




**SECTION 5: TECHNICAL SPECIFICATION**  
**SUPPLY OF TRANSFORMERS FOR**  
**ISTS/ InSTS CONNECTED RE POWER PROJECTS AT VARIOUS LOCATIONS ACROSS INDIA**

**RFP NO.: TeCL/CC/TRANSFORMER/2025-26/11**


Issued by  
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New Delhi-110023

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## Group A - Power Transformer

The design, manufacture, testing, inspection, supply, and performance of Power Transformers shall conform to the “**Standard Technical Specifications for Transformer(s) for Solar Park Pooling Stations**” issued by the **Central Electricity Authority (CEA)**, including all **latest amendments**, along with the following requirements.


### 1 TECHNICAL REQUIRMENTS

#### 1.1 Technical Parameters for 165 MVA, 140 MVA and 130 MVA power transformer


S No	Description	Unit	Technical Parameters		
1.	Rated capacity	MVA	165	140	130
2.	Voltage ratio (Line-to-Line)	kV	220/33 /33	220/ 33	220/3 3
3.	Winding material		electrolytic grade copper		
4.	Rated Capacity HV	MVA	165	140	130
5.	Rated Capacity LV1	MVA	82.5	140	130
6.	Rated Capacity LV2	MVA	82.5	-	-
7.	No. of phases		3		
8.	No. of secondary windings		Two	One	One
9.	Vector Group		YNynyn0	YNyn0	YNyn0
10.	Applicable Standard		IEC 60076 / IS 2026		
11.	Cooling type		ONAN/ONAF		
12.	Rating at different cooling	%	70/100		
13.	Cooler Bank Arrangement		2 x 50%		
14.	Frequency	Hz	50		
15.	Tap Changer (type)		On-load tap changer/OCTC		
15.1	Tap Changer range		-10% to +10% in 1.25% for HV variation		
15.2	Tap Changer location		HV neutral end		
16.	HV-LV Impedance at 75 °C, at 82.5 MVA base for 165 MVA and at highest MVA base for other corresponding transformer rating (Max voltage tap /Principal tap/Min tap)	%	16.2 / 15 / 14		
16.1	Impedance LV1-LV2	%	20 (min.)	-	-
16.2	Tolerance on impedance	%	As per IEC		
17.	Service		Outdoor		
18.	Duty		Cyclic		

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S No	Description	Unit	Technical Parameters		
19.	Overload capacity		IEC 60076-7		
20.	Temperature rise over 50-degree ambient temp - Top oil temp	°C	50		
20.1	Temperature rise over 50-degree ambient temp - Average winding temp	°C	55		
21.	Winding hot-spot rise over yearly weighted temp (32°C)	°C	66		
22.	Tank hotspot temperature	°C	110		
23.	Max design ambient temperature	°C	50		
<b>24. Windings</b>					
24.1	Lightning impulse withstand voltage	kVp	HV 950; LV 170; HV-N 95; LV-N 170		
24.2	Chopped Wave Lightning Impulse Withstand Voltage	kVp	HV 1045; LV1&L V2 187	HV 1045; LV 187	HV 1045; LV 187
24.3	Switching Impulse withstand Voltage (HV)	kVp	750		
24.4	One Minute Power Frequency withstand Voltage	kVrms	HV 395; LV 70; HV-N 38; LV-N 70		
24.5	Neutral grounding (HV & LV)		Solidly grounded		
24.6	Insulation (HV/LV)		HV graded; LV1&L V2 uniform	HV graded; LV uniform	HV graded; LV uniform
24.7	Tan delta of winding	%	≤ 0.5		
<b>25. Bushing</b>					
25.1	Bushing rated voltage	kV	HV 245; LV1&L V2 36; HV-N 36; LV-N 36	HV 245; LV 36; HV-N 36; LV-N 36	HV 245; LV 36; HV-N 36; LV-N 36
25.2	Bushing rated current	A	HV 1250; LV1&L V2 3150; HV-N 3150;	HV 1250; LV 3150; HV-N 3150	HV 1250; LV 3150; HV-N 3150;

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S No	Description	Unit	Technical Parameters		
			LV-N 3150	; LV-N 3150	LV-N 3150
25.3	Bushing Lightning Impulse withstand Voltage	kVp	HV 1050; LV1&L V2 170; HV-N 170; LV-N 170	HV 1050 ; LV 170; HV-N 170; LV-N 170	HV 1050; LV 170; HV-N 170; LV-N 170
25.4	Bushing switching Impulse withstanding Voltage (HV)	kVp	850		
25.5	Bushing One-minute PF withstand voltage	kVrms	HV 505; LV1&L V2 77; HV-N 77; LV- N 77	HV 505; LV 77; HV-N 77; LV-N 77	HV 505; LV 77; HV-N 77; LV-N 77
25.6	Bushing tan delta at ambient	%	≤ 0.5		
25.7	Minimum creepage distance (HV/LV/HV-N/LV-N)	mm	HV 7595; LV 1116; HV-N/LV-N 1116		
25.8	Max Partial discharge level at Um (HV)	pC	10		
26.	Max PD level at $1.58 \cdot U_r / 3$	pC	100		
27.	Maximum Noise level	dB	80		
28.	Termination details		Cable box/Bare bushing		
28.1	Max permissible losses: Max. No Load Loss at rated voltage and frequency	kW	65	58	57
28.2	Max permissible losses:Max. Load Loss at rated current and at 75°C for HV and LV (LV1+LV2)	kW	390	365	341
28.3	Max permissible losses: Max. I2R Loss at rated current and at 75°C for HV and LV (LV1+LV2) windings at principal tap position	kW	319	301	279
28.4	Max permissible losses: Max. Auxiliary Loss at rated voltage and frequency	kW	8	8	7

