


UNINHIBITED MINERAL INSULATING OIL

REV-03	DATE 09.09.20	ALT-CKD- 	REV-02	DATE 10/05/13	ALT--sd-CKD--sd-	REV 00	NAME	SIGN	DATE
Completely reviewed as per latest IEC:60296-2020			Test methods at sl. No. 1.3&3.2 in Annex-1 revised.			PREP	D.VARYANI	-Sd-	04.08.08
						CKD	S.K.MAHAJAN	-Sd-	04.08.08
DWI/TCB/TRE/010									

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8. TEST CERTIFICATE:

Three copies of test certificates shall be supplied with each consignment. In addition, the supplier shall ensure to enclose one copy of the test certificate along with the dispatch documents / packing list to facilitate quick clearance of the material.

The test certificate shall bear the following information:

TRE 158: Uninhibited mineral insulating oil

BHEL Order No.

Batch No./ Lot No.

Quantity in litres / Number of drums:

Test report to be furnished as per format enclosed as per Table-1.

9. PACKING AND MARKING:

Oil shall be delivered in perfectly clean steel drums of 210 litres nominal capacity with flat or dished fixed ends. Inside surface of the drums shall be coated with a suitable coating (e. g. epoxy lacquer, phosphate etc.) resistant to insulating oil of minimum 25 micron thickness. Out side surface of the drum shall be painted to minimum paint thickness of 40 microns or hot dip galvanized for protection against atmospheric corrosion. The drums used shall be specially reserved for this purpose & immediately after filling with oil the drums shall be effectively sealed so as to exclude ingress of moisture.

The drums shall be tested as per IS: 1783(Latest Revision).

When stated on the order, oil shall be delivered in sea-worthy tankers specially reserved for this purpose and shall be suitably sealed so as to exclude ingress of moisture.

The drums/ tankers shall be indelibly marked with the following information:

TRE – 158 : Uninhibited mineral insulating oil

BHEL Order No.

Manufacturer's Name or trade Mark

Quantity in litres

Batch no. / LOA No.

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Table-1
Technical Parameters and Test report format

Sl.no.	Property	Unit	Test method	Required value	Measured value	Remark
1.	PHYSICAL					
1.1	Appearance	-	IEC:60296	Clear, transparent and free from suspended matter & sediment.		
1.2	Colour	-	ISO:2049	Max. 1.5		
1.3	Density at 29.5°C	Kg/m ³	ISO:3675 or ISO:12185 or ASTM:D7042	820 to 895		
1.4	Interfacial tension at 27°C	N/m	IEC:62961 or ASTM D971	0.04 Min.		
1.5.	Kinematic Viscosity	cst	ISO:3104 or ASTM:D7042	11 at 40°C (Max.) 16 at 27°C (Max.) 1800 at -30°C (Max.)		
1.6	Flash Point	°C	Pensky Marten ISO 2719	140 (Min.)		
1.7	Water Content	mg/kg	IEC:60814	30 (Max.) in Bulk Supply 40 (Max.) in Drum Supply		
1.8	Pour Point	°C	ISO:3016	-30(Max.)		
2.	ELECTRICAL :					
2.1	Electrical Strength (BDV) As Delivered After Treatment	kVrms	IEC:60156	30(Min.) 70(Min.)		
2.2	Resistivity	Ω - cm	IEC:60247	150 x 10 ¹² at 90°C (Min.) 2500 x 10 ¹² at 27°C (Min.)		
2.3	Dielectric Dissipation factor (Tan delta) at 50Hz	-	IEC:60247 or IEC:61620	0.002 at 90°C(Max.) 0.0005 at 27°C(Max.)		
3.	CHEMICAL :					
3.1	Neutralization Value (Total Acidity)	mgKOH/g	IEC:62021-2 or IEC:62021-1	0.01 (Max.)		
3.2	Corrosive Sulphur	-	DIN 51353	Non-Corrosive		
3.3	Potentially Corrosive Sulphur	-	IEC 62535	Non-Corrosive		
3.4	DBDS	mg/kg	IEC 62697-1	Not detectable (<5)		
3.5	Metal Passivator Additives	mg/kg	IEC 60666	Not detectable (<5)		
3.6	Other Additives	-	-	See Note 1 below		
3.7	2-Furfural and related compounds content	mg/kg	IEC 61198	Not detectable (<0.05) for each compound		
3.8	Total Sulphur Content	%	ISO:14596 or ISO 8754	0.05% (Max.)		
3.9	Aromatic Content	%	IEC:60590	4 - 8%		
3.10	Ring Analysis	%	IEC:60590	Na - %, Pa - %, Ar - %		

