil-filled compartments shall be tested for oil tightness by completely filling with oil of viscosity, not greater than that of insulating oil, conforming to IS: 335 at the ambient temperature and applying a pressure, equal to the normal pressure plus 35KN/Sq.m., measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours, during which time, no leakage shall occur. Bidder shall arrange for witnessing the leakage test of each tank.
- (x) **Pressure Relief Device Test:-**
The pressure relief device of each size shall be subjected to increasing oil pressure. It shall operate before reaching the test pressure, specified at

Cl.No.5.4.4 of this specification. The operating pressure shall be recorded. The device shall seal off after the excess pressure has been relieved. The following functional checks shall be conducted as acceptance tests on each of the pressure relief devices.

- i) Air- Pressure Test.
- ii) Liquid Pressure Test.
- iii) Leakage Test.
- iv) Contact Test.
- v) Di-electric Test.

(y) **Frequency Response Analysis (FRA) test:-**

The supplier shall conduct the test at the time of final testing of the transformer and record the amplitude and phase shift results on CDS for subsequent analysis. The test shall also be carried out by the supplier before commissioning at site and compare this result with the results, obtained before dispatching the transformer and submit the report along with the above results in CDs for future analysis. Each transformer is subjected to FRA test and frequency responses, recorded as above and analysed in any of the following:-

- i) Shift in the response of the winding.
- ii) Differences between the responses of all the phases of the transformer.

(z) **Dew point measurement test before dispatching:-**

Positive Gas pressure is generally maintained at 0.175 Kg/m² during transportation and during storage. To ensure the same, dew point measurement shall also be carried out at site. The procedure and acceptance limits are as per CBIP Manual Pub. No.295 (2006) or latest.

Besides the above, the OLTC manufacturer shall conduct the following routine tests fully in compliance with IEC: 60214 on every unit, as given below, for which no extra cost will be payable by OPTCL. OPTCL will authorize its representative(s) for witnessing the said routine tests on any or some or all the OLTCs for the Transformers as per contract. It is the responsibility of the supplier to offer the OLTCs for following routine tests, to be conducted at the works of OLTC Manufacturer.

SL. No.	IEC reference	Test Description	Acceptance level
01.	60214 I. No.5.3.1	Mechanical Endurance Test	Minimum 1000 operations
02.	60214 Cl. No.5.3.2	Sequence Test	Switching operation with timing less than 50 m-secs.
03.	60214 Cl. No.5.3.4	Pressure Test	10PSI (0.7kg/sq.cm.) for 8hours at room Temperature.
04.	60214 Cl. No.5.3.4	Vacuum Test	Vacuum level, as guaranteed by manufacturer.
05	Special Test	Gas tightness Test,	Helium based or any other mutually agreed method.
06	60214 Cl. No.5.3.4	Auxiliary Circuits Insulation earth Test	Should withstand 2kV relative to for 1 Minute.
07	Special Test	Contact resistance	< 2 milli- Ohms.
08	Special Test	Physical & Dimensional Checks.	As per approved drawing.

All the relevant Test reports shall be submitted for OPTCL's approval.

N: B- 1) Any other test as per IS / IEC with amendments if any, shall also be carried out with no extra cost to OPTCL.

2) The Purchaser reserves the right to have the tests carried out on the transformer(s) at his own cost in an independent Government approved laboratory to ensure that the Transformer complies with the requirements of this Specification.

3) Functional tests on auxiliary equipment of transformer as per Cl. No – 3.24, 3.25, 3.26 and 3.29 of CBIP publication – 317 will be conducted in presence of OPTCL inspecting officer(s). The details of such test shall be decided during design review.

6.4.3 **TESTS ON SITE:-**

The following site tests shall be performed on all units:-

- a) General mechanical checks.
- b) Core and winding insulation tests (Earth fault check on arrival at site).
- c) Ratio and HV magnetization current tests.
- d) Vector group check.
- e) Motors - Overload protection tests.
- f) Motor pumps and motor/fans - Direction of rotation check for correct flow.
- g) Buchholz device tests.
- h) Silica gel breather check.
- i) Temperature instrument calibration and tests.
- j) Operational tests on tap change equipment.
- k) Electric strength tests on insulating oil.
- l) Bushing tests.
- m) Impedance voltage at highest, rated and lowest voltage taps.
- n) Zero sequence impedance at rated voltage tap.
- o) DC resistance at all voltage taps.
- p) Correct operation of all C.Ts
- q) On-load tests.
- r) Capacitance & Tan-Delta of Winding & Bushing
- s) Magnetic Balance test
- t) DGA
- u) SFRA
- v) Measurement of Magnetizing current at 10kV

7.0 TEST REPORTS:-

- (a) Two (2) sets of certified test reports and oscillograms shall be submitted for approval prior to the despatch of the equipment. The equipment shall be despatched only when all the required type and routine tests have been carried out and test reports have been approved by the Purchaser.
- (b) Each test report shall contain the following informations:-
 - (i) Complete identification, date, including serial number of the transformer.
 - (ii) Method of application, where applied, duration and interpretation of test results for each test.
- (c) Two (2) copies of the test reports for the tests carried out on the ancillary apparatus be furnished to the Purchaser for approval prior to despatch.
- (d) All auxiliary equipment/accessories shall be tested as per the relevant standards for the tests, as mentioned in this Specification. Test Certificates for the same shall be submitted to the Purchaser in four copies for scrutiny and record.

8.0 LIST OF TRANSFORMER ACCESSORIES AND TEST CERTIFICATES REQUIRED FOR THEM:-

Before offering for stage inspection of the Transformer, the supplier shall have to furnish the test certificates for the Transformer accessories, as enumerated below, wherever required.

<u>Sl. No.</u>	<u>Accessory</u>	<u>Ref. Standard</u>	<u>Test Certificates required.</u>
1.	Condenser Bushing	IS-2099	<ol style="list-style-type: none">1. Appearance, construction and dimensional check.2. Test for leakage of internal filling at a pressure of 1.Kg/Cm² for 12h.3. Insulation resistance measurement with 2 KV megger.4. Dry power frequency voltage withstand test.5. Dry power frequency voltage withstand test for test tap insulation.6. Partial discharge measurement upto 1.5UN/ 1.732KV7. Measurement of tan delta and capacitance.8. Thermal stability9. Measurement of PD10. Switching Impulse Voltage withstand test
2.	Bushings.	IS-2099	<ol style="list-style-type: none">1. Appearance, construction and dimensional check.2. Insulation resistance measurement with 2 KV megger.3. Dry power frequency voltage withstand test.
3.	OLTC	IS-8468	<ol style="list-style-type: none">1. Oil tightness test for the diverter switch oil chamber at an oil pressure of 0.5 Kg/Cm² at 100 degree C for 1 h.2. Mechanical operation test.3. Operation sequence measurement.4. Insulation resistance measurement using 2 KV Megger.5. Power frequency voltage withstand test on diverter switch to earth and between even and odd contacts.6. Power frequency voltage withstand test on tap selector between maximum and minimum taps, between phases and supporting frames, between phases.7. Operation test of complete tap changer.8. Operation and dielectric test of driving mechanism.9. Temp. rise of contacts10. Short circuit current test11. IP-55 test
4	Winding temperature indicator.		<ol style="list-style-type: none">1 Calibration test.2 Dielectric test at 2 KV for one minute.3 Accuracy test for indication and switch setting scales.4 Test for adjustability of switch setting.5 Test for switch rating.6 Measurement of temperature rise with respect to the heater coil current.

5	Oil temperature indicator.		<ol style="list-style-type: none"> 1 Calibration test. 2 Dielectric test of 2 KV for one minute. 3 Accuracy test for indication and switch setting scales. 4 Test for adjustability of switch setting. 5 Test for switch rating.
6	Pressure Relief Valve.		<ol style="list-style-type: none"> 1 Functional test with compressed air to check bursting, pressure indication, flag operation and switch operation. 2 Dielectric tests at 2 KV for one minute. 3 Switch contact testing at 5A, 240V AC.
7	Cooling fan. IS: 2312 & motor assembly		<ol style="list-style-type: none"> 1. Insulation resistance measurement. 2. Dielectric test at 2 KV between winding and body for 1 minute. 3. Operation check. 4. Appearance, construction and Dimensional check. 5. free air delivery 6. temperature rise 7. Sound level 8. Running at reduced voltage 9. IP-55 of terminal Box
8	Buchholz ` Relay.	IS-3637	<ol style="list-style-type: none"> 1. Leak test with transformer oil at a pressure of 3 Kg. /Cm² for 30 minutes at ambient temperature for relay casing. 2. Insulation resistance measurement with 500 V Megger. 3. Dielectric test at 2 KV for 1 minute. 4. Elements' test at 1.75 Kg/ Cm² for 15 minute using transformer oil at ambient temperature. 5. Loss of oil and surge test. 6. Gas volume test. 7. Mechanical strength test. 8. Velocity calibration test. 9. Appearance, construction and dimensional check. 10. IP- 55 on Terminal Box
9.	Oil level Indicators.		<ol style="list-style-type: none"> 1 Test for oil levels. 2 Switch operations for low level alarm. 3 Switch contact test at 5A, 240V, A.C. 4 Dielectric tests at 2 KV for 1 minute. 5 Appearance, construction and dimensional check.
10	Pressed Steel Radiators.		<ol style="list-style-type: none"> 1. Air pressure test at 2 Kg/ Cm² under water for 15 minutes. 2. Appearance, construction and dimensional check.
11	OLTC Control Cubicle/cooler		<ol style="list-style-type: none"> 1 Appearance, construction and Dimensional check. 2. Electrical operation.

	control cubicle.		<ol style="list-style-type: none"> 3. Insulation resistance measurement using 500 V megger at ambient temperature. 4. Dielectric test at 2 KV for 1 minute.
12	Bushing current transformer.	IS-2705	<ol style="list-style-type: none"> 1. Appearance, construction and dimensional check. 2. Polarity check. 3. Measurement of insulation resistance. 4. High voltage power frequency test. 5. Determination of ratio error and phase angle of measuring and protection BCTS. 6. Determination of turns ratio error for PS Class BCTS. 7. Inter-turn insulation withstand test. 8. Excitation current characteristic test. 9. Secondary winding resistance measurement. 10. Knee-point voltage measurement for PS Class BCT.
13	Pressure check. gauges/ differential pressure gauges.		<ol style="list-style-type: none"> 1. Appearance, construction and dimensional 2. Calibration test. 3. Alarm contact setting test.
14	Transformer Oil Pump	IS-325 & IS-9137	<ol style="list-style-type: none"> 1. Insulation resistance measurement. 2. Cold resistance measurement at ambient temperature. 3. Motor efficiency at full load. 4. No load voltage, current, power input, frequency and speed. 5. Locked-rotor readings of voltage, current and power input. 6. Water pressure test for pump casing at 5Kg/Cm² for 10 minutes at ambient temperature. 7. Transformer oil pressure test for the pump set assembly at 2Kg/ Cm² for 30 minutes at 80° C. 8. Measurement of head discharge, current, power input to motor and overall efficiency of the pump set at rated voltage. 9. Appearance, construction and dimensional check. 10. Vacuum Test 11. Temperature rise test by resistance method 12. IP-55 test of terminal box
15	Oil flow Indicator.		<ol style="list-style-type: none"> 1. Observation of flow with respect to requirement. 2. Switch contact test at 5A, 240V A.C. 3. Dielectric test at 2KV for 1 minute. 4. Appearance, construction and dimensional check.