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S No	Description	Unit	Technical Parameters
<i>HV: High Voltage</i> <i>LV: Low Voltage</i> <i>HV-N: HV Neutrals</i> <i>LV-N: LV Neutrals</i> <i>LV1: Low voltage winding 1</i> <i>LV2: Low voltage winding 2</i>			


## 1.2 Technical parameters for 80 MVA and 65 MVA power transformers

S No	Description	Unit	Technical Parameters	
1.	Rated capacity	MVA	80	65
2.	Voltage ratio (Line-to-Line)	kV	132/33	
3.	Winding material		electrolytic grade copper	
4.	Rated Capacity HV	MVA	80	65
5.	Rated Capacity LV	MVA	80	65
6.	No. of phases		3	
7.	No. of secondary windings		One	
8.	Vector Group		YNyn0	
9.	Applicable Standard		IEC 60076 / IS 2026	
10.	Cooling type		ONAN/ONAF	
11.	Rating at different cooling	%	70/100	
12.	Cooler Bank Arrangement		1 x 100%	
13.	Frequency	Hz	50	
14.	Tap Changer (type)		On-load (CFVV)	
14.1.	Tap Changer range		-10% to +10% in 1.25% for HV variation	
14.2.	Tap Changer location		HV neutral end	
15.	HV-LV Impedance at 75 °C, at highest MVA base (Max voltage tap /Principal tap/Min tap)	%	13.2 / 12.5 / 11.8	
15.1.	Tolerance on impedance	%	As per IEC	
16.	Service		Outdoor	
17.	Duty		Cyclic	
18.	Overload capacity		IEC 60076-7	
19.	Temperature rise over 50 degree ambient temp - Top oil temp	°C	50	

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S No	Description	Unit	Technical Parameters	
19.1.	Temperature rise over 50 degree ambient temp - Average winding temp	°C	55	
20.	Winding hot-spot rise over yearly weighted temp (32°C)	°C	66	
21.	Tank hotspot temperature	°C	110	
22.	Max design ambient temperature	°C	50	
<b>23.</b>	<b>Windings</b>			
23.1.	Lightning impulse withstand voltage	kVp	HV 650; LV 170; HV-N 95; LV-N 170	
23.2.	Chopped Wave Lightning Impulse Withstand Voltage	kVp	HV 715; LV 187	
23.3.	Switching Impulse withstand Voltage (HV)	kVp	540	
23.4.	One Minute Power Frequency withstand Voltage	kVrms	HV 275; LV 70; HV-N 38; LV-N 70	
23.5.	Neutral grounding (HV & LV)		Solidly grounded	
23.6.	Insulation (HV/LV)		HV graded; LV uniform	
23.7.	Tan delta of winding	%	≤ 0.5	
<b>24.</b>	<b>Bushing</b>			
24.1.	Bushing rated voltage	kV	HV 145; LV 36; HV-N 36; LV-N 36	
24.2.	Bushing rated current	A	HV 1250; LV 3150; HV-N 3150; LV-N 3150	
24.3.	Bushing Lightning Impulse withstand Voltage	kVp	HV 650; LV 170; HV-N 170; LV-N 170	
24.4.	Bushing switching Impulse withstanding Voltage (HV)	kVp	-	
24.5.	Bushing One-minute PF withstand voltage	kVrms	HV 305; LV 77; HV-N 77; LV-N 77	
24.6.	Bushing tan delta at ambient	%	≤ 0.5	
24.7.	Minimum creepage distance (HV/LV/HV-N/LV-N)	mm	HV 4495; LV 1116	
24.8.	Max Partial discharge level at Um (HV)	pC	10	
25.	Max PD level at 1.58*Ur/3	pC	100	
26.	Maximum Noise level	dB	75	
27.	Termination details		Cable box/Bare bushing	
27.1.	Max permissible losses: Max. No Load Loss at rated voltage and frequency	kW	35	30
27.2.	Max permissible losses:Max. Load Loss at rated current and at 75°C for HV and LV	kW	221	186




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S No	Description	Unit	Technical Parameters	
27.3.	Max permissible losses: Max. I2R Loss at rated current and at 75°C for HV and LV windings at principal tap position	kW	189	159
27.4.	Max permissible losses: Max. Auxiliary Loss at rated voltage and frequency	kW	5	4


*HV: High Voltage*  
*LV: Low Voltage*  
*HV-N: HV Neutrals*  
*LV-N: LV Neutrals*  
*LV1: Low voltage winding 1*  
*LV2: Low voltage winding 2*

### 1.3 Technical Parameters for 55 MVA power transformers

S No	Description	Unit	Technical Parameters
1.	Rated capacity	MVA	55
2.	Voltage ratio (Line-to-Line)	kV	66/33kV
3.	Winding material		electrolytic grade copper
4.	Rated Capacity HV	MVA	55
5.	Rated Capacity LV	MVA	55
6.	No. of phases		3
7.	No. of secondary windings		One
8.	Vector Group		YNyn0
9.	Applicable Standard		IEC 60076 / IS 2026
10.	Cooling type		ONAN/ONAF
11.	Rating at different cooling	%	70/100
12.	Cooler Bank Arrangement		1 x 100%
13.	Frequency	Hz	50
14.	Tap Changer (type)		On-load (CFVV)
14.1.	Tap Changer range		-10% to +10% in 1.25% for HV variation
14.2.	Tap Changer location		HV neutral end
15.	HV-LV Impedance at 75 °C, at highest MVA base (Max voltage tap /Principal tap/Min tap)	%	11.2/10/9
15.1.	Impedance LV1-LV2	%	-
15.2.	Tolerance on impedance	%	As per IEC