DWI/TCB/TRE/010

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Sl.no.	Property	Unit	Test method	Required value	Measured value	Remark
3.11	Oxidation Stability for 164hours at 120°C		IEC:61125:2018			
3.11.1	Neutralization Value	mg KOH/g	4.8.4 of IEC 61125:2018	0.4 max.		
3.11.2	Total Sludge by mass	%	4.8.1 of IEC 61125:2018	0.1 max.		
3.11.3	Dielectric Dissipation factor (Tan delta) at 50Hz	-	4.8.5 of IEC 61125:2018	0.05 at 90°C(Max.)		
3.12	Presence of oxidation inhibitor		IEC:60666	Shall not contain any anti-oxidant additives.		
4.0	PCA Content	%	IP 346	3 (Max.)		
5.0	PCB Content	mg/kg	IEC:61619	Not Detectable (<2)		

Note-1 – Supplier to declare the function and chemical family of all additives and the concentrations in the cases of inhibitors antioxidants and Passivators, as applicable, if any.

INHIBITED MINERAL INSULATING OIL

The oil covered under this specification is an unused (**Virgin**) inhibited mineral oil mixed with a suitable oxidation inhibitor.

For use as a dielectric and cooling medium in power and instrument transformers.

There is no Indian Standard covering this type of oil, however assistance has been drawn from IEC: 60296 - 2020


Unless otherwise specified, the tests shall be conducted in accordance with the relevant IEC: 60296 – 2020 and as per Table-1.

5 litres of oil shall be supplied for testing and approval purposes in glass bottle with glass stopper and adequately sealed to protect it from moisture ingress.

The properties and method of testing of Transformer oil shall be as per Table-1. The testing shall be carried out on the oil after filling into drums or tankers in which the oil shall be dispatched.

Oil sample taken from barrels as per the sampling plan and procedure laid down in IEC: 60475 shall meet all test requirements stipulated in this specification.

The oil shall be accepted only if the above parameters are met at site/works just prior to filling in transformer.

REV-04	DATE 09.09.20	ALT-CKD- 	REV-03	DATE 22.07.15	ALT- -sd-CKD- -sd-	REV 00	NAME	SIGN	DATE
Completely reviewed as per latest IEC:60296-2020			Specification is revised to incorporate changes in Cl. 6.7, 7.1.1, & 8.6 and Annexure-A			PREP	D.VARYANI	-Sd-	04.08.08
						CKD	S.K.MAHAJAN	-Sd-	04.08.08
DWI/TCB/TRE/010									

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8. TEST CERTIFICATE:

Three copies of test certificates shall be supplied with each consignment. In addition, the supplier shall ensure to enclose one copy of the test certificate along with the dispatch documents / packing list to facilitate quick clearance of the material.

The test certificate shall bear the following information:

TRE 176: Inhibited mineral insulating oil

BHEL Order No.

Batch No./ Lot No.

Quantity in litres / Number of drums:

Test report to be furnished as per format enclosed as per Table-1.

9. PACKING AND MARKING:

Oil shall be delivered in perfectly clean steel drums of 210 litres nominal capacity with flat or dished fixed ends. Inside surface of the drums shall be coated with a suitable coating (e. g. epoxy lacquer, phosphate etc.) resistant to insulating oil of minimum 25 micron thickness. Outside surface of the drum shall be painted to minimum paint thickness of 40 microns or hot dip galvanized for protection against atmospheric corrosion. The drums used shall be specially reserved for this purpose & immediately after filling with oil the drums shall be effectively sealed so as to exclude ingress of moisture.

The drums shall be tested as per IS: 1783(Latest Revision).

When stated on the order, oil shall be delivered in sea-worthy tankers specially reserved for this purpose and shall be suitably sealed so as to exclude ingress of moisture.