16. Air Cell Oil side coating, Air side undercoating, Air side outer coating and coated fabric as per IS-3400 /BS-903/IS-7016.
17. Test reports of Valves as per Cl.4. 6.4 of CBIP publication No -317.
18. Test reports of all other accessories as per relevant standard.

9.0 INSPECTION:-

9.1 GENERAL:-

- (i) The purchaser shall have access at all times to the works and all other places of manufacture where the transformer is being manufactured and the supplier shall provide all facilities for unrestricted inspection of the supplier's works, raw materials, manufacture of all the accessories and for conducting necessary tests, as detailed herein.
- (ii) The supplier shall keep the purchaser informed in advance of the time of starting and of the progress of the manufacture of the equipment in its various stages so that arrangements could be made for inspection.
- (iii) No material shall be despatched from its point of manufacture unless the material has been satisfactorily inspected and tested.
- (iv) The acceptance of the equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this specification and shall not prevent subsequent rejection of such equipment, if found to be defective later.

9.2 INSPECTION PROGRAMME:-

- (a) The supplier shall chalk out a detailed inspection and testing programme for manufacturing activities for the various components. An indicative programme of inspection as envisaged by the purchase is given below. This is not however intended to form a comprehensive programme, as it is supplier's responsibility to draw up and carry out such a programme, duly approved by the Purchaser. Stage inspection on core and winding will be carried out before tanking of core. For this, the supplier shall give at least ten days notice in advance. **The purchaser reserves the right to carry out the stage inspection, final inspection & testing by a third party.**
- (b) Additional tests, if required, are deemed to be included in the scope of work.
- (c) Stages of inspection and purchaser's participation would be defined and tied up at the time of award of contract within 15 days of issue of the Purchase order.
- (d) The supplier shall arrange all his tests in such a fashion that the inspection and testing shall not exceed 5 (five) days for the above transformer.
- (e) On site testing, if any discrepancies will occur, the supplier will be asked immediately for its rectification and the supplier shall depute his representative for rectification without any delay.
- (f) At the time of final inspection, the supplier shall identify each & every item/accessories of the particular Transformer under testing. Unless all the items are identified, the manufacturing will not be treated as complete. Serial No. of bushings, Tap-changer, WTI, OTI and other details shall be entered into the Test reports to ensure that these items are not being applied to the subsequent Transformer units while testing. Various tests as per the specification shall be performed in the presence of OPTCL Engineers or when the inspection waiver has been given, in such a case, the testing as per the specification shall be done at the manufacturers works and same should be confirmed by documentary evidence by way of Test Certificate, which shall be got approved by OPTCL.
- (g) In case, for any reason(s), inspection is not completed or the equipment is not found to be complete with all accessories as per confirmation, given with the inspection call, the

purchaser reserves the right to recover the complete cost of deputation of inspection team to the works of the manufacturer.

- (h) The supplier shall submit the test certificates of the bought-out items and Raw materials at the time of the routine testing of the fully assembled equipment.
- (i) It may be noted that “No change in any accessory or associated equipment after passing all the tests successfully shall be allowed and if this is subsequently detected, it shall be binding on the supplier to replace with the same item with which the initial tests were conducted at his works, failing which the entire test shall become null & void. The purchaser at his discretion may consider for rejection of the units, thus supplied. The entire cost for replacement of such rejected units, thus supplied and for repeating acceptance tests shall be borne by the suppliers.

9.2.1 **TANK AND CONSERVATOR:-**

- (a) Certification of chemical analysis and material test of plates.
- (b) Check for flatness.
- (c) Electrical interconnection of top and bottom by braided tinned copper flexible
- (d) Welder’s qualification and welding procedure.
- (e) Testing of electrodes for quality of base materials and coatings.
- (f) Inspection of major weld preparation.
- (g) Crack detection of major strength weld seams by dye penetration test.
- (h) Measurement of film thickness of:
 - (i) Oil insoluble varnish.
 - (ii) Zinc chromate paint.
 - (iii) Finished coat.
- (i) Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.
- (j) Check for physical properties of materials for lifting lugs, jacking pads etc. All load bearing welds including lifting lug welds shall be subjected to N.D.T.
- (k) Leakage test of the conservator.
- (l) Certification of all test results.

9.2.2 **CORE:**

- (a) Sample testing of core material for checking specific loss, bend properties, magnetization characteristics and thickness.
- (b) Check on the amount of burrs.
- (c) Bow-check on stampings.
- (d) Check for overlapping of stampings, corners of the sheets are to be apart.
- (e) Visual and dimensional check during assembly stage.
- (f) Check for inter laminar insulation between core sections, before and after pressing.
- (g) Check on completed core for measurement of iron loss, determination of knee point voltage.
- (h) Determination of core hot spot temperature by exciting the core with suitable voltage, which is the voltage per turn, multiplied with the wound turns around the core. The required voltage is applied to the transformers and the readings of temperature at the different points on core using thermo vision camera or laser temperature scanner are noted down. The reading of the temperature should not vary too much from point to point. If the temperature is varying from one point to the other then the flux is not distributed uniformly around the core. The point around the core, where the highest temperature occurs is scanned. This is the Hot Spot Temperature of the core.
- (i) Visual and dimensional checks for straightness and roundness of core, thickness of

limbs and suitability of clamps.

- (j) High voltage test (2 KV for one minute) between core, its bolts and clamps.
- (k) Certification of all test result.

9.2.3 **INSULATING MATERIAL.**

- (a) Sampling check for physical properties of materials.
- (b) Check for dielectric strength.
- (c) Visual and dimensional check.
- (d) Check for the reaction of hot oil on insulating materials.
- (e) Dimensional stability test at high temperature for insulating material.
- (f) Tracking resistance test on insulating materials.
- (g) Certification of all tests results.

9.2.4 **WINDING:**

- (a) Sample check on winding conductor for mechanical properties and electrical conductivity.
- (b) Check insulating distance between high voltage connection, cables and earth and other live parts.
- (c) Check insulating distance between low voltage connection and earth and other parts.
- (d) Check for proper cleanliness and absence of dust.
- (e) Visual dimensional checks on conductor for scratches, dent marks etc.
- (f) Sample check on insulating paper for PH value, electric strength & bursting strength.
- (g) Check for the bonding of insulating paper on the conductor.
- (h) Check for absence of short circuit between parallel strands.
- (i) Check for brazed joints wherever applicable.
- (j) Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.
- (k) Conductor flexibility test.
- (l) Certification of all test results.

9.2.5 **CHECKS BEFORE DRYING PROCESS:**

- (a) Check condition of insulation on the conductor and between the windings.
- (b) Check insulation distance between high voltage connections, cables and earth and other live parts
- (c) Check insulating distances between low voltage connections and earth and other parts
- (d) Insulation of core shall be tested at 2 kV/minute between core and Yoke clamps, Yoke clamps to tank and Core to Tank
- (e) Check for proper cleanliness and absence of dust etc.
- (f) Certification of all test results

9.2.6 **CHECKS DURING DRYING PROCESS:**

- (a) Measurement and recording of temperature, vacuum and drying time during vacuum treatment.
- (b) Check for completeness of drying by measuring IR value and TAN DELTA. Polarisation index of the winding i.e., ratio of IR value taken at 10 minutes to 1 minute shall be taken.
- (c) Certification of all test results.

9.2.7 **ASSEMBLED TRANSFORMER:**

- (a) Check completed transformer against approved out line drawings, provision for all

fittings, finish level etc.

- (b) Test to check effective shielding of the tank
- (c) Jacking test with oil on the assembled transformers.
- (d) Dye Penetration (DP) test shall be carried out after jacking test.

9.2.8 **OIL:**

Site test shall be performed on oil samples before and after filling in the transformer. Oil parameters shall conform to relevant IEC & IS prior to filling at site and oil samples taken from the tank top, bottom and cooling system after filling shall possess characteristics as per above standards. The supplier shall warrant that oil furnished is in accordance with the relevant clause of this specification. The purchaser at his discretion may send oil sample(s) to Govt. approved laboratory for determination of quality of oil including confirmation on percentages of naphthenic and paraffinic content, as specified at Cl. No.5.4.17 (a) of this Specification.

9.2.9 **Bought Out Items:**

The makes of all major bought-out items shall be subject to purchaser's approval. The supplier shall also prepare comprehensive inspection and testing programme for all bought-out/sub-contracted items and shall submit the same to the purchaser for approval. Such programme shall include the following components.

- (a) Buchholz Relay.
- (b) Axles and wheels.
- (c) Winding temperature indicators for local and remote mounting.
- (d) Oil temperature indicators.
- (e) Bushings.
- (f) Bushing current transformers.
- (g) Cooler control cabinet / Individual Marshalling box and common marshaling box as applicable.
- (h) Cooling equipment.
- (i) Oil pumps.
- (j) Fans/Air blowers.
- (k) Tap changing switch.
- (l) Terminal connectors.
- (m) Pressure relief device

The above list is not exhaustive and the supplier shall also include other bought-out items in his programme.

9.2.10 **TYPE TESTS ON FITTINGS:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings. The list of fittings and the type test requirement is:

- 1) Bushing (Type Test as per IEC:60137 including Snap back/Seismic test for 400 kV and above voltage class bushing)
- 2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)
- 3) Buchholz relay (Type Test as per IS: 3637 and IP-55 Test on terminal box)
- 4) Cooler Control cabinet, Individual Marshalling & common marshalling box (IP-55 test)
- 5) Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test

above. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

The terminal box / boxes of PRD shall conform to degree of protection of IS 13947 / Equivalent IEC standard.