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S No	Description	Unit	Technical Parameters
16.	Service		Outdoor
17.	Duty		Cyclic
18.	Overload capacity		IEC 60076-7
19.	Temperature rise over 50-degree ambient temp - Top oil temp	°C	50
19.1.	Temperature rise over 50-degree ambient temp - Average winding temp	°C	55
20.	Winding hot-spot rise over yearly weighted temp (32°C)	°C	66
21.	Tank hotspot temperature	°C	110
22.	Max design ambient temperature	°C	50
<b>23.</b>	<b>Windings</b>		
23.1.	Lightning impulse withstands voltage	kVp	HV 320; LV 170; HV-N 95; LV-N 170
23.2.	Chopped Wave Lightning Impulse Withstand Voltage	kVp	HV 354; LV 187
23.3.	Switching Impulse withstand Voltage (HV)	kVp	
23.4.	One Minute Power Frequency withstand Voltage	kVrms	HV 140; LV 70; HV-N 38; LV-N 70
23.5.	Neutral grounding (HV & LV)		Solidly grounded
23.6.	Insulation (HV/LV)		HV graded; LV uniform
23.7.	Tan delta of winding	%	≤ 0.5
<b>24.</b>	<b>Bushing</b>		
24.1.	Bushing rated voltage	kV	HV 72.5; LV 36; HV-N 36; LV-N 36
24.2.	Bushing Lightning Impulse withstand Voltage	kVp	HV 325; LV 170; HV-N 170; LV-N 170
24.3.	Bushing switching Impulse withstanding Voltage (HV)	kVp	-
24.4.	Bushing One-minute PF withstand voltage	kVrms	HV 155; LV 77; HV-N 77; LV-N 77
24.5.	Bushing tan delta at ambient	%	≤ 0.5
24.6.	Minimum creepage distance (HV/LV/HV-N/LV-N)	mm	HV 2248; LV 1116; HV-N/LV-N 1116
24.7.	Max Partial discharge level at Um (HV)	pC	10
25.	Max PD level at 1.58*Ur/3	pC	100

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S No	Description	Unit	Technical Parameters
26.	Maximum Noise level	dB	70
27.	Termination details		Cable box/Bare bushing
27.1.	Max permissible losses: Max. No Load Loss at rated voltage and frequency	kW	45
27.2.	Max permissible losses: Max. Load Loss at rated current and at 75° C for HV and LV	kW	180
27.3.	Max permissible losses: Max. I2R Loss at rated current and at 75° C for HV and LV windings at principal tap position	kW	170
27.4.	Max permissible losses: Max. Auxiliary Loss at rated voltage and frequency	kW	7
<i>HV: High Voltage</i> <i>LV: Low Voltage</i> <i>HV-N: HV Neutrals</i> <i>LV-N: LV Neutrals</i> <i>LV1: Low voltage winding 1</i> <i>LV2: Low voltage winding 2</i>			

**NOTE:**

- The bidder shall submit the Transformer Technical Data Sheet in the Owner's prescribed format. The format shall be obtained from the Owner during the design review / detailed engineering stage.
- All tests (Type Tests and Routine Tests) shall be carried out in accordance with the "Standard Technical Specifications for Transformer(s) for Solar Park Pooling Stations" issued by the Central Electricity Authority (CEA). In addition, Type Tests shall conform to the CEA "Guidelines for Type Tests for Major Equipment in the Power Sector".
- Quality Assurance Plan (QAP) shall be as per "Standard Technical Specifications for Transformer(s) for Solar Park Pooling Stations" issued by the Central Electricity Authority (CEA).
- List of accessories and Spares shall be supplied by the bidder as mentioned in the "Standard Technical Specifications for Transformer(s) for Solar Park Pooling Stations" issued by the Central Electricity Authority (CEA).

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## Group B - Auxiliary transformer


### 1 TECHNICAL REQUIRMENTS

#### 1.1 Technical parameters for 250 KVA,100KVA,300KVA & 200KVA transformers

S.No.	Particulars	Unit	Technical Parameters			
1.	Rated Capacity	KVA	250	100	300	200
2.	Voltage Ratio	KV	33/0.433			
3.	Winding material		Electrolytic grade Aluminium			
4.	No of phases		3 Ph			
5.	Windings		2			
6.	Frequency	Hz	50 Hz			
7.	Vector Group		Dyn11			
8.	Tapping Mode		Off Circuit Tap Changer			
9.	Tapping Range & Step %		+5 to -5 in Steps of 2.5% 5 Positions			
10.	Impedance %		4.00% IST			
11.	Cooling		ONAN			
12.	Termination HV / LV		CBCB			
13.	Temperature rise over 50 degrees ambient temp - Top oil temp	°C	50			
14.	Temperature rise over 50-degree ambient temp - Average winding temp	°C	55			
15.	Specification reference		IS 1180:2014 / IS 2026:2011			