The drums/ tankers shall be indelibly marked with the following information:

TRE – 176: Inhibited mineral insulating oil

BHEL Order No.

Manufacturer's Name or trade Mark

Quantity in litres

Batch no. / LOA No.

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Table-1
Technical Parameters and Test report format

Sl.no.	Property	Unit	Test method	Required value	Measured value	Remark
1.	PHYSICAL					
1.1	Appearance	-	IEC:60296	Clear, transparent and free from suspended matter & sediment.		
1.2	Colour		ISO: 2049	L0.5 (less than 0.5)		
1.3	Density at 29.5°C	Kg/m ³	ISO:3675 or ISO:12185 or ASTM:D7042	820 to 895		
1.4	Interfacial tension at 27°C	N/m	IEC:62961 or ASTM D971	0.043 Min.		
1.5	Kinematic Viscosity	cst	ISO:3104 or ASTM:D7042	12 at 40°C (Max.) 16 at 27°C (Max.) 1800 at -30°C (Max.)		
1.6	Flash Point	°C	Pensky Marten ISO 2719	140 (Min.)		
1.7	Water Content	mg/kg	IEC:60814	30 (Max.) in Bulk Supply 40 (Max.) in Drum Supply		
1.8	Pour Point	°C	ISO:3016	-40(Max.)		
2.	ELECTRICAL :					
2.1	Electrical Strength (BDV) As Delivered After Treatment	kVrms	IEC:60156	50(Min.) 70(Min.)		
2.2	Resistivity	Ω - cm	IEC:60247	150 x 10 ¹² at 90°C (Min.)		
2.3	Dielectric Dissipation factor (Tan delta) at 50Hz	-	IEC:60247 or IEC:61620	0.002 at 90°C(Max.)		
3.	CHEMICAL :					
3.1	Neutralization Value (Total Acidity)	mgKOH/g	IEC:62021-2 or IEC:62021-1	0.01 (Max.)		
3.2	Corrosive Sulphur	-	DIN 51353	Non-Corrosive		
3.3	Potentially Corrosive Sulphur	-	IEC 62535	Non-Corrosive		
3.4	DBDS	mg/kg	IEC 62697-1	Not detectable (<5)		
3.5	Metal Passivator Additives	mg/kg	IEC 60666	Not detectable (<5)		
3.6	Other Additives	-	-	See Note 1 below		
3.7	2-Furfural and related compounds content	mg/kg	IEC 61198	Not detectable (<0.05) for each compound		
3.8	Stray gassing under thermo-oxidative stress		Procedure in Clause A.4 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H ₂) and < 50 µl/l methane (CH ₄) and < 50 µl/l ethane (C ₂ H ₆)		

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Sl.no.	Property	Unit	Test method	Required value	Measured value	Remark
3.9	Total Sulphur Content	%	ISO:14596 ISO 8754	0.05% (Max.)		
3.10	Aromatic Content	%	IEC:60590	4 - 12%		
3.11	Naphthenic Content	%	IEC:60590	46% (Min.)		
3.12	Ring Analysis	%	IEC:60590	Na - %, Pa - %, Ar - %		
3.13	Oxidation Stability for 500 hours at 120°C		IEC:61125:2018			
3.13.1	Neutralization Value	mgKOH/g	4.8.4 of IEC 61125:2018	0.15 max.		
3.13.2	Total Sludge by mass	%	4.8.1 of IEC 61125:2018	0.05 max.		
3.13.3	Dielectric Dissipation factor (Tan delta) at 50Hz	-	4.8.5 of IEC 61125:2018	0.05 at 90°C(Max.)		
3.14	Oxidation Stability(rotating bomb test)	Minutes	IEC:61125 (Method B) / ASTM D2112(a)	220 min.		
3.15	Presence of oxidation inhibitor		IEC:60666	0.08%(Min.) - 0.40% (Max.)		
4.0	PCA Content	%	IP 346	3 (Max.)		
5.0	PCB Content	Mg/kg	IEC:61619	Not Detectable		

Note-1 – Supplier to declare the function and chemical family of all additives and the concentrations in the cases of inhibitors antioxidants and Passivators, as applicable, if any.