- 6) Sudden Pressure Relay Test
- 7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
- 8) 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
- 9) OTI & WTI
- 10) Oil pump
- 11) Cooling fan and motor assembly

9.3 PRE-SHIPMENT CHECK AT SUPPLIER'S WORKS:

- (a) Check for proper packing and preservation of accessories like radiators, Bushings, dehydrating breather, rollers, Buchholz relay, fans, control cubicle, connecting pipes, conservator etc.
- (b) Check for inter-changeability of components of similar transformers for mounting dimensions.
- (c) Check for proper provision of bracing to arrest the movement of core and winding assembly inside the tank.
- (d) Gas tightness test to conform tightness and record of dew point of gas inside the tank.
- (e) Derivation of leakage rate and ensure adequate reserve gas capacity.
- (f) Items must be clearly identified by assigning a number, which needs to be tallied with challan.

9.4 INSPECTION AND TESTING AT SITE

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

9.5 RECEIPT AND STORAGE CHECKS

- (a) Check and record condition of each package, visible parts of the transformer etc. for any damage.
- (b) Check and record the gas pressure in the transformer tank as well as in the gas cylinder.
- (c) Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
- (d). Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

9.6. INSTALLATION CHECKS

- (a) Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.
- (b) Check the direction of rotation of fans and pumps and Check the bearing lubrication.
- (c) Check whole assembly for tightness, general appearance etc.
- (d) Oil leakage test
- (e) Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- (f) Leakage check on bushing before erection.

9.7 **RECOMMENDED COMMISSIONING CHECKS:**

- (a) Check the colour of silicagel breather.
- (b) Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- (c) Check the bushing for conformity of connection to the lines etc. and tan delta test for bushings at 10 KV (min.)
- (d) Check for correct operation of all protection devices and alarm/trip.
 - (i) Buchholz Relay.
 - (ii) Excessive winding temperature.
 - (iii) Excessive oil temperature.
 - (iv) Low oil flow.
 - (v) Low oil level indication.
 - (vi) Fan and pump failure protection.
- (e) Check for the adequate protection of the electric circuit supplying the accessories.
- (f) Check resistance of all windings on all the taps.
- (g) Insulation resistance measurement of:
 - (i) Control wiring.
 - (ii) Tap changer motor and control.
 - (iii) Cooling system motor and control.
 - (iv) Main windings.
- (h) Check for cleanliness of the transformer and the surroundings.
- (i) Continuously observe the transformer operation at no load for 24 hours.
- (j) Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise, noise level etc.
- (k) Phase sequence and vector group test.
- (l) Ratio tests on all taps.
- (m) Magnetising current test.
- (n) Capacitance & Tan delta measurement of windings and bushings.
- (o) Frequency response analysis (FRA). FRA equipment shall be arranged by the supplier.
- (p) DGA of oil just before commissioning and after 24 hours energisation at site.
- (q) Supplier shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures and forward to Purchaser for future record.

10.0 **QUALITY ASSURANCE PLAN:**

The Bidder shall invariably furnish following information alongwith his offer, failing which the offer shall be liable for rejection.

- (i) Statement giving list of important raw materials, names of Sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw material in presence of Bidder's representative, copies of test certification.
- (ii) Information and copies of test certificates as in (i) above in respect of bought out items.
- (iii) List of manufacturing facilities available.
- (iv) Level of automation achieved and list of areas where manual processing exists.
- (v) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspection.
- (vi) Special features provided in the equipment to make it maintenance free.
- (vii) List of testing equipments available with the Bidder for final testing of equipment

specified and test plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in 'Schedule of Deviations'.

- 10.1 The supplier shall within 30 days of placement of order, submit the following informations to the purchaser.
- (i) Name of the raw materials as well as bought- out accessories and the names of sub-suppliers selected from those furnished along-with the offer.
 - (ii) Type test certificates of the raw material and bought out accessories.
 - (iii) Quality Assurance Plan (QAP) withhold points for purchaser's inspection. The QAP and hold points shall be discussed between the purchaser and the supplier before the QAP is finalised. The QAP shall include all the quality checks as stipulated in this specification.
- 10.2 The supplier shall submit the routine test certificates of bought out items and raw materials at the time of routine testing of the fully assembled transformer.

11.0 DOCUMENTATION:

- 11.1 All drawings shall conform to relevant International Standards Organisation (ISO) specification. All drawing shall be in ink and suitable for micro filming. All dimensions and data shall be in S.I. Units.
- 11.2 The Bidder shall furnish along-with the bid dimensional drawings of transformer and all other accessories. These drawing shall include the following information.
- (a) Dimensions.
 - (b) Tolerances on dimensions.
 - (c) Material designation used for different components with reference to standards.
 - (d) Fabrication details such as welds, finishes and coatings.
 - (e) Catalogue or part members for each component and the total assembly with bill of materials.
 - (f) Identification marking.
 - (g) Weight of individual components and total assembled weight.
- 11.3 The supplier shall, within 15 (fifteen) days of placement of order submit the final version of following drawings/ documents in AutoCAD format and two sets in hard copy for purchaser's approval. All Drawings and Designs in complete shape (not in a piece-meal manner) as per the specification and without any deviation should be submitted within 15 (Fifteen) days of placement of Purchase Order.
- a) Outline dimensional drawings of transformer and accessories. The clearances between HV, IV & LV terminals and ground should be shown.
 - b) Table of fittings for OGA.
 - c) Combined Rating and Diagram plate. It should contain various weights (core, winding, oil etc.), C.T. ratio (WTI CT, OTI CT, all bushings CT) and details of OLTC, RTCC etc.
 - d) HV Bushing.
 - e) IV Bushing.
 - f) LV Bushing.
 - g) HVN Bushing.
 - h) Twin Bi-directional Roller. Detailed drawing showing wheel loading and its centre of gravity.
 - i) Valve schedule plate
 - j) Detailed Foundation drawings along with structural drawings showing design criteria and loadings.

- k) Oil filling Instruction plate.
- l) On line Drying System
- m) Schematic control and wiring diagram for all auxiliary equipments including OLTC cooler control etc.
- n) GA of Marshalling Kiosk.
- o)) General Arrangement of RTCC panel.
- p) Assembly of core with details of stacks, dimensions and weights etc.
- q) Details of winding arrangement, conductor cross-section & weights etc.
- r) CT rating plate.
- s) Schematic diagram showing the flow of oil in the cooling system as well as each limb and winding Longitudinal and cross-sectional view showing the duct sizes, cooling pipes etc. for the transformer/ heat exchanger, drawn to scale shall be furnished.
- t) Inter connection-cabling diagram between transformer and all panels.
- u) Constructional details and sectional views of on-Load Tap Changer.
- v) Complete bill of materials.
- w) Detailed dimensions, assembly and description of auxiliaries.
- x) Constructional details of tank including material, dimensions thickness, reinforcing members, used, if any.
- y) Galvanising and painting procedure.
- z) Factory Test procedures, lay-out of testing equipment/circuits and Test schedules for tests.
- aa) Commissioning test procedure and report.
- bb) Operation and Maintenance Manual.
- cc) QAP during manufacturing and during erection of the transformer.
- dd) Nitrogen Gas Fire Extinguishing System
- ee) Maintenance free Breather
- ff) Any other drawings(s) as required by the purchaser.

The purchaser shall communicate his comments/ approval on the drawings/documents to the supplier within reasonable period. The supplier shall, if necessary, modify the drawings and resubmit two copies of the modified drawings for purchaser's approval within one week from the date of comments.

11.4 DESIGN REVIEW:-

- 11.4.1. The Transformers shall be designed, manufactured and tested in accordance with the best International Engineering Practices under strict Quality Control to meet the requirements, stipulated in the Technical specification. Adequate safety margin with respect to thermal, mechanical, di-electric, electrical stresses and electrical clearances shall be maintained during design, selection of raw materials, manufacturing process etc. so that the Transformer provides long life with least maintenance.
- 11.4.2. Raw material and sub-vendors used by transformer manufacturer shall be declared before commencement of manufacturing. The validity of Type tests (except dynamic short circuit test) of Transformer shall be 5 years as on the originally scheduled date of bid opening, provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the contractor at no extra cost to Employer. Transformer type test report from the same

- manufacturing plant shall only be acceptable. With regard to Validity of Dynamic short circuit test once conducted shall be applicable.
- 11.4.3 The design review will commence after placement of award with successful Bidder and shall be finalized before final drawing approval. The supplier shall depute their design engineer(s) to OPTCL for design review and finalization of drawings. However, the entire responsibility of design shall rest with the manufacturer.
- 11.4.4 The representative of the purchaser may visit to the manufacturer's works to inspect design, manufacturing and testing facilities.
- 11.4.5 The design review shall be conducted generally following the "Guidelines for conducting design reviews, prepared by CIGRE SC12 working Group 12.22 and as per Appendix-VI(Design Review parameters) of CBIP Publication No – 317.
- 11.4.6 The manufacturer shall provide all necessary information and calculations during design review to demonstrate that the Transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and CIGRE SC12 shall be applied for short circuit withstand evaluation.
- 11.4.7 The manufacturer will be required to demonstrate the use of adequate safety margin for thermal, mechanical, dielectric and vibration etc. to take into account the uncertainties of his design and manufacturing processes.
- 11.4.8 The scope of such a design review shall at least include the followings:-
- i) Core design
 - ii) Winding, tapping and Insulation design
 - iii) Short-circuit withstand capability
 - iv) Electrical clearances between windings to core (both axially and radially) between windings, outer windings to tank etc.
 - v) Thermal design including areas, prone to hot spots including thermal modeling for placement of the Optic Fiber Temperature Sensors.
 - vi) Cooler design
 - vii) Over-load capacity
 - viii) Over-fluxing
 - ix) Magnetising Inrush current
 - x) Eddy current losses
 - xi) Seismic design
 - xii) Insulation co-ordination
 - xiii) Tank & Accessories
 - xiv) Bushings & barrier design
 - xv) Tap-changer
 - xvi) Protective devices
 - xvii) Fans & radiators
 - xviii) Oil & oil preservation system
 - xix) Corrosion protection
 - xx) Electrical and physical interfaces with sub-station
 - xxi) Earthing
 - xxii) Processing and assembly
 - xxiii) Testing capabilities
 - xxiv) Inspection and Test plan
 - xxv) Transport and storage
 - xxvi) Sensitivity of design to specified parameters
 - xxvii) Acoustic noise
 - xxviii) Spares, inter-changeability and standardization
 - xxix) Maintainability

- xxx) Nitrogen Gas Fire Extinguishing System
- xxxii) Breather
- xxxiii) Digital RTCC
- xxxiv) On line Drying System
- xxxv) On line Dissolved Gas (Multi-gas) and Moisture Analyser
- xxxvi) Any other design aspect, as deemed necessary

11.5 The supplier shall also furnish five copies of bound manuals for each transformer covering erection, commissioning, operation and maintenance instructions and all relevant information and drawings pertaining to the main equipment as well as auxiliary devices. Marked erection drawings shall identify the component parts of the equipment as shipped to enable purchaser to carry out erection with his own personnel. Each manual shall also contain one set of all the approved drawings, type test reports as well as acceptance reports of the corresponding consignment dispatched.