#### 1.2 Technical parameters for 25 KVA, 20KVA, 30KVA,15 KVA transformers


S.No.	Particulars	Unit	Technical Parameters			
1.	Rated Capacity	KVA	25	20	30	15
2.	Voltage Ratio	KV	0.8/0.433			
3.	Winding material		Electrolytic grade Copper			
4.	No of phases		3 Ph			
5.	Windings		2			
6.	Frequency	Hz	50 Hz			
7.	Vector group		Dyn11			
8.	Impedance %		4.00% IST			
9.	Transformer type		Dry			
10.	Termination HV / LV		CBCB			

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S.No.	Particulars	Unit	Technical Parameters
11.	Temperature rise over 50 degrees ambient temp - Average winding temp	°C	55

### 1.3 Other Technical parameters

SN	Particulars	Description
1	SC withstand time (thermal)	2 Sec.
2	Fault Level & Bushing CT	Vendor to specify
3	Termination	Vendor to specify
4	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC Creepage distance: 31 mm/kV
5	Noise level	AS PER NEMA TR-1
6	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600.
7	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
8	Air Clearance	As per CBIP
9	Spares	20% additional quantity of transformer insulating oil (based on the oil capacity of each transformer) shall be supplied in separate sealed drums, along with one complete set of gaskets and one number each of HV and LV bushings, at no additional cost.
10	Inspection & Testing	
10.1	Inspection	Transformer shall be subjected to inspection by the owner or by an agency authorized by the owner at the manufacturer's work.
10.2	Testing	As per QAP for transformer mentioned in Annexure - A of Model Quality Assurance Plan (MQAP) for Equipment of Substation, Switchyards and Transmission Lines issued by CEA, Bidder shall submit the QAP for owners approval
11	Drawings, Data & Manuals	

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SN	Particulars	Description
11.1	General	<ul style="list-style-type: none"> <li>i. The supplier shall develop his own general arrangement and schematic drawing adding necessary auxiliary devices, accessories, and components specific to supplied equipment etc., which are required for safe, convenient, efficient and proper operation of the Transformer</li> <li>ii. The Owner's approval of the drawings shall not relieve the supplier of his responsibility for supplying transformer conforming with the relevant specifications and standards or of any mistakes, errors or omissions in the drawing</li> </ul>
11.2	Documents to be submitted on PO placements	<p>The following drawings of the transformer offered shall be submitted within 4 weeks of placement of purchase order, for owner's approval:</p> <ul style="list-style-type: none"> <li>i. Outline dimensional drawing of transformer and accessories.</li> <li>ii. Connection diagram.</li> <li>iii. GA &amp; Schematic diagram of tap changing mechanism.</li> <li>iv. Shipping drawing showing dimensions and weights of heaviest package.</li> <li>v. Nameplate diagram.</li> <li>vi. Interconnecting / control cable schedule.</li> <li>vii. Bushing drawings and specification.</li> <li>viii. Schematic diagram showing flow of oil in cooling system as well as each limb and winding.</li> <li>ix. Foundation plan of the transformer.</li> <li>x. Cross-sectional drawing of HV Cable box &amp; LV Bus Duct flange / cable box.</li> <li>xi. Any other document / drawing requested by the owner at the time of drawing approval</li> </ul>
11.3	Documents to be submitted for Dispatch Clearance	<ul style="list-style-type: none"> <li>i. sets of Tests &amp; Inspection report duly certified by Inspector</li> <li>ii. sets of the final As-Built drawings with the latest instructions manual (including a soft copy of the drawings in CAD &amp; PDF file in a DVD/CD/PD)</li> <li>iii. The supplier shall also submit sets of maintenance and operation manual</li> <li>iv. Any other relevant drawing, document or data necessary for satisfactory installation, operation and maintenance</li> </ul>

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SN	Particulars	Description
11.4	Documents to be submitted with Delivery	i. Copies of inspection report and approved documents to each consignee at the time of effecting delivery along with a copy of Dispatch Clearance issued by Owner. ii. All the documents submitted for Dispatch Clearance, along with one set of reproducible (Soft copy of CAD & PDF file in a DVD/CD/PD)
12	Delivery (Packing & Forwarding)	i. The transformer supplied shall be transported to site after taking precautions to prevent entry of rainwater, dust and damage during handling & shipment. Packing list shall be supplied along with the material. ii. The accessories like radiators, bushings, explosion vent, dehydrating breather, rollers, Buchholz relay, connecting pipes, conservator etc. shall be properly packed for shifting to site.
13	Guarantee	The transformer and other equipment supplied shall be guaranteed for trouble-free operation for a period of <b>12 months from the date of commissioning or 18 months from the date of supply, whichever is earlier.</b>

## 2 CODES AND STANDARDS

SN	Particulars	Codes and Standards
1.	Transformers	IS:2026, IS:6600
2.	Bushings	IS:2099, IS 3347
3.	Insulating oil	IS 16659 / IS 16081
4.	Bushing CTs	IS:2705
Indian Electricity Act 2003, BEE Guideline & CEA notifications		

### 2.1 General Construction


- 2.1.1 Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier. The important construction particulars shall be as below.
- 2.1.2 The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- 2.1.3 A double float type Buchholz relay conforming to IS: 3637 shall be provided.