UNINHIBITED MINERAL INSULATING OIL

This specification governs the quality of an unused (**Virgin**) and pure hydrocarbon mineral oil, clean and free from matter likely to impair its properties and without any additive including oxidation inhibitor. Pour point depressants shall not be included in the oil formulation.

For use as a dielectric and cooling medium in power and instrument transformers.

There is no Indian Standard covering this type of oil, however assistance has been drawn from IEC: 60296 - 2020


Unless otherwise specified, the tests shall be conducted in accordance with the relevant IEC: 60296 – 2020 and as per Table-1.

5 litres of oil shall be supplied for testing and approval purposes in glass bottle with glass stopper and adequately sealed to protect it from moisture ingress.

The properties and method of testing of Transformer oil shall be as per Table-1. The testing shall be carried out on the oil after filling into drums or tankers in which the oil shall be dispatched.

Oil sample taken from barrels as per the sampling plan and procedure laid down in IEC: 60475 shall meet all test requirements stipulated in this specification.

The oil shall be accepted only if the above parameters are met at site/works just prior to filling in transformer.

REV-	DATE	ALT-CKD-	REV-01	DATE 09.09.20	ALT-CKD- 	REV 00	NAME	SIGN	DATE
			Completely reviewed as per latest IEC:60296-2020			PREP	D.VARYANI	-Sd-	13.04.11
						CKD	S.K.MAHAJAN	-Sd-	13.04.11
DWI/TCB/TRE/010									

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8. TEST CERTIFICATE:

Three copies of test certificates shall be supplied with each consignment. In addition, the supplier shall ensure to enclose one copy of the test certificate along with the dispatch documents / packing list to facilitate quick clearance of the material.

The test certificate shall bear the following information:

TRE 186: Uninhibited mineral insulating oil

BHEL Order No.

Batch No./ Lot No.

Quantity in litres / Number of drums:

Test report to be furnished as per format enclosed as per Table-1.

9. PACKING AND MARKING:

Oil shall be delivered in perfectly clean steel drums of 210 litres nominal capacity with flat or dished fixed ends. Inside surface of the drums shall be coated with a suitable coating (e. g. epoxy lacquer, phosphate etc.) resistant to insulating oil of minimum 25 micron thickness. Outside surface of the drum shall be painted to minimum paint thickness of 40 microns or hot dip galvanized for protection against atmospheric corrosion. The drums used shall be specially reserved for this purpose & immediately after filling with oil the drums shall be effectively sealed so as to exclude ingress of moisture.

The drums shall be tested as per IS: 1783(Latest Revision).

When stated on the order, oil shall be delivered in sea-worthy tankers specially reserved for this purpose and shall be suitably sealed so as to exclude ingress of moisture.

The drums/ tankers shall be indelibly marked with the following information:

TRE – 186: Uninhibited mineral insulating oil

BHEL Order No.

Manufacturer's Name or trade Mark

Quantity in litres

Batch no. / LOA No.

PRODUCT PURCHASE SPECIFICATION	Specification No. TRE 186 R01
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Table-1
Technical Parameters and Test report format