11.6 The manufacturing of the equipment shall be strictly in accordance with this Specification, approved drawings and no deviation shall be permitted without the written approval of the purchaser. All manufacturing and fabrication work in connection the equipment prior to the approval of the drawings shall be at the supplier's risk.

However, approval of the drawings by the purchaser shall not relieve the supplier of his responsibility and liability for ensuring correctness and correct interpretation of the latest revision of applicable standards, rules and codes of practices. The Transformer shall conform in all respects to high standards of engineering, design, workmanship and latest revisions of relevant standards at the time of ordering and the purchaser shall have the power to reject any material, which in his judgement is not in full accordance therewith.

11.7 TEST REPORTS:

- (i) Two copies of type test reports shall be furnished to the purchaser. One copy will be returned duly certified by the purchaser to the supplier.
- (ii) Two copies of routine test reports shall be furnished to the purchaser. One copy will be returned duly certified by the purchaser and only thereafter shall the materials be despatched.
- (iii) All records of routine test reports shall be maintained by the supplier at his works for periodic inspection by the purchaser.
- (iv) All test reports for tests conducted during manufacture shall be maintained by the supplier. These shall be produced for verification as and when requested for by the purchaser.

12.0 TRANSPORTATION, PACKING AND FORWARDING:-

12.1 The supplier shall dispatch the transformer, filled with oil or in an atmosphere of nitrogen or dry air at positive pressure. In the former case, the supplier shall take care of the weight limitation on transport and handling facility at site. In the latter case, necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen or dry air during transit and at site of installation. The nitrogen or dry air cylinder, provided to maintain positive pressure can be taken back by the supplier after oil filling. A gas pressure-testing valve with necessary pressure gauge and adapter valve shall be provided. Transformer shall also be fitted with at least two Electronic Impact Recorders (on returnable basis) during transportation to measure the magnitude and

duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions, which can be withstood by the equipment during transportation and handling, shall be submitted by the supplier during detailed engineering. The recording shall commence in the factory before dispatch and must continue till the unit is received/installed at destination sub-station. The data of electronic impact recorder(s) shall be downloaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks, the supplier shall communicate the interpretation of the data.

- 12.2 The equipment shall be suitable for vertical/horizontal transport as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit, due to improper and inadequate handling during transfer, loading and unloading. The easily damageable material shall be carefully packed and marked with the appropriate caution symbol. Whenever necessary, proper arrangement for lifting, such as lifting hooks etc. shall be provided. Any material found short inside the packing cases shall be supplied by supplier without any extra cost.
- 12.3 Each consignment shall be accompanied by a detailed packing list containing the following informations:-
- (a) Name of the consignee.
 - (b) Details of consignment.
 - (c) Destination.
 - (d) Total weight of consignment.
 - (e) Sign showing upper/lower side of the crate.
 - (f) Handling and unpacking instructions.
 - (g) Bill of materials indicating contents of each package.
 - (h) Two sets of approved copies of drawings, instruction and commissioning manuals, approved test certificates and certificates of bought out items, approved copies of guarantee certificate.
- 12.4 The supplier shall ensure that the packing and bill of materials are approved by the purchaser before dispatch.

13.0 SUPERVISION OF ERECTION, TESTING AND COMMISSIONING (ET&C):

The erection, testing and commissioning of the transformers shall be supervised by trained personnel (Engineer) of the supplier. The Engineer shall direct the sequence of ET& C. The Engineer shall correct in the field, any errors or omissions on the part of the supplier, in order to make the equipment and material properly perform in accordance with the intent of this specification. The Engineer shall also instruct the plant operators in the operation and maintenance of the commissioned equipment. The supplier shall be responsible for any damage to the equipment, on commissioning the same, if such damage results from faulty or improper ET&C procedure. Purchaser shall provide adequate number of skilled/semi-skilled workers as well as all ordinary tools and equipment and cranes required for equipment erection, at his own expenses. Apart from the above, the purchaser shall not be responsible for any other expenses such as Engineer's salary, insurance against personal injuries to the Engineer etc. Special tools, if required for erection and commissioning, shall be arranged by the supplier at his cost and on commissioning, these shall be supplied to the purchaser, free of cost for future use. The supervision of erection, testing and commissioning charges will be borne by the Purchaser as per tender price schedule.

14.0 QUANTITY AND DELIVERY REQUIREMENTS:

- (i) This is set out in Annexure -I of this Specification. The firm will submit a 'PERT CHART', indicating the manufacturing, inspection, testing and delivery schedule in details immediately after receipt of the Purchase Order.
- (ii) The scope of supply shall also include supply of 2.5% extra quantity of bolts, nuts, washers, split pins, cotter pins and such other small loose items, free of cost in addition to the materials/equipments as spelt out in this specification.

15.0 Values quoted in the G.T.P. and in details of loss calculations shall not differ. In case if it differs, then values quoted in the G.T.P. will be taken as final for all purposes.

16.0 METHOD OF TECHNICAL EVALUATION :

Bids will be evaluated in the following manner.

- (a) To check the flux density at the rated voltage i.e., 400KV/220KV/33KV, rated frequency i.e., 50 Hz and maximum stacking factor as 0.97.
- (b) To check the data furnished in the GTP as correct as per the Technical Specification. If on calculation, GTP data will be different from the calculated data, then the bid will not be considered or owner may take any other decision. GTP furnished in incomplete shape may not be considered for evaluation.
- (c) If HI-B grade sheet steel for core material has not been quoted and specific loss and B-H curve for the said material alongwith the materials name and test report has not been furnished, the bid will be rejected. Details of HIB core particulars like length, Breadth, thickness of each stack alongwith core dia., L.V.,I.V. & H.V. No of turns and lamination thickness, weight of core shall be submitted alongwith the bid failing which tender will be liable for rejection.
- (d) Bid will be rejected, if firm will not accept all the specified Technical terms and conditions.
- (e) Bid will be rejected if Maximum Flux Density and Core weight calculation (As per Annex-II) and details of Loss calculations (As per Annex-III) will not be found to be in order and if there is any ambiguity/discrepancy, noticed in the above calculations.
- (f) The Bidder shall submit along with the bid the graph depicting the saturation characteristic curve between the no load voltage (RMS) vs.-measured excitation current starting from 10% of rated no load voltage to 125% of the same, failing which the tender is liable for rejection. The knee point voltage shall have to satisfy the specified value as per the criteria stipulated at Clause No.4 (18) of this Specification.

Bidders are required to be careful in choosing the maximum flux density, best possible core materials (HIB or better) and type of corner joints of the core etc.so as to quote the practicable no-load current at different percentages of rated no-load voltage as per given GTP format and submit a linear graph along with the tender, confirming to achieve the specified minimum knee point voltage i.e.110% of the rated voltage during no-load test as per the method, stipulated at CL.No.6.4.2 (k) of this Technical Specification, which will be confirmed through testing both during stage inspection and final inspection.

ANNEXURE-I
SCHEDULE OF QUANTITY AND DELIVERY

Sl.No	Description of materials	Quantity required	Desired Delivery	Destination	Remarks
1	2	3	4	5	6
1.	500MVA, 400/220/33KV ICT.	02 Nos.	As per Schedule	BHADRAK in the state of Odisha.	

Place:

Date:

Signature of Tenderer
with seal of Company.

ANNEXURE-II

MAXIMUM FLUX DENSITY, CORE WEIGHT & NO LOAD LOSS CALCULATION FOR 500 MVA,400/220/33 kV AUTO INTER CONNECTING TRANSFORMER

[To be filled in by the Bidder]

Name of the bidder: -

Address:-

Type and Grade of Core material: -

Thickness [in mm]:-

<u>Step No</u>	<u>Width of steps [mm]</u>	<u>Stack thickness [mm]</u>	<u>Gross Iron area [mm²]</u>
----------------	----------------------------	-----------------------------	---

1

2

3

4

5

6

7

8

9

10

11

12.

13

14

15 to

$E = 4.44 \times f \times B_{max} \times A_i \times N$

Where E = L.V. winding rated voltage / phase = 33000 volts.

f = Rated frequency = 50 HZ. , B max. = Maximum flux density in Tesla.

1) Flux Density Calculation	
Gross iron area in sq.m =	
Stacking factor =	
A _i (Net iron area in sq.m) = Gross iron area in sq.m x stacking factor =	
N = Number of L.V. winding turns/phase=	
B max. (At rated voltage & frequency)= $E/4.44 \times f \times A_i \times N =$	
B max [at Maximum System voltage (410kV/245 KV/36 KV) and minimum system frequency (48.5 HZ)]	

2) Core weight Calculation	
Core dia [in mm] =	
Window height [in mm] =	
Limb center [in mm] =	
W=Weight of core = [3 x window height + 4 x limb centre + 2 x max. width] x Net iron area x Density of core = (In case of any other formula is used by	

the bidder, then the same is to be mentioned here explaining each parameter & the detailed calculation also to be furnished)	
--	--

3) No load loss_Calculation	
Core loss in watt/kg. from graph for grade/type of core material and selected Flux density=	
Building factor=	
Calculated No-load loss in watts =core weight x watts/kg. x Building factor=	
Guaranteed No-load loss in watts =	

- NB: -
1. Specific loss vs. flux density graph for the type of core lamination to be used has to be furnished.
 2. VA/Kg. Vs flux density graph for the core lamination to be used has to be furnished.
 3. Any other factor assumed for above calculation to be explained with reasons.

Place
Date

Bidder's name:
Signature, designation, seal

NB- The Bidders are required to up load this calculation sheet duly filling the required data, in PDF format.

ANNEXURE-III
DETAILS OF LOSS CALCULATIONS FOR 500MVA, 400/220/33KV AUTO INTER
CONNECTING TRANSFORMER

1. Name of the Firm
2. Flux density as adopted for offered transformer design, at
 - i) 420/245/36 KV and 48.5 Hz [Tesla]
 - ii) 400/220/33 kV and 50.0Hz (Tesla)
3.
 - i. Core weight in Kg.
 - ii. Gross core area [mm²]
 - iii. Stacking factor.
 - iv. Building Factor
 - v. Net core iron area [mm²] [ii x iii]
 - vi. No. of LV Turns/Phase
4. [a] Specific losses [W/Kg.]
 - i. At designed flux density corresponding to 420/245/36 KV and 48.5 HZ.
 - ii. At designed flux density corresponding to 400/220/33 kV and 50Hz.[b] Volt ampere /Kg.
 - (i) At designed flux density corresponding to 420/245/36 KV and 48.5 Hz
 - (ii) At designed flux density corresponding to 400/220/33 kV and 50 Hz.
5. Calculated/guaranteed iron loss in KW at-
 - (i) Rated voltage and rated frequency.
 - (ii) Maximum system voltage and lowest system Frequency.
6. Current density (A/Sq.mm) at normal tap for
 - (i) HV (Series)
 - (ii) IV (Common)
 - (iii) LV
 - (iv) Regulating at Normal
7. Conductor size (in mm) and Area of conductor (in mm²)
 - a. HV
 - i. Bare
 - ii Insulated.
 - iii No. of conductors in parallel.
 - b. IV winding
 - i. Bare
 - ii Insulated.
 - iii No. of conductors
 - c. L.V.winding.
 - i. Bare
 - ii. Insulated.
 - iii. No. of conductors in parallel.