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- 2.1.4 Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.
- 2.1.5 All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site
- 2.1.6 The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal- (As applicable).
- 2.1.7 Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.(As applicable)
- 2.1.8 Transformer shall have Oil Temperature Indicator- (As applicable) and Winding temperature Indicator (WTI applicable for transformer above 50 KVA) with accuracy class of +/-2 deg.
- 2.1.9 For Transformers above 100KVA, radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.
- 2.1.10 M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level (for transformer above 100 KVA). For transformer above 100 KVA, wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.
- 2.1.11 In case Natural Ester oil (IS 16659) filled transformer, the Transformer should be hermetically sealed and corrugated tank design. It should fitted with monitoring equipment like DGPT etc. for accessing the healthiness of Natural ester oil. As transformer becomes hermetically sealed, fitting, valves and accessories shall be decided appropriately, but all other part of tender specification related to design of transformer active part and testing requirement shall remain same. HV/LV Bushing shall be fitted vertically on tank cover and all necessary measures to be taken to make the transformer leakage proof. Suitable nitrogen capping system shall be provided for preserving Natural ester oil for O&M.(As applicable)

## 2.2 Windings



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2.2.1 The bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.

2.2.2 The conductors shall be of electrolytic grade Aluminium free from scales & burrs.

2.2.3 All windings of the transformers shall have uniform insulation.

2.2.4 Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

### 2.3 Core

2.3.1 The core shall be constructed from non-ageing, cold rolled, super grain-oriented silicon steel laminations equivalent to M4 grade steels or better.


2.3.2 Core isolation level shall be 2 kV (rms.) for 1 minute in air.

2.3.3 Adequate lifting lugs will be provided to enable the core & windings to be lifted.

### 2.4 Insulating Mineral oil

2.4.1 No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters. (As applicable)

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm <sup>2</sup> /s	≤ 12 at 40°C; ≤ 1800.0 at (-)30°C
2.	Flash Point, °C	≥ 140°C
3.	Pour Point, °C	≤ (-)40°C
4.	Appearance	Clear, free from sediment and suspended matter
5.	Density kg/dm <sup>3</sup> at 20°C	≤ 0.895
6.	Interfacial Tension N/m at 25°C	≥ 0.04
7.	Neutralisation value, mgKOH/g	≤ 0.01
8.	Corrosive sulphur	Non-Corrosive
9.	Water content mg/kg	≤ 30 in bulk supply; ≤ 40 in drum supply
10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability - Neutralization value, mgKOH/g	≤ 1.2
12.	Oxidation Stability - Sludge, % by mass	≤ 0.8
13.	Breakdown voltage (As delivered), kV	≥ 30
14.	Breakdown voltage (After treatment), kV	≥ 70
15.	Dissipation factor, at 90°C and 40 Hz to 60 Hz	≤ 0.005
16.	PCA content	≤ 1%
17.	Impulse withstand Level, kVp	≥ 145

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S.No.	Property	Permissible values
18.	Gassing tendency at 50 Hz after 120 min, mm <sup>3</sup> /min	≤ 5

2.4.2 Subsequently oil samples shall be drawn at:

Sr. No.	Parameters BDV	Before filling in main tank & tested for	Prior to energization for following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

## 2.5 Bushings

2.5.1 Bushing below 52 kV shall be oil communicating type with porcelain insulator. (As applicable)

2.5.2 No arcing horns to be provided on the bushings.

## 2.6 Bushing CTs

2.6.1 Shall be of adequate rating for protection as required, WTI (WTI CT applicable for transformer above 50 KVA) etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

2.6.2 All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

## 2.7 Valves

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


2.7.2 Sampling & drain valves should have zero leakage rate

## 2.8 Gaskets

2.8.1 Gasket shall be fitted with weather proof, hot oil resistant, rubberized cork gasket.

2.8.2 If gasket is compressible, metallic stops shall be provided to prevent over compression.

2.8.3 The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of

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these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

## 2.9 Painting


S. No.	PARTS NAME	TYPE OF PAINT	NO. OF COATS	TOTAL DFT
1.	Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
2.	External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
3.	External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
4.	Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
5.	Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 microns

## 2.10 Neutral Earthing Arrangement

2.10.1 Neutral earthing shall be done as per system requirement and SLD. In case of solidly earthed neutral of Transformers, it shall be brought through insulated support from tank to the ground level at a convenient point with 2 nos. copper flat, for connection to ground network (as applicable). Neutral of Transformer if not used should be taken out through bushing and covered by insulating cap.

## 2.11 Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above)

2.11.1 HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Owner's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)


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- 2.11.2 Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.
- 2.11.3 A suitable removable gland plate of non-magnetic material drilled as per the Owner's instruction shall also be provided in the cable box
- 2.11.4 The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron
- 2.11.5 The contractor shall provide earthing terminals on the cable box, to suit Owner's GI flat.
- 2.11.6 The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided.
- 2.11.7 Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).
- 2.11.8 Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

## 2.12 Fittings

The following fittings & accessories shall be provided with each transformer. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the equipment are deemed to be included.

SN	Description
a)	Conservator for main tank shall be provided with MOG with low oil level alarm contact, drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement.
c)	It shall be provided with minimum two numbers of spring operated PRD (with trip contacts) with suitable discharge arrangement for oil shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level).
e)	Top & bottom filter valves with threaded male adapters, bottom sampling valve, drain valve/sludge removal valve at the bottom most point of the tank.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.

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SN	Description
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.	

## 2.13 Tests and Inspection

2.13.1 Test shall be carried out as per Owners approved QAP. In addition, Type test of Auxiliary transformer shall conform to the CEA “Guidelines for Type Tests for Major Equipment in the Power Sector”.