Sl.no.	Property	Unit	Test method	Required value	Measured value	Remark
1.	PHYSICAL					
1.1	Appearance	-	IEC:60296	Clear, transparent and free from suspended matter & sediment.		
1.2	Colour	-	ISO:2049	Max. 1.5		
1.3	Density at 29.5°C At 20°C	Kg/m ³	ISO:3675 or ISO:12185 or ASTM:D7042	890 Max. 895 Max.		
1.4	Interfacial tension at 27°C	N/m	IEC:62961 or ASTM D971	0.04 Min.		
1.5	Kinematic Viscosity	cst	ISO:3104 or ASTM:D7042	11 at 40°C (Max.) 1800 at -30°C (Max.)		
1.6	Flash Point	°C	Pensky Marten ISO 2719	140 (Min.)		
1.7	Water Content	mg/kg	IEC:60814	30 (Max.) in Bulk Supply 40 (Max.) in Drum Supply		
1.8	Pour Point	°C	ISO:3016	-45(Max.)		
2.	ELECTRICAL :					
2.1	Electrical Strength (BDV) As Delivered After Treatment	kVrms	IEC:60156	30(Min.) 70(Min.)		
2.2	Resistivity	Ω - cm	IEC:60247	150 x 10 ¹² at 90°C (Min.) 2500 x 10 ¹² at 27°C (Min.)		
2.3	Dielectric Dissipation factor (Tan delta) at 50Hz	-	IEC:60247 or IEC:61620	0.002 at 90°C(Max.)		
3.	CHEMICAL :					
3.1	Neutralization Value (Total Acidity)	mgKOH/g	IEC:62021-2 or IEC:62021-1	0.01 (Max.)		
3.2	Corrosive Sulphur	-	DIN 51353	Non-Corrosive		
3.3	Potentially Corrosive Sulphur	-	IEC 62535	Non-Corrosive		
3.4	DBDS	mg/kg	IEC 62697-1	Not detectable (<5)		
3.5	Metal Passivator Additives	mg/kg	IEC 60666	Not detectable (<5)		
3.6	Other Additives	-	-	See Note 1 below		
3.7	Total Sulphur Content	%	ISO:14596 or ISO 8754	0.05% (Max.)		
3.8	2-Furfural and related compounds content	mg/kg	IEC 61198	Not detectable (<0.05) for each compound		
3.9	Ring Analysis	%	IEC:60590	Na - % Pa - % Ar - %		

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Sl.no.	Property	Unit	Test method	Required value	Measured value	Remark
3.10	Oxidation Stability for 164hours at 120°C		IEC:61125:2018			
3.10.1	Neutralization Value	mgKOH/g	4.8.4 of IEC 61125:2018	0.4 max.		
3.10.2	Total Sludge by mass	%	4.8.1 of IEC 61125:2018	0.1 max.		
3.10.3	Dielectric Dissipation factor (Tan delta) at 50Hz	-	4.8.5 of IEC 61125:2018	0.05 at 90°C (Max.)		
3.11	Presence of oxidation inhibitor		IEC:60666	Shall not contain any anti-oxidant additives.		
4.0	PCA Content	%	IP 346	1 (Max.)		
5.0	PCB Content	Mg/kg	IEC:61619	Not Detectable		
6.0	Impulse Withstand Level	kVp	ASTM D3300	> 145		
7.0	Gassing tendency at 50Hz after 120 min,	Mm ³ /min		≤ 5		

Note-1 – Supplier to declare the function and chemical family of all additives and the concentrations in the cases of inhibitors antioxidants and Passivators, as applicable, if any.

Table 4 – General specifications, Type B (uninhibited and inhibited standard grade oils)

Property	Test method	Limits	
		Transformer oil	Low temperature switchgear oils
1 – Function			
Viscosity at 40 °C	ISO 3104 ^a or ASTM D7042	Max. 12 mm ² /s	Max. 3,5 mm ² /s
Viscosity at –30 °C ^b	ISO 3104 ^a or ASTM D7042	Max. 1 800 mm ² /s	–
Viscosity at –40 °C ^c	IEC 61868	–	Max. 400 mm ² /s
Pour point	ISO 3016	Max. –40 °C	Max. –60 °C
Water content	IEC 60814	Max. 30 mg/kg ^d / 40 mg/kg ^e	
Breakdown voltage	IEC 60156	Min. 30 kV / 70 kV ^f	
Density at 20 °C	ISO 12185 ^a or ISO 3675 or ASTM D7042	Max. 895 kg/m ³	
DDF at 90 °C	IEC 60247 ^a or IEC 61620	Max. 0,005	
2 – Refining/stability			
Colour	ISO 2049	Max. 1,5	
Appearance	–	Clear, free from sediment and suspended matter	
Acidity	IEC 62021-2 ^a or 62021-1	Max. 0,01 mg KOH/g	
Interfacial tension	IEC 62961 ^a or ASTM D971	Min. 40 mN/m	
Corrosive sulphur	DIN 51353	Not corrosive	
Potentially corrosive sulphur	IEC 62535	Not corrosive	
DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)	
Inhibitors of IEC 60666	IEC 60666	Uninhibited (U): not detectable (< 0,01 %) Trace inhibited (T): ≥ 0,01 < 0,08% Inhibited oil (I): 0,08 % to 0,40 % (see 3.5 to 3.7)	
Metal passivator additives of IEC 60666	IEC 60666	Not detectable (< 5 mg/kg), or as agreed upon with the purchaser	
Other additives		See ^g	
2-furfural and related compounds content	IEC 61198	Not detectable (< 0,05 mg/kg) for each individual compound ^h	
3 – Performance			
Oxidation stability	IEC 61125 Test duration ⁱ (U) Uninhibited oil: 164 h (T) Trace inhibited oil: 332 h (I) Inhibited oil: 500 h	For oils with other antioxidant additives and metal passivator additives, see 6.12.2	
– Total acidity ^j	4.8.4 of IEC 61125:2018	max. 1,2 mg KOH/g	
– Sludge ^j	4.8.1 of IEC 61125:2018	max. 0,8 %	
– DDF at 90 °C ^j	4.8.5 of IEC 61125:2018	max. 0,500	
4 – Health, safety and environment (HSE) ^k			
Flash point	ISO 2719	Min. 135 °C	Min. 100 °C
PCA content ^l	IP 346	< 3 %	
PCB content	IEC 61619	Not detectable (< 2 mg/kg)	