- d. Regulating winding.
 - i. Bare
 - ii. Insulated.
 - iii. No. of conductors in parallel.
8. Total Bare copper conductor area (A) (Sq.mm)
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
9. No.of turns/ phase (N) at Highest volt tap Lowest volt tap Normal volt tap
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
10. Internal Diameter (in mm.)
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
11. Outside Diameter (in mm).
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
12. Mean Diameter (Dm) (in mm)
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
13. Length of copper conductor(L)MTR Highest Lowest Normal
- $=\text{Pie} \times \text{Dm} \times \text{N}$ volt tap volt tap volt tap
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
14. Per-phase resistance of winding tap Highest Lowest Normal
- (in ohms) at $75^{\circ}\text{C} = 0.0211\text{XL/A}$ volt tap volt tap volt tap
- i. HV
 - ii. IV
 - iii. LV
 - iv. Regulating.
- b. {i} Series winding Resistance in ohms at 75°C /phase
- {ii} Common winding Resistance in ohms at 75°C /phase
15. I^2R loss for winding at 75°C

- i. At normal tap position (in KW)
 - ii. At maximum tap position (in KW)
 - iii. At minimum tap position (in KW)
16. I²R loss at 75⁰C towards connecting leads for windings, bushings, OLTC etc.
- i. At normal tap position (in KW)
 - ii. At maximum tap position (in KW)
 - iii. At minimum tap position (in KW)
17. Eddy current losses in winding (in KW) at 75 deg.C
- i. At normal tap position.
 - ii. At maximum tap position.
 - iii. At minimum. tap position.
18. Stray losses in tank & other parts of transformer (in KW) at 75 deg.C
- i. At normal tap position.
 - ii. At maximum tap position.
 - iii. At minimum. tap position.
19. Calculated guaranteed Load losses (in KW) at 75 deg. C
[15 + 16 + 17 + 18]
- i. At normal tap position.
 - ii. At maximum tap position.
 - iii. At minimum. tap position.
20. Guaranteed Cooler Losses{ in KW}
21. Computed/guaranteed total loss in KW at rated Voltage and rated frequency.
(Copper loss + cooler loss + Iron loss)
- i. At normal tap position.
 - ii. At maximul tap position.
 - iii. At minimum. tap position.
22. Copper Weight (L X A X 8.89 X 10⁻³) BARE/INSULATED
- i. HV
 - ii. LV
 - iii. Regulating
 - iv. IV
 - i. For Tap connections, star connection and any Other [please specify]
 - ii. Total copper weight [i]+[ii]+[iii]+[iv]+[v]

NB: - 1 Approximate values in weight and losses etc. are not allowed.
2 Tolerance of + 5% in weights may be quoted without any approximation

Place:

Date

Bidder's name:

Signature, designation, seal

NB- The Bidders are required to up load this calculation sheet duly filling the required data, in PDF format.

ANNEXURE-IV

GUARANTEED TECHNICAL PARTICULARS

[TO BE FILLED IN BY THE BIDDER, IN EXCEL FORMAT OF THE TECHNO COMMERCIAL BID SHEET]

Sl.	<u>Description</u>	500MVA, 400/220/33KV Auto Inter Connecting Transformer
<u>No</u>		
1	Name of the Manufacturer	
2	Installation [indoor/outdoor]	
3	Reference standards	
4	Continuous Ratings	
	a	Type of cooling
	b	Rating [MVA]
	i	With ONAN cooling
	ii	With ONAF cooling
	iii	With OFAF/ODAF cooling
	c	Rated voltage
	i	HV [KV rms.]
	ii	IV [KV-rms.]
	iii	LV [KV-rms.]
	d	Highest system voltage
	i	HV [KV rms.]
	ii	IV [KV-rms.]
	iii	LV [KV-rms.]
	e	Rated frequency with $\pm\%$ variation
	f	Number of phases
	g	Current at rated full load and on principal tap
	i	HV [Amps]
	ii	IV [Amps]
	iii	LV [Amps]
5	Connections	
	i.	HV
	ii.	IV
	iii.	LV
6	Connection symbol and vector group	
7	Temperature rise	
	a	Temperature rise of oil above ambient temperature [by Thermometer & Optic Fiber Temperature Sensor]
	i	At full ONAN rating [°C]
	ii	At full ONAF rating [°C]
	iii	At full OFAF/ODAF rating [°C]
	b	Temperature rise of windings above ambient temperature [By resistance method]
	i	At full ONAN rating [°C]
	ii	At full ONAF rating [°C]
	iii	At full OFAF/ODAF rating [°C]
	c.	Hot Spot Temperature rise of Windings above ambient

- Temperature [By Optic Fiber Temperature Sensors]
 - i At full ONAN rating [°C]
 - ii At full ONAF rating [°C]
 - iii At full OFAF/ODAF rating [°C]
 - d. Temperature gradients between windings & oil.
 - For ONAN/ONAF/OFAF(ODAF) rating
 - a. Limit of Hot spot temperature for which the Transformer is designed [°C]
 - b. Period of operation of transformer at full load without calculated winding hot spot temperature exceeding 140°C and with
 - i 50% Coolers
 - ii 100% Coolers
- 8 Type of ON load tap changing switch
- 9 Tapping on windings for
 - i Constant flux/variable flux/combined regulation.
 - ii Tapping provided at
 - iii Number of steps
 - iv Range of tapping for variation [+ percent to- percent]
- 10 i No load loss at rated voltage and frequency at principal tap [KW]
 - ii No load loss at the voltage corresponding to highest tap [KW]
- 11 Load loss at rated output, rated frequency, ONAN ONAF OFAF/ODAF corrected for 75 °C winding temperature at:- [Copper loss + cooler loss]
 - i Principal tap [In KW]
 - ii Highest tap [In KW]
 - iii Lowest tap [In KW]
- 11 Auxiliary losses at rated output, normal ratio, rated voltage, rated frequency and ambient temperature [KW]
- 13 Total losses at normal ratio inclusive of auxiliary equipment losses [KW]
- 14 Positive sequence impedance on rated MVA HV to IV HV to LV IV to LV base at rated current and frequency at 75° Centigrade winding temperature at
 - i Principal tap [%]
 - ii Highest tap [%]
 - iii Lowest tap [%]
- 15 Zero sequence impedance at reference temperature of 75°C at principal tap [%]
- 16 % reactance at rated MVA base at rated current and rated frequency at HV to IV HV to LV IV to LV
 - i Principal tap [%]
 - ii Highest tap [%]
 - iii Lowest tap [%]
- 17 % resistance at rated MVA base at rated current and rated frequency at HV to IV HV to LV IV to LV
 - i Principal tap [%]
 - ii Highest tap [%]
 - iii Lowest tap [%]

18	% Impedance at rated MVA base at rated current and rated frequency at	<u>HV to IV</u>	<u>HV to LV</u>	<u>IV to LV</u>
	i Principal tap [%]			
	ii Highest tap [%]			
	iii Lowest tap [%]			
19	a. Polarisation index i.e. ratio of Megger values at 600 secs to 60 secs, (H.V. to E,I.V. to E, L.V. to E, H.V. to I.V., H.V. to L.V.& I.V.to L.V).			
	b. Regulation at full load and 75°C winding temperature expressed as a percentage of normal voltage			
	i At unity power factor [%]			
	ii At 0.8 power factor [lagging][%]			
20	Efficiency at 75°C winding temperature as derived from guaranteed loss figures at	Unity power factor	0.8 Power factor	
	a At full load [%]			
	b At $\frac{3}{4}$ load [%]			
	c At $\frac{1}{2}$ load [%]			
21	i Maximum efficiency [%]			
	ii Load at which maximum efficiency occurs[% of full load]			
22	Time in minutes for which the transformer can be run at full load without exceeding the maximum permissible temperature at reference ambient temperature when supply to:-			
	i Fans are cut off			
	ii Fans & pumps are cut off			
23	Short time thermal rating of			
	i Tertiary winding in kA and duration in seconds			
	ii IV winding in KA and duration in seconds			
	iii HV winding in KA and duration in seconds			
24	Permissible over loading:-			
	a HV winding			
	b IV winding			
25	Terminal arrangement			
	a High voltage [HV]			
	b Intermediate voltage [IV]			
	c Low voltage (LV)			
	d Neutral			
26	Insulating and cooling medium			
27	[A] Test voltage	<u>HV</u>	<u>IV</u>	<u>LV</u>
	i. Lightning impulse withstand test voltage [KVP]			
	ii Power frequency withstand test voltage [dry and wet][for 1 minute] [KV-rms.]			
	iii Switching impulse test voltage [KVP]			
	[B] Design value of surges transferred on tertiary terminals:			
	I For 1300[900] KVP, 1.2/50 micro second surge striking HV terminal and with			
	a Both the tertiary terminals open[KVP]			
	b One terminal earthed [KVP]			