2.13.2 Some of the Critical Routine test and Type test to be performed by the bidder is as follows:

SN	Routine Tests
1.	All routine test shall be carried out in accordance with IEC 60076.
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1).
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1).
4.	Vector group and Polarity Check (as per IEC 60076-1).
5.	Magnetic Balance and Magnetising Current Test.
6.	Measurement of no load current with 415 V, 50 Hz AC supply.
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1).
8.	Load Loss & Short Circuit Impedance Measurement on principal & extreme taps.
9.	IR measurement (As per IEC 60076-1).
10.	Separate Source Voltage Withstand Test / Applied voltage test (as per IEC 60076-3).
11.	Induced overvoltage test / Induced voltage withstand (IVW) test as per IEC 60076 part 3.
12.	Repeat no load current/loss & IR after completion of all electrical tests.
13.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause).
14.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.
15.	IR measurement on wiring of Marshalling Box.
16.	Measurement of Insulation Resistance as per IS 1180
17.	Pressure test as per IS 1180
18.	Lightning impulse (Full & Chopped Wave) test on HV & LV winding (as per IEC 60076-3)

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SN	Routine Tests
19.	Frequency Response Analysis test
20.	LTAC test (as per IEC 60076-3)
21.	Applied voltage test (AV) as per IEC 60076-3
22.	Induced voltage test with PD measurement (as per IEC 60076-3)
23.	Breakdown voltage test on transformer oil as per IS 335

SN	Type Tests
1	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample before & after the test (as per IS: 9434 / IS: 10593).
2	Tank Vacuum & Pressure Test (as per CBIP norms).
3	Lightning Impluse Test [IS 2026 (Part 3)].
4	Measurement of harmonics of no load current (special test).
5	Measurement of acoustic noise level as per NEMA TR-1 (special test).
6	Tank Vacuum & Pressure Test (as per CBIP norms).
7	Short circuit test (special test) as per IEC 60076-5 (if applicable).
8	Zero sequence impedance measurement test
9	Measurement of power taken by Fans
10	Measurement of transferred surge on Tertiary due to HV lightning impulse (if applicable)
11	Measurement of transferred surge on Tertiary due to HV switching impulse (if applicable)
12	Switching impulse test for the line terminal (SI) (applicable for Um>72.5 kV & ≤170 kV)

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## Group C - Solar inverter Duty transformer

### 1 TECHNICAL REQUIRMENTS

#### 1.1 Technical Parameters for 17.6 MVA, 12.5MVA transformers

Sno	Description	Technical Parameters			
1.	Power rating	17.6 MVA	12.5 MVA	17.6 MVA	12.5 MVA
2.	Voltage rating (KV)	33/ 0.80kV	33/ 0.80kV	33/ (0.63 to 0.69) kV	33/ (0.63 to 0.69) kV
3.	Winding material	Electrolytic grade Aluminium			
4.	No. of LV winding	4 No's			
5.	Vector group reference	Ynd11d11d11d11			
6.	Frequency	50			
7.	No. of Phases	3			
8.	Applicable Standard	IS:2026			
9.	Service	Outdoor			
10.	Cooling	ONAN			
11.	Tap Changer	Off circuit tap changer			
12.	Tap Changer range	+5% to -5 %, 4 Steps @ 2.5%			
13.	<b>Performance figures</b>				
13.1.	a) Max No load Loss	0.10%			
13.2.	b) Max Full Load Loss	1.00%			
14.	<b>Impedance at 75 °C</b>				
14.1.	a) Principal Tap	8% (with +/- IS tol.)			
15.	<b>Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)</b>				
15.1.	a) Top Oil	50 deg C			
15.2.	b) Each Individual Winding	55 deg C			
16.	SC withstand time (thermal)	2 Sec			
17.	Fault Level & Bushing CT	as per IS			
18.	Bushing rating, Insulation class (Winding & bushing)	36/3.6 kV			
19.	Noise level	65 dB			
20.	Loading Capability	as per IS			
21.	Flux density	<= 1.7 Tesla			




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## 1.2 Other Technical Paramters

SN	Particulars	Description
1	Termination	Vendor to specify
2	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV) Creepage distance: 31 mm/kV
3	Noise level	AS PER NEMA TR-1
4	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600/ IEC60076-7. As minimum requirement, Transformers shall be designed with 110% continuous thermal overloading capability. The same shall be tested during Temp Rise Type test.
5	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
6	Noise level	AS PER NEMA TR-1
7	Air Clearance	As per CBIP
8	Spares	20% additional quantity of transformer insulating oil (based on the oil capacity of each transformer) shall be supplied in separate sealed drums, along with one complete set of gaskets and one number each of HV and LV bushings, at no additional cost.
9	Inspection & Testing	
9.1	Inspection	Transformer shall be subjected to inspection by the owner or by an agency authorized by the owner at the manufacturer's works.
9.2	Testing	Bidder shall submit the detailed manufacturing quality assurance plan covering all routine, type and special test as per relevant clause for Owners approval.
10	Drawings, Data & Manuals	