Stray gassing under thermo-oxidative stress (see 6.19) is not included as a normative test for mineral oils Type B, because there has been insufficient data to determine appropriate limits. The requirement for a stray gassing test, as well as the limit values, if stipulated, can be negotiated between the user and supplier.

- a Reference method.
- b This is the standard LCSET for a transformer oil (see 6.1) and can be modified depending on the climatic condition of each country. Pour point should be minimum 10 °C below LCSET.
- c Standard LCSET for low temperature switchgear oil.
- d For bulk supply.
- e For delivery in drums and IBC.
- f After laboratory treatment (see 6.4).
- g The supplier shall declare the function and chemical family of all additives (3.3), and the concentrations in the cases of inhibitors antioxidants and passivators (3.4).
- h In agreement with the customer, oils with a higher furfural content can be delivered, when these values do not jeopardize the application.
- i In some countries there can be lower requirements for oxidation stability.
- j At the end of oxidation stability tests.
- k In some countries there can be additional requirements, e.g. REACH in the EU.
- l Some individual PAH compounds can be determined by EN 16143.

Table 3 – General specifications, Type A (fully inhibited high grade oils)

Property	Test method	Limits	
		Transformer oil	Low temperature switchgear oils
1 – Function			
Viscosity at 40 °C	ISO 3104 ^a or ASTM D7042	Max. 12 mm ² /s	Max. 3,5 mm ² /s
Viscosity at –30 °C ^b	ISO 3104 ^a or ASTM D7042	Max. 1 800 mm ² /s	–
Viscosity at –40 °C ^c	IEC 61868	–	Max. 400 mm ² /s
Pour point	ISO 3016	Max. –40 °C	Max. –60 °C
Water content	IEC 60814	Max. 30 mg/kg ^d / 40 mg/kg ^e	
Breakdown voltage	IEC 60156	Min. 30 kV / 70 kV ^f	
Density at 20 °C	ISO 12185 ^a or ISO 3675 or ASTM D7042	Max. 895 kg/m ³	
DDF at 90 °C	IEC 60247 ^a or IEC 61620	Max. 0,005	
2 – Refining/stability			
Colour	ISO 2049	L0,5 (less than 0,5)	
Appearance	–	Clear, free from sediment and suspended matter	
Acidity	IEC 62021-2 ^a or 62021-1	Max. 0,01 mg KOH/g	
Interfacial tension	IEC 62961 ^a or ASTM D971	Min. 43 mN/m	
Total sulphur content	ISO 14596 ^a or ISO 8754	Max. 0,05 %	
Corrosive sulphur	DIN 51353	Not corrosive	
Potentially corrosive sulphur	IEC 62535	Not corrosive	
DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)	
Inhibitors of IEC 60666	IEC 60666	(I) Inhibited oil: 0,08 % to 0,40 % (see 3.7)	
Metal passivator additives of IEC 60666	IEC 60666	Not detectable (< 5 mg/kg), or as agreed upon with the purchaser	
Other additives		See ^g	
2-furfural and related compounds content	IEC 61198	Not detectable (< 0,05 mg/kg) for each individual compound	
Stray gassing under thermo-oxidative stress	Procedure in Clause A.4 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H ₂) and < 50 µl/l methane CH ₄) and < 50 µl/l ethane (C ₂ H ₆)	
3 – Performance			
Oxidation stability	IEC 61125: Test duration (I) Inhibited oil: 500 h	For oils with other antioxidant additives and metal passivator additives, see 6.12.2	
– Total acidity ^h	4.8.4 of IEC 61125:2018	Max. 0,3 mg KOH/g	
– Sludge ^h	4.8.1 of IEC 61125:2018	Max. 0,05 %	
– DDF at 90 °C ^h	4.8.5 of IEC 61125:2018	Max. 0,050	
4 – Health, safety and environment (HSE) ⁱ			
Flash point	ISO 2719	Min. 135 °C	Min. 100 °C
PCA content ^j	IP 346	< 3 %	
PCB content	IEC 61619	Not detectable (< 2 mg/kg)	