- ii For 900[550] KVP, 1.2/50 micro second surge striking IV terminal and with
 - a Both the tertiary terminals open [KVP]
 - b One terminal earthed [KVP]
- 28 Partial discharge level as per relevant IEC/ISS
- 29 Noise level when energized at normal voltage, frequency without load and with all cooling fans, oil pumps in running condition.
- 30 External short circuit withstand capacity [MVA] and duration [seconds]
- 31 Over-fluxing withstand capability of the Transformer
- 32 DETAILS OF CORE
 - a Type of core construction
 - b Type of corner joints of the core
 - c Flux density as adopted for offered transformer design at
 - i Rated voltage [400/220/33 KV] & rated frequency 50 Hz][in Tesla]
 - ii Highest system voltage [420/245/36 KV] and lowest system frequency [48.5Hz.][in Tesla]
 - d No load current, no load loss and no load power factor at normal ratio and frequency [Amp/KW/p.f.]
 - i 10 percent of rated voltage
 - ii 25percent of rated voltage
 - iii 50 percent of rated voltage
 - iv 85 percent of rated voltage
 - v 100 percent of rated voltage
 - vi 105percent of rated voltage
 - vii 110 percent of rated voltage
 - viii 112.5 percent of rated voltage
 - ix 115 percent of rated voltage
 - x 120 percent of rated voltage
 - xi 121 percent of rated voltage
 - xii 125 percent of rated voltage
 - e Core laminations:-
 - i Make & type[HIB/Laser grade] of core Material
 - ii BIS Grade of core laminations
 - iii Thickness of core lamination [mm]
 - iv Specific loss [watt/Kg.] at Design Flux Density at rated voltage & rated frequency
 - v Specific loss [watt/Kg.] at Design Flux Density at highest system voltage & lowest system frequency
 - vi Whether specific core loss graph [flux density vs. watt/Kg.submitted]
 - vii VA/Kg at Design Flux Density at rated voltage & rated frequency
 - viii VA/Kg at Design Flux Density at 110% of rated voltage & rated frequency
 - ix. VA/Kg at Design Flux Density at 121% of rated voltage & rated frequency
 - x VA/Kg. at Design Flux Density and at highest system voltage & lowest system frequency
 - xi Whether VA/Kg. Vs. flux density graph submitted.
 - xii Insulation of core laminations
 - f CORE ASSEMBLY:-

- i Core diameter [mm]
- ii Core window height [mm]
- iii Core leg centre [mm]
- iv Gross core cross-sectional area [m²]
- v Whether details of core widths, stacks and calculation furnished as per enclosed annexure
- vi Distance between centres [mm]
- vii Total height of core [mm]
- viii. **core belting**
 - 1) Details of core belting.
 - 2) Material, grade & type.
 - 3) Width.
 - 4) Thickness.
 - 5) Fixing method.
- ix Details of top end frame.
- x Details of Bottom end frame.
- xi Details of clamp plate [Material, thickness, Insulation]
- xii **Core stacking factor**
- xiii **Net core area Sq. m.**
- xiv **Total core weight [kg]**
- xv **Building Factor**
- xvi Core loss basing on core loss graph at operating Flux density [rated voltage and rated Frequency] [kw]
- xvii Margin towards corner joints, cross fluxing etc [kw]
- xviii Total core loss at rated voltage and rated frequency [xvi+xviii] [kw]
- xix Dielectric loss at rated voltage and rated frequency [KW]
- xx No load loss at rated voltage and rated frequency [xviii+xix] [KW]
- g Describe location/method of core grounding
- h Details of oil ducts in core
- i Peak value of magnetising Inrush current (% of HV rated current).

33 **DETAILS OF WINDINGS.**

- | | HV
(Series Winding) | IV
(Common winding) | Regulating winding | LV winding |
|------------|---|-----------------------------------|--------------------------------------|------------|
| a | Type of winding | | | |
| b | Material of the winding conductor. | | | |
| c | Maximum current density of windings [at rated current] and conductor area | Conductor area [cm ²] | Current density [A/cm ²] | |
| i | HV | | | |
| ii | I.V. | | | |
| iii | Regulating | | | |
| iv | L.V. | | | |
| d | Whether HV/IV windings are interleaved. | | | |
| e | Whether windings are pre-shrunk? | | | |
| f | Whether adjustable coil clamps are provided for | | | |

	H.V., I.V. and L.V. windings?	
g	Whether steel rings are used for the windings? If so, whether these are split?	
h	Whether electrostatic shields are provided to obtain uniform voltage distribution in the windings?	
i	Winding Insulation	Type & class. Graded or ungraded
i.	H.V. & Regulating	
ii	IV	
iii	LV	
j	Insulating material used for	
i	H.V. & Regulating winding.	
ii	IV Winding	
iii	L.V Winding	
iv	For core bolts washers and end plates.	
v	Tapping connection.	
k	Insulating material used between	
i	H.V. and I.V. winding	
ii	I.V. and Regulating winding.	
iii	Regulating winding and H.V.winding.	
iv	Core and L.V winding.	
v	L.V. Winding and core.	
vi	I.V.Winding and core	
vii	Regulating winding and core	
viii	H.V.winding and core	
ix	H.V. to H.V.winding [between phases]	
l	Type of axial coil supports.	
i	H.V. winding	
ii	IV winding	
iii	Regulating winding	
iv	LV winding	
m	Type of radial coil supports	
i	HV winding	
ii	IV winding	
iii	Regulating winding	
iv	LV winding	
n	Maximum allowable torque on coil clamping bolts	<u>HV</u> <u>IV</u> <u>Regulating</u> <u>LV</u>
o	Bare conductor size (mm).	
p	Insulated conductor size (mm).	
q	No. of conductors in parallel (Nos.).	
r	No. of turns/phase	
s	No. of discs/phase	
t	No. of turns/disc	
u	Gap between discs. (mm).	
v	Inside diameter (mm).	
w	Outside diameter (mm).	
x	Axial height after shrinkage (mm).	
y	D.C.RESISTANCE	
i	L.V winding at 75 ° C (Ohms).	

- ii I.V. winding at 75 ° C (Ohms).
- iii HV winding and Regulating winding at normal tap at 75° C (Ohms).
- iv HV winding and Regulating winding at highest tap at 75° C (Ohms).
- v HV winding and regulating winding at lowest tap. (Ohms).
- Z** I²R loss for winding at 75⁰C
 - i. At normal tap position (in KW)
 - ii. At maximum tap position (in KW)
 - iii. At minimum tap position (in KW)
- aa.** I²R loss at 75⁰C towards connecting leads for windings, bushings, OLTC etc.
 - i. At normal tap position (in KW)
 - ii. At maximum tap position (in KW)
 - iii. At minimum tap position (in KW)
- bb.** Eddy current losses in winding (in KW) at 75 deg.C
 - i. At normal tap position.
 - ii. At maximum tap position.
 - iii. At minimum. tap position.
- cc.** Stray losses in tank & other parts of transformer (in KW) at 75 deg.C
 - i. At normal tap position.
 - ii. At maximum tap position.
 - iii. At minimum. tap position.
- dd.** Any special measures taken to reduce eddy current losses and stray losses, mention in details.
- ee.** Load losses at 75°C [I²R + stray].
 - i. Normal tap position [KW].
 - ii. Highest tap position [KW].
 - iii. Lowest tap position [KW].
- ff.** Details of special arrangement provided to improve surge voltage distribution in the windings
- gg.** Tandelta(Power factor) of Winding(Max.) at measured temperature

34 BUSHINGS.

HV IV LV Neutral

- a Make and type
 - i Rated voltage class [KV-rms.]
 - ii Rated current [Amps.]
- b. Lightning Impulse withstand test voltage [1.2/50 micro second][KVP]
- c Switching surge withstand test voltage [KVP]
- d Power frequency withstand test voltage
 - i Wet for 1 minute [KV-rms]
 - ii Dry for 1 minute [KV-rms]
- e. Power frequency visible corona discharge voltage [KV-rms.]
- f Partial discharge level [PC]
- g Minimum creepage distance in mm
- h Minimum creepage distance in mm [protected]

- i Whether test-tap is provided?
 - j Quantity and grade of oil in bushing and Specification of oil used [Kg.]
 - k Weight of assembled bushing [Kg.]
 - l Minimum clearance height for removal of bushing [mm]
 - m Under oil flashover or puncture impulse voltage [KVP]
 - n. Under oil flashover or puncture power frequency voltage (KV-rms).
 - o. Phase to earth clearance in air of live parts at the top of bushings.
 - p. Maximum tan delta value at measured temperature
- 35** **Minimum clearance [mm]** Between Windings Phase to ground
- (A) **Out of Oil**
- HV
 - IV
 - LV
- (B) **In Oil**
- (i) Tertiary to Core
 - (ii) Tertiary to top yoke
 - (iii) Tertiary to bottom yoke
 - (iv) Tertiary to IV (radially)
 - (v) IV to HV (radially)
 - (vi) HV to Regulating (radially)
 - (vii) IV to top yoke
 - (viii) IV to bottom yoke
 - (ix) HV to top yoke
 - (x) HV to bottom yoke
 - (xi) Regulating to Top yoke
 - (xii) Regulating to bottom yoke
 - (xiii) Outer winding to Outer winding
 - (xiv) Outer winding to Tank
 - (a) Length wise
 - (b) Breadth wise
 - (c) Width wise
- 36** **Weight [Tolerance + 5%]**
 [Approximate value is not allowed]
- a Core [Kg.]
 - b Core with clamping [Kg.]
 - c H.V. [series] winding insulated conductor [Kg.]
 - d I.V. [common] winding insulated conductor [Kg.]
 - e Regulating winding insulated conductor [Kg.]
 - f L.V. winding insulated conductor [Kg.]
 - g Coils with insulation [Kg.]
 - h Core and winding [Kg.]
 - i Oil required for first filling [Liter/Kg.]
 - j Tank and fittings with accessories [Kg.]

- k Untanking weight [Kg.]
 - l Total weight with oil and fittings [kg.]
- 37** **DETAILS OF TANK**
- a Material for Transformer tank
 - b Type of tank
 - c Thickness of sheet
[No approximate value to be mentioned]
 - i Sides [mm]
 - ii Bottom [mm]
 - iii Cover [mm]
 - iv Radiators [mm]
 - d Inside dimensions of main tank
[No approximation in dimensions to be used]
 - i Length [mm]
 - ii Breadth [mm]
 - iii Height [mm]
 - e Outside dimensions of main tank
[No approximation in dimensions to be used]
 - i Length [mm]
 - ii Breadth [mm]
 - iii Height [mm]
 - f. Thickness of spray galvanization of tank bottom.
 - g. Vacuum recommended for hot oil circulation [torr]
 - h. Vacuum to be maintained during oil filling in Transformer tank [torr]
 - i. Vacuum to which the tank can be subjected without distortion [torr]
 - j. No. of bi-directional wheels provided
 - k. Track gauge required for the wheels
 - i Transverse axis
 - ii Longitudinal axis
 - l. Type and make of pressure relief device and minimum pressure at which it operates [Kpa]
- 38** **CONSERVATOR**
- a Total volume [Liters]
 - b Volume between the highest and lowest visible oil levels [Litres]
 - c Power required by heaters
[if provided][KW]
 - d. Conservator sheet thickness
- 39** **DETAILS OF AIRCELL OF CONSERVATOR**
- a Make
 - b Type
 - c Capacity
 - d Size
- 40** **OIL QUALITY**
- a Governing standard
 - b Density in gms/cu-cm

	c	Kinematics viscosity in CST		
	d	Inter facial tension at 27°C in N/m		
	e	Flash point in °C		
	f	Pour point in °C		
	g	Acidity [neutralization value] in mg of KOH/gm		
	h	Corrosive sulfur in %		
	i	Electric strength [breakdown voltage]		
	i	As received [KV-rms.]		
	ii	After treatment [KV-rms.]		
	j	Dielectric dissipation factor [tan delta] at 90°C		
	k	Saponification value in mg of KOH/gm		
	l	Water content in ppm		
	m	Specific resistance		
	i	At 90°C [ohm-cm]		
	ii	At 27 °C [ohm-cm]		
	n	N- dm analysis CA%		
		CM%		
		CP%		
	o	Oxidation stability		
	i	Neutralization value after oxidation		
	ii	Total sludge after oxidation		
	p	Characteristic of oil after ageing test as per ASTM-D-1934		
	i	Specific resistance at 27°C [ohm-cms]		
		90°C [ohm-cms]		
	ii	Tan delta		
	iii	Sludge content		
	iv	Neutralization number		
	v.	% of Napthanic Content		
	vi.	% of Paraffinic Content		
	vii.	Details of oil preserving equipment offered		
41		<u>RADIATORS</u>		
	a	Overall dimensions lxbxh [mm]		
	b	Total weight with oil [Kg.]		
	c	Total weight without oil [Kg.]		
	d	Thickness of radiator tube [mm]		
	e	Types of mounting		
	f	Vacuum withstand capability		
	g	Total radiating surface in sq.m		
	h	Type and make of material used for the radiators		
	i	Total number of radiators/Banks for Transformer and dimensions of tubes.		
	j.	Thickness of hot dip galvanization of radiators.		
42		<u>COOLING EQUIPMENT</u>	Fan motor	Pump motor
	a	Make and type		
	b	No. of connected units		