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SN	Particulars	Description
10.1	General	<ul style="list-style-type: none"> <li>i. The supplier shall develop his own general arrangement and schematic drawing adding necessary auxiliary devices, accessories, and components specific to supplied equipment etc., which are required for safe, convenient, efficient and proper operation of the Transformer</li> <li>ii. The Owner's approval of the drawings shall not relieve the supplier of his responsibility for supplying transformer conforming with the relevant specifications and standards or of any mistakes, errors or omissions in the drawing</li> </ul>
10.2	Documents to be submitted on PO placements	<p>The following drawings of the transformer offered shall be submitted within 4 weeks of placement of purchase order, for owner's approval:</p> <ul style="list-style-type: none"> <li>i. Outline dimensional drawing of transformer and accessories.</li> <li>ii. Connection diagram.</li> <li>iii. GA &amp; Schematic diagram of tap changing mechanism.</li> <li>iv. Shipping drawing showing dimensions and weights of heaviest package.</li> <li>v. Nameplate diagram.</li> <li>vi. Interconnecting / control cable schedule.</li> <li>vii. Bushing drawings and specification.</li> <li>viii. Schematic diagram showing flow of oil in cooling system as well as each limb and winding.</li> <li>ix. Foundation plan of the transformer.</li> <li>x. Cross-sectional drawing of HV Cable box &amp; LV Bus Duct flange / cable box.</li> <li>xi. Type Test Reports, Manufacturing Quality Plan</li> <li>xii. Any other document / drawing requested by the owner at the time of drawing approval</li> </ul>
10.3	Documents to be submitted for Dispatch Clearance	<ul style="list-style-type: none"> <li>i. sets of Tests &amp; Inspection report duly certified by Inspector</li> <li>ii. sets of the final As-Built drawings with the latest instructions manual (including a soft copy of the drawings in CAD &amp; PDF file in a DVD/CD/PD)</li> <li>iii. The supplier shall also submit sets of maintenance and operation manual</li> <li>iv. Any other relevant drawing, document or data necessary for satisfactory installation, operation and maintenance</li> </ul>

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SN	Particulars	Description
10.4	Documents to be submitted with Delivery	i. Copies of inspection report and approved documents to each consignee at the time of effecting delivery along with a copy of Dispatch Clearance issued by Owner. ii. All the documents submitted for Dispatch Clearance, along with one set of reproducible (Soft copy of CAD & PDF file in a DVD/CD/PD)
11	Delivery (Packing & Forwarding)	i. The transformer supplied shall be transported to site after taking precautions to prevent entry of rainwater, dust and damage during handling & shipment. Packing list shall be supplied along with the material. ii. The accessories like radiators, bushings, explosion vent, dehydrating breather, rollers, Buchholz relay, connecting pipes, conservator etc. shall be properly packed for shifting to site.
12	Guarantee	The transformer and other equipment supplied shall be guaranteed for trouble-free operation for a period of <b>12 months from the date of commissioning or 18 months from the date of supply</b> , whichever is earlier.

**Note:**

- a) Inverter Transformer shall have copper/Aluminum Shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and Inverter manufacturer recommendation. Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.
- b) Harmonic Factor as per Inverter manufacturer/Owner recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.
- c) The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).
- d) The thermal design of Inverter Transformer needs to consider the temperature dependent performance of the Inverter. It is to in accordance with Inverter output and under worst condition it should not limit Inverter output.

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- e) The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one Inverter supplying power to only one LV winding.
- f) For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings.
- g) In case of inverter transformer, it shall be proven and of successfully type tested design
- h) Contacts from Inverter transformer fittings/protection devices shall be wired for tripping of Inverter transformer Circuit Breaker.

## 2 CODES AND STANDARDS

SN	Particulars	Codes and Standards
1.	Transformers	IS:2026, IS:6600, IEC:60076
2.	Bushings	IS:2099, IEC:60137, IS 3347, IS 12676
3.	Insulating oil	IEC 60296, IEC 61099/IS16081
4.	Bushing CTs	IS:2705, IEC 60185
Indian Electricity Act 2003, BEE Guideline & CEA notifications		

### 2.1 General Construction

- 2.1.1 Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier. The important construction particulars shall be as below.
- 2.1.2 The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- 2.1.3 A double float type Buchholz relay conforming to IS: 3637 shall be provided.
- 2.1.4 Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.
- 2.1.5 All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site.
- 2.1.6 The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.

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- 2.1.7 Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
- 2.1.8 Transformer shall have Oil Temperature Indicator and Winding temperature Indicator with accuracy class of +/-2 deg.
- 2.1.9 Radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.
- 2.1.10 M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

## 2.2 Windings

- 2.2.1 The Bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.
- 2.2.2 The conductors shall be of electrolytic grade Aluminium free from scales & burrs.
- 2.2.3 All windings of the transformers shall have uniform insulation.
- 2.2.4 Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.


## 2.3 Core

- 2.3.1 The core shall be constructed from non-ageing, cold rolled, super grain-oriented silicon steel laminations equivalent to M4 grade steels or better.
- 2.3.2 Core isolation level shall be 2 kV (rms.) for 1 minute in air.
- 2.3.3 Adequate lifting lugs will be provided to enable the core & windings to be lifted.

## 2.4 Insulating Mineral oil

- 2.4.1 No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

SN	Property	Permissible values
1	Kinematic Viscosity, mm <sup>2</sup> /s	≤ 12 at 40°C; ≤ 1800.0 at (-)30°C
2	Flash Point, °C	≥ 140°C
3	Pour Point, °C	≤ (-)40°C

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SN	Property	Permissible values
4	Appearance	Clear, free from sediment and suspended matter
5	Density kg/dm <sup>3</sup> at 20° C	≤ 0.895
6	Interfacial Tension N/m at 25° C	≥ 0.04
7	Neutralisation value, mgKOH/g	≤ 0.01
8	Corrosive sulphur	Non Corrosive
9	Water content mg/kg	≤ 30 in bulk supply; ≤ 40 in drum supply
10	Anti-oxidants additives	Not detectable
11	Oxidation Stability - Neutralization value, mgKOH/g	≤ 1.2
11a	Oxidation Stability - Sludge, % by mass	≤ 0.8
12	Breakdown voltage (As delivered), kV	≥ 30
12a	Breakdown voltage (After treatment), kV	≥ 70
13	Dissipation factor, at 90° C and 40 Hz to 60 Hz	≤ 0.005
14	PCA content	≤ 1%
15	Impulse withstand Level, kVp	≥ 145
16	Gassing tendency at 50 Hz after 120 min, mm <sup>3</sup> /min	≤ 5