- a Reference method.
- b This is the standard LCSET for a transformer oil (see 6.1) and can be modified depending on the climatic condition of each country. Pour point should be minimum 10 °C below LCSET.
- c Standard LCSET for low temperature switchgear oil.
- d For bulk supply.
- e For delivery in drums and IBC.
- f After laboratory treatment (see 6.4).
- g The supplier shall declare the chemical family and function of all additives (3.3), and the concentrations in the cases of inhibitors, antioxidants and passivators (3.4).
- h At the end of oxidation stability tests.
- i In some countries there can be additional requirements, e.g. REACH in the EU.
- j Some individual PAH compounds can be determined by EN 16143.

Annexure – F

UNUSED INHIBITED HIGH GRADE INSULATING OIL PARAMETERS

Sl. No.	Property	Test Method	Limits
A	Function		
1a.	Viscosity at 40degC	IS 1448 Part 25 or ISO 3104 or ASTM D7042	(Max.)12 mm ² /s
1b.	Viscosity at -30degC		(Max.)1800 mm ² /s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	IS 1448 Part 10/Sec 2 or ISO 3016	(Max.) - 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IS 6792 or IEC 60156	(Min.) 50kV (new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	IS 1448 Part 16 or ISO 12185 or ISO 3675 or ASTM D7042	Max 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IS 16086 or IEC 60247 or IEC 61620	(Max) 0.0025
8.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic: 4 to12 % Paraffins: <50% & balance Naphthenic compounds.
B	Refining/Stability		
1.	Colour	ISO 2049	L0.5 (less than 0.5)
2.	Acidity	IEC 62021-2 or 62021-1	(Max) 0.01 mg KOH/g
3.	Interfacial tension at 27degC	IEC 62961 or ASTM D971	0.043 N/m (min)
4.	Total sulphur content	ISO 14596 or ISO 8754	0.05 % (Max.) (before oxidation test)
5.	Corrosive sulphur	DIN 51353	Not-Corrosive
6.	Potentially corrosive sulphur	IEC 62535	Not-Corrosive
7.	DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)
8.	Presence of oxidation inhibitor	IS 13631 or IEC 60666	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
9.	Metal passivator additives	IEC 60666	Not detectable (<5 mg/kg)

10.	2-Furfural content and related compound content	IS 15668 or IEC 61198	Not detectable (<0.05 mg/kg) for each individual compound
11.	Stray gassing under thermooxidative stress	Procedure in Clause A.4 of IEC 60296-2020 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H ₂) and < 50 µl/l methane (CH ₄) and < 50 µl/l ethane (C ₂ H ₆)
C Performance			
1.	Oxidation stability	IEC 61125 (method c) Test duration 500 hour	
2.	Total acidity*	4.8.4 of IEC 61125:2018	0.3 mg KOH/g (Max.)
3.	Sludge*	4.8.1 of IEC 61125:2018	0.05 % (Max.)
4.	Dielectric dissipation factor (tan delta) at 90degC	4.8.5 of IEC 61125:2018	0.05 (Max.)
*values at the end of oxidation stability test			
D Health, safety and environment (HSE)			
1.	Flash point	IS 1448 Part 21 or ISO 2719	(Min.)135deg C
2.	PCA content	IP 346	< 3%
3.	PCB content	IS 16082 or IEC 61619	Not detectable (< 2 mg/kg)
E	Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	Each lot of the oil shall be tested prior to filling in main tank at site for the following:		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		0.04 N/m (min)
G	After filtration & settling and prior to energisation at site oil shall be tested for following:		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability		
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of EMPLOYER.			