- c No. of stand -by units
 - d Rated power input
 - e Capacity [cu-m/min. or] [liters/min]
 - f Rated voltage [volts]
 - g Locked rotor current [Amps.]
 - h Efficiency of motor at full load [%]
 - i Temperature rise of motor at full load [°C]
 - j BHP of driven equipment
 - k Temperature range over which control is adjustable [°C]
 - l Whether the fans and pumps are suitable for continuous operation at 85 % of their rated voltage.
 - m Estimated time constant in hours for
 - i Natural cooling
 - ii Forced air cooling
 - iii Forced oil cooling
- 43** **GAS AND OIL OPERATED RELAY**
- a Make
 - b Type
 - c Size
 - d Whether supervisory alarm and trip contacts provided and their sizes and Nos.
- 44** **[I] TEMPERATURE INDICATORS** Oil Temp. Indicator Winding Temp. Indicator
- a Make and type
 - b Permissible setting ranges for alarm and trip
 - c Number of contacts
 - d Current rating of each contact
 - e Whether supervisory alarm contacts provided?
 - f Size [lxbxd]
 - g Nos.
 - h Ratio and type of CT used for winding
- [II] OPTIC FIBER TEMPERATURE SYSTEM**
- a. MAKE & TYPE
 - b. Whether the offered Optic Fiber Temperature System fulfills the stipulations as per this Specification
 - c. Whether the end-user's certificate for offered Optic Fiber Temperature System, from Indian Utilities furnished
 - d. Whether, the Bidder has got past experience of supply of Transformers with Optic Fiber Temperature System [YES/NO]
 - e. If 'YES', please state the No. of such Transformers, supplied along with the name(s) of Organisation(s), to whom supplied with Make of the Optic Fiber Temperature System, quantity supplied and performance of the same.
 - f. Address of FO system supplier
 - g. Nos. of channels
 - h. Sensors per channel

- i. Channel switching frequency
- j. Sampling sensor rate
- k. Switching reliability
- l. Wave length operational length
- m. PC output interface
- n. Data display
- o. Self Diagnostic
- p. Temp range & resolution
- q. Accuracy
- r. Response time
- s. Front panel display
- t. Probe signal strength readout
- u. Input power
- v. Serial Output
- w. Fiber type
- x. Nos. of relays
- y. Temperature Data storage
- z. LED alarm indicators
- aa. System fault relay
- bb. System fault status indicator
- cc. Surge protection
- dd. Connectors
- ee. Operating temperature range
- ff. Storage temperature
- gg. Probes material & dimensions
- hh. Analog output
- ii. SCADA compatibility
- jj. Nos. of probes
- kk. Tank wall adaptor plate with cover
- ll. EMI/RMI susceptibility
- mm. Signal conditioner compatibility
- nn. Connector for tank wall feed through

45 APPROXIMATE OVERALL DIMENSIONS
OF TRANSFORMER INCLUDING
COOLING SYSTEM, TAP CHANGING
GEAR ETC.

- a Length [mm]
- b Breadth [mm]
- c Height [mm]

- 46
- a Minimum clearance height for lifting core and winding from tank [mm]
 - b Minimum clearance height for lifting tank cover [mm]

47 **SHIPPING DETAILS**

	a	Approximate weight of heaviest package [Kg.]		
	b	Approximate dimensions of largest Package [Kg.]		
48		Transformers will be transported with oil/gas.		
49		Size of rail recommended for the track.		
50		Details of NCT & Bushing current transformers	<u>NCT</u>	<u>Bushing CT</u>
	a	Quantity		
	b	Type and voltage class		
	c	No. of cores		
	d	Ratio		
	e	VA burden		
	f	Accuracy class		
	g	Minimum knee point voltage [volts]		
	h	Maximum magnetization current at minimum knee point voltage [mA]		
	i	Maximum secondary winding resistance at 75°C[ohms]		
51		<u>LIFTING JACKS:-</u>		
	a	Governing standard		
	b	No. of jacks in one set		
	c	Type and make		
	d	Capacity [tonnes]		
	e	Pitch [mm]		
	f	Lift [mm]		
	g	Height in closed position [mm]		
	h	Mean diameter of thread [mm]		
52		<u>MARSHALLING KIOSK</u>		
	a	Make and type		
	b	Details of apparatus proposed to be housed in the kiosk		
53		Details of anti-earthquake device provided, if any		
54		Separate conservator and Buchholz relay provided		
55		<u>TAP CHANGING EQUIPMENT</u>		
		[These details refer to the basic rating of O.L. T.C. as guaranteed by OLTC manufacturers]		
	a	Make		
	b	Type		
	c	Power flow [Uni.-directional/bi - directional/restricted bi-directional]		
	d	Rated voltage to earth [KV]		
	e	Rated current [Amps.]		
	f	Step voltage [volts]		
	g	Number of steps		
	h	Control - manual/local-electrical/remote-electrical		
	i	Voltage control [Automatic/Non -automatic]		
	j	Line drop compensation provided/not provided		
	k	Parallel operation		
	l	protective devices		

- m Auxiliary supply details
 - n Time for complete tap change [one step][Sec.]
 - o Diverter selector switch transient time [cycles]
 - p Value of maximum short circuit current [Amps]
 - q Maximum impulse withstand test voltage with 1.2/50 micro seconds full wave between switch assembly and ground [KVP]
 - r Maximum power frequency test voltage between switch assembly and earth [KV-rms]
 - s Maximum impulse withstand test voltage with 1.2/50 micro-seconds across the tapping range [KVP]
 - t Approximate overall dimensions of tap changer [WxBxD] in mm.
 - u Approximate overall weight [Kg.]
 - v Approximate mass of oil [Kg.]
 - w Particulars of the OLTC control panel for installation in control room
- 56 DRIVING MECHANISM BOX
- a Make and type
 - b Details of apparatus proposed to be housed in the box
- 57 Types of terminal connectors and drawing No
- a HV
 - b IV
 - c LV
- 58 Details of painting, galvanization conforming to this Specification [Yes/No]
- 59 Type of oil level indicator and whether Supervisory alarm contact for low oil level provided [Yes/No]
- 60 Type and size of thermostat to be used
- 61 No. of breathers provided [Nos.]
- 62 Type of dehydrating agent used for breathers
- 63 Valve sizes and numbers
- a Drain valves- mm-Nos.
 - b Filter valves- mm-Nos.
 - c Sampling valves- mm-Nos.
 - d Radiator valves- mm-Nos.
 - e Other valves- mm-Nos.
- 64
- a) Type and make of PRV.
 - b) No. of each type of devices per transformer
 - c) Min. pressure at which device operates.
- 65 Please enclose the list of accessories and fittings, being provided on transformer. Please confirm, these are as stipulated in the tender.
- 66 Whether the transformer, covered is fully type tested and if so, whether copies of type test certificates, enclosed with the tender.
- 67 Whether tenderer can supply transformer, wound

- on vertical coil winding machine. Preference shall be given to the tenderer who will ensure supply of transformer wound on vertical winding machines.
- 68 In case Sl.No.67 is not confirmed, what are the additional pre-cautions which shall be taken by the tenderer to justify that the coil, wound on horizontal machine shall be equivalent in all respects to that which are wound on vertical winding machine.
- 69 What are the arrangements, available for jointing the winding. Preference shall be given to the tenderer using high-frequency brazing machines. In case other jointing techniques are used, adequacy of the same is to be recorded. Please note that bolted joints in the winding are not acceptable. This should be confirmed here.
- 70 Please confirm that you will guarantee maximum Impedance variation between phases within the limit of 2% only.
- 71 a) Please confirm that the transformer shall be dried by vapour-phase drying method. Please specify level of dryness.
b) In case, other methods of drying are used, the level of dryness, so achieved should be identical to that by VPD. Adequacy of such system should be justified.
- 72 Please confirm whether the In-House facilities for all routine tests as per this Tender Specification are available with the tenderer and the tenderer shall agree to conduct these tests on the transformer in the event of order.
- 73 **Whether the Tenderer has got In-House core-cutting facility for cutting core materials for the transformer ratings as offered. (YES/NO)**
- 74 **If 'YES', following informations/confirmations are required: -**
- a. Name of the manufacturer of HIB Grade core material from whom core materials will be directly imported or through their accredited marketing organization of repute. If to be imported through the accredited Marketing Organisation, Please state the name of such Marketing Organisation and please enclose the relevant documents with the Tender Offer regarding accreditation of the said Marketing Organisation by the manufacturer of the HIB core material.
 - b. Grade, Trade Name and Thickness of the core material, to be imported
 - c. Whether agreed for witnessing of core materials by OPTCL's representative(s)
 - d. Whether, the Bidder has past experience towards direct import of core materials. If 'YES', the copies of recent past Import documents to be furnished with the Tender Offer (Please state, whether the said import documents are enclosed with the Tender Offer)
 - e. Whether, the Bidder has got In-House CNC Machine

- facility for cutting of core materials
- f. Whether the Bidder is agreed to follow the procedures, as stipulated at Cl.No.5.4.8 (o), (p) &(q) of this Technical Specification, as applicable for those, who have got In-House core-cutting facility

75. If the Bidder has no In-House core-cutting facility, the following informations/confirmations are required: -

- a. Name of the core manufacturer of core materials from whom core materials will be directly imported or through their accredited marketing organization of repute. If to be imported through the accredited Marketing Organisation, Please state the name of such Marketing Organisation and please enclose the relevant documents with the Tender Offer regarding accreditation of the said Marketing Organisation by the manufacturer of the HIB core material.
- b. Grade, Trade Name and Thickness of the core material, to be imported
- c. Name of the core-cutting vendor and whether the said vendor has got In-House CNC Machine facility for cutting of core materials and whether the said vendor has been accredited by ISO
- d. Whether, the Bidder has past experience towards direct import of core materials. If 'YES', the copies of recent past Import documents to be furnished with the Tender Offer (Please state, whether the said import documents are enclosed with the Tender Offer)
- e. Whether the Bidder is agreed to follow the procedures, as stipulated at Cl.No.5.4.8 (o), (p) &(q)(1), (2), (3), (4), (5),(6) & (7) of this Technical Specification, as applicable for those, who have got no In-House core-cutting facility.