2.4.2 Subsequently oil samples shall be drawn at:

Sr. No.	Parameters BDV	Before filling in main tank & tested for	Prior to energization for following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

## 2.5 Bushings


2.5.1 Bushing below 52 kV shall be oil communicating type with porcelain insulator.

2.5.2 Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil. LV Bushing below 3.6 kV used within transformer cable box, epoxy type bushing confirming to IS 2099/IEC 60137 also allowed as alternate to porcelain type

2.5.3 No arcing horns to be provided on the bushings.

2.5.4 Inverter Transformer LV bushing palms shall be silver/tin plated.

## 2.6 Bushing CTs

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2.6.1 Shall be of adequate rating for protection (differential and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

2.6.2 All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

## 2.7 Valves

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

2.7.2 Sampling & drain valves should have zero leakage rate.

## 2.8 Gaskets


2.8.1 Gasket shall be fitted with weatherproof, hot oil resistant, nitrile rubber-based gasket.

2.8.2 If gasket is compressible, metallic stops shall be provided to prevent over compression.

2.8.3 The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

## 2.9 Painting

SN	PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
1.	Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
2.	External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron


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SN	PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
3.	External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
4.	Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
5.	Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

## 2.10 Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above & for Inverter Transformer both side)

- 2.10.1 HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Owner's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)
- 2.10.2 Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.
- 2.10.3 A suitable removable gland plate of non-magnetic material drilled as per the Owner's instruction shall also be provided in the cable box
- 2.10.4 The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron
- 2.10.5 The contractor shall provide earthing terminals on the cable box, to suit Owner's GI flat.
- 2.10.6 The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided.
- 2.10.7 Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).



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2.10.8 Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

## 2.11 Fittings

2.11.1 The following fittings & accessories shall be provided with each transformer. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the equipment are deemed to be included.


S. No.	Description
a)	Conservator for main tank shall be provided with MOG with low oil level alarm contact, drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement.
c)	- It shall be provided with minimum two numbers of spring operated PRD (with trip contacts) with suitable discharge arrangement for oil shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level). For Inverter Transformers, WTI shall be provided at least for all LV windings.
e)	Top & bottom filter valves with threaded male adapters, bottom sampling valve, drain valve/sludge removal valve at the bottom most point of the tank.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil for the first filling, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.

## 2.12 Tests And Inspection


SN	Routine Tests
1.	All routine test shall be carried out in accordance with IEC 60076.
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1).
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1).
4.	Vector group and Polarity Check (as per IEC 60076-1).



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5.	Magnetic Balance and Magnetising Current Test.
6.	Measurement of no load current with 415 V, 50 Hz AC supply.
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1).
8.	Load Loss & Short Circuit Impedance Measurement on principal & extreme taps.
9.	IR measurement (As per IEC 60076-1).
10.	Measurement of capacitance & tan delta to determine capacitance between winding & earth.
11.	Separate Source Voltage Withstand Test / Applied voltage test (as per IEC 60076-3).
12.	Induced overvoltage test / Induced voltage withstand (IVW) test as per IEC 60076 part 3.
13.	Repeat no load current/loss & IR after completion of all electrical tests.
14.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause).
15.	Jacking test followed by D.P. test.
16.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.
17.	IR measurement on wiring of Marshalling Box.
18.	Lightning impulse (Full & Chopped Wave) test on HV & LV winding (as per IEC 60076-3)
19.	Frequency Response Analysis test
20.	LTAC test (as per IEC 60076-3)
21.	Applied voltage test (AV) as per IEC 60076-3
22.	Induced voltage test with PD measurement (as per IEC 60076-3)
23.	Breakdown voltage test on transformer oil as per IS 335

SN	Type Tests (To be carried out on one transformer of each rating)
1.	Lightning impulse (Full and chopped wave) test on windings (as per IEC 60076-3). (Not applicable for LV).
2.	Short circuit test (special test) as per IEC 60076-5 (if applicable).
3.	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample before & after the test (as per IS: 9434 / IS: 10593).
4.	Measurement of harmonics of no load current (special test).
5.	Measurement of acoustic noise level as per NEMA TR-1 (special test).
6.	Tank Vacuum & Pressure Test (as per CBIP norms).
7.	Short circuit test (special test) as per IEC 60076-5 (if applicable).
8.	Zero sequence impedance measurement test
9.	Measurement of power taken by Fans

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SN	Type Tests (To be carried out on one transformer of each rating)
10.	Measurement of transferred surge on Tertiary due to HV lightning impulse (if applicable)
11.	Measurement of transferred surge on Tertiary due to HV switching impulse (if applicable)
12.	Switching impulse test for the line terminal (SI) (applicable for Um>72.5 kV & ≤170 kV)

**NOTE: -**

- a) All the type and special tests shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.
- b) Inverter Transformer LV winding Di-electric tests (except for lightning impulse test for LV winding) shall be carried out corresponding to levels (as per IEC 60076) for 3.6 kV class.
- c) All Type tests should be done as per Owner's approved procedure.