- 76 Please confirm that the facility for partial discharge test is available with the tenderer and the tenderer shall agree to conduct this test on transformer in the event of order.

Place
Date

Bidder's name:
Signature, Designation, Seal

GUARANTEED TECHNICAL PARTICULARS NITROGEN INJECTION SYSTEM FOR PREVENTION OF FIRE/ EXPLOSION FOR TRANSFORMERS/REACTORS.

Sr. No.	Description	Guaranteed Particulars
1	Name of Manufacture and country of origin	
2	Reference standards	
3	Details of system equipments	
4	FEC (Fire Extinguishing Cubicle)	

4.1	Dimensions (LXBXH) mm	
4.2	Weight	
4.3	Capacity of Nitrogen cylinder	
4.4	Number of cylinders	
4.5	Pressure of Nitrogen filing	
4.6	Minimum distance of FE cubicle from the transformer	
4.7	Method of mounting	
4.8	Whether the following items are provided in FE cubicle. If so furnish make, type & other details	
4.9	Contact Manometer	
4.10	Pressure Regulator	
4.11	Oil Release Unit	
4.12	Gas release unit	
4.13	Oil drain assembly	
4.14	Pressure / limit switches	
4.15	No. of contacts & spare contacts (NO & NC)	
4.16	Oil drain Valve (ABOVE FEC)	
4.17	Make	
4.18	Type	
4.19	Size	
4.20	Type of metal	
4.21	Nitrogen Injection Valve (Above FEC)	
4.22	Make	
4.23	Type	
4.24	Size	
4.25	Oil drain pipe	
4.26	Size	
4.27	Length	
4.28	Number of openings in the transformer tank	
4.29	Material	
5	Control Box	
5.1	Dimensions (LXBXH) mm	
5.2	mm	
5.3	Type & Thickness of sheet steel	
5.4	Details of components provided in the control box	
5.5	Control voltage	
5.6	Method of mounting	
5.7	Whether audio and visual alarm provided?	
6.	Transformer Conservator Isolation Valve	
6.1	Make	
6.2	Type	
6.3	Location	
6.4	Whether suitable for pipe of size 80 mm dia	
6.5	No. of contacts & spare contacts (NO & NC)	
6.6	Padlocking provision	

7	Detectors	
7.1	Make	
7.2	Type	
7.3	Quantity required	
7.4	Method of fixing	
7.5	Effective heat sensing area	
7.6	Temperature recommended for effective heat sensing	
7.7	Number of contacts NO / NC	
7.8	Necessity and condition of Refilling	
8	Whether approved by Tariff Advisory Committee of India	
9	TECHNICAL PARTICULARS FOR NITROGEN INJECTION SYSTEM FOR PREVENTION OF TRANSFORMER EXPLOSION	
10	Power Supply	
10.1	Control box	
10.2	FEC (lighting)	
10.3	Extinction period	
10.4	On system activation	
10.5	On commencement of Nitrogen injection	
11	FEC Suitable for capacity	
11.1	Dimensions (LXBXH) mm	
11.2	Weight	
11.3	Nitrogen cylinder capacity	
12	Control Box	
12.1	Dimensions (LXBXH) mm	
12.2	Weight	
13	Detectors	
13.1	Heat sensing temperature	
13.2	Time of operation	Transformer Tank Explosion Prevention
	For system activation	Fire Extinction
	For reduction of pressure in tank by Nitrogen Release	

13.3 Any other technical details not covered above.

N.B.

The bidder must fill up all the points of GTP for offered item(s). Instead of indicating “refer drawing” or “as per IS/IEC”, the exact value(s) must be filled in.

ANNEXURE - V.

ADDITIONAL SCHEDULE OF INFORMATIONS.

(To be furnished by the bidder along with the Tender Offer)

<u>Sl. No.</u>	<u>Item.</u>	<u>Remarks.</u>
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SIGNATURE OF THE TENDERER
WITH SEAL AND DATE

NB- The Bidders are required to up load this sheet duly filling the required data, in PDF format.

ANNEXURE - VI.

CHECK-LIST TOWARDS TYPE TEST REPORTS.

Name of the Type Test.	Date of Test	Name of the Laboratory where the test has been conducted.	Whether Laboratory is Govt. Approved .	Name of the Govt. Organisation Which has witnessed the type test.	Whether the test report is valid as per Clause No.6.4.1 of TS	Whether the copy of test report in complete shape along with the drawings etc. furnished or not?	Whether the type tested 500 MVA transformer fulfills the technical requirements as per TS	Remarks
1	2	3	4	5	6	7	8	9

Place

Dated:

SIGNATURE OF THE TENDERER
WITH SEAL AND DATE:

NB- The Bidders are required to up load this sheet duly filling the required data, in PDF format.

ANNEXURE - VII

CALIBRATION STATUS OF TESTING EQUIPMENTS AND INSTRUMENTS / METERS.

Name of the Test.	Meters & Equipment required for the corresponding test with range accuracy, make and Sl.No.	Date of calibration	Due date of calibration	Name of the Calibrating Agency.	Whether calibrating agency is Govt. Approved.
1	2	3	4	5	6

Whether documents related to Govt. approval of the Calibrating Agency furnished.	Whether the meters/equipments fulfill the accuracy class as per calibration report.	Whether calibrating Agency has put any limitation towards the use of the particular meters/equipments. If yes, state the limitations.	In spite of imposed limitations, whether the particular meter/ equipments can still be used. Justify its use for corresponding test(s)	Remarks.
7	8	9	10	11

Place

Dated:

SIGNATURE OF THE TENDERER
WITH SEAL AND DATE:

NB- The Bidders are required to up load this sheet duly filling the required data, in PDF format.

ANNEXURE - VIII.

CHECK - LIST FOR DELIVERY SCHEDULE

<u>Sl. No.</u>	<u>Description of the equipment.</u>	<u>Quantity.</u>	<u>Delivery Schedule</u>
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Place:

SIGNATURE OF THE TENDERER

Dated:

WITH SEAL AND DATE:

N: B:-Period of delivery is to be quoted from the date of issue of the purchase order only. Any other form of quotation such as delivery from the date of approval of drawings or any other form will not be accepted.

NB- The Bidders are required to up load this sheet duly filling the required data, in PDF format.

ANNEXURE - IX

ABSTRACT OF TERMS AND CONDITIONS.

[TECHNICAL]

[To be filled in by the Bidder]

- | | | |
|-----|--|--------|
| 1. | Whether accepted Clause 1.0 "Scope" and its Sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 2. | Whether accepted Clause 2.0 "Standards" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 3. | Whether accepted Clause 3.0 "Auxiliary Power Supply". If 'no' then indicate your terms. | Yes/No |
| 4. | Whether accepted Clause 4.0 "Principal Parameters". If 'no' then indicate your terms. | Yes/No |
| 5. | Whether accepted Clause 5.0 "General Technical Requirements" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 6. | Whether accepted Clause 6.0 "Inspection and Testing" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 7. | Whether accepted Clause 7.0 "Test Reports". If 'no' then indicate your terms. | Yes/No |
| 8. | Whether accepted Clause 8.0 "List of Transformer Accessories and Test Certificates required for them". If 'no' then indicate your terms. | Yes/No |
| 9. | Whether accepted Clause 9.0 "Inspection" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 10. | Whether accepted Clause 10.0 "Quality Assurance Plan" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 11. | Whether accepted Clause 11.0 "Documentation" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 12. | Whether accepted Clause 12.0 "Packing and Forwarding" and its sub-clauses. If 'no' then indicate your terms. | Yes/No |
| 13. | Whether accepted Clause 13.0 "Supervision of Erection, Testing and Commissioning". If 'no' then indicate your terms. | Yes/No |

- | | | |
|-----|---|--------|
| 14. | Whether accepted Clause 14.0 “Quantity and Delivery requirements”.
If ‘no’ then indicate your terms. | Yes/No |
| 15. | Whether accepted Clause 15.0.
If ‘no’ then indicate your terms. | Yes/No |
| 16. | Whether accepted Clause 16.0. “Method of Technical Evaluation”. If ‘no’ then indicate your terms. | Yes/No |
| 17. | Whether furnished ‘ANNEXURE-II’ in full shape. | Yes/No |
| 18. | Whether furnished ‘ANNEXURE-III’
(Loss calculations) in full shape. | Yes/No |
| 19. | Whether furnished ‘ANNEXURE-IV’
(G.T.P.) in full shape. | Yes/No |
| 20. | Whether furnished ‘ANNEXURE-V’
(Additional Schedule of Informations). | Yes/No |
| 21. | Whether furnished ‘ANNEXURE-VI’
(Check List towards type test reports).
in full shape. | Yes/No |
| 22. | Whether furnished ‘ANNEXURE-VII’
(Calibration Status).
in full shape. | Yes/No |
| 23. | Whether furnished ‘ANNEXURE-VIII’
in full shape (Check list for Delivery Schedule). | Yes/No |
| 24. | Whether furnished B.H. and Sp. Loss Curve
for the core material? | Yes/No |
| 25. | Whether furnished “Knee Point Voltage” Graph? | Yes/No |
| 26. | Whether furnished ‘Short Circuit Temperature rise’
and ‘force calculation’ as per clause No.5.1.2 of T.S.? | Yes/No |
| 27. | Whether furnished calculation towards H.V.Air-core
reactance and ‘Magnetizing Inrush current’? | Yes/No |
| 28. | Whether all other documents/calculations relating to
different clauses as per the Technical Specification furnished? | Yes/No |

PLACE:
DATE:

SIGNATURE OF THE TENDERER
WITH SEAL AND DATE

NB- The Bidders are required to up load this sheet duly filling the required data, in PDF format.