Note: Supplier shall declare the chemical family and function of all additives and the concentrations in the cases of inhibitors, antioxidants and passivators.

CLAUSE NO.	TECHNICAL REQUIREMENTS	
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1.06.04

Insulating oil

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

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm ² /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 ³ 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 -Sludge, % by mass	≤ 1.2 ≤ 0.1
12.	Breakdown voltage	
	As delivered, kV After treatment, kV	≥ 30 ≥ 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 ³ /min	≤ 5

TELANGANA STPP-I (2X800MW) BALANCE OF PLANT PACKAGE	TECHNICAL SPECIFICATIONS SECTION – VI, PART-B BID DOC. NO.:CS-9591-001C-2	B-19: TRANSFORMERS/REACTOR AND ASSOCIATED MAINTENANCE, MONITORING & TESTING EQUIPMENTS	PAGE 8 OF 34
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A) ANNEXURE-A

Un-Inhibited Napthenic based EHV grade Transformer Oil for 700 MWe Projects

S.NO.	Characteristics	Limiting values of parameter	Test Results
1	Appearance	Clear & transparent and free from suspended matter or sediments	
2	Density at 20 Deg.C Kg/dm ³ , Maximum.	0.895	
3	Kinematic Viscosity, mm ² /S		
	a) at 40 deg.C, Maximum	11	
	b) at Minus 30 deg.C, Maximum.	1800	
4	Interfacial Tension at 27 deg.C (N/m), Minimum	0.04	
5	Flash Point deg.C, Minimum.	140	
6	Pour Point deg.C, Minimum	Minus 45	
7	Neutralization Value		
7-a	Total Acidity, Maximum	0.03 mg KOH/g	
7-b	Inorganic Acidity / alkalinity	Nil	
8	Corrosive Sulphur (CIGRE test method (TF A2.32.01 Revision of tests and pecifications for corrosive sulphur in Transformer Oils)	Non-Corrosive	
9	Electric Strength (Break Down Voltage)		
	a) New Unfiltered oil, kV, Minimum	30 kV	
	a) After Filtration kV, Minimum	70 kV	
10	Dielectric Dissipation Factor (Tan Delta) at 90 deg.C , Maximum	0.002	
11	Specific Resistance (Resistivity)		
	a) at 90 deg.C, Minimum	35x10 ¹² Ohm - cm	
	b) at 27 deg.C, Minimum	1500x10 ¹² Ohm - cm	
12	Oxidation Stability after 164 Hrs. at 100 deg.C		
	a) Neutralization Value, Maximum	0.2 mg KOH/g	
	b) Total sludge % Wt., Maximum	0.05% by weight	

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13	Ageing characteristics after accelerated aging (Open beaker method with Copper Catalyst)		
	a) Specific resistance :		
	At 27 deg.C, Minimum	2.5×10^{12} Ohm - cm	
	At 90 deg.C Minimum	0.2×10^{12} Ohm - cm	
	b) Tan Delta at 90 deg.C, Maximum	0.20	
	c) Total acidity , Maximum	0.05 mg KOH/g	
	d) Total sludge, Maximum	0.05% by Wt.	
14	Water content, mg/kg	30 in bulk delivery 40 in drum delivery	
15	Presence of oxidation inhibitor, percent by weight	Not Detectable with respect to IS-335 Amendment-1997	
16-a	Napthenic Content	46 to 53%	
16-b	Paraffinic Content	36 to 46%	
16-c	Aromatic Content	Remaining/balance	
17	Health, Safety and Environment (HSE)		
17.1	PCA content (BS 2000 Part 346), %, Maximum	3 %	
17.2	PCB content (IEC 61619), mg/kg	Less than 1	
17.3	Negative Impluse Voltage testing kVp (ASTM D-3300), Minimum	145	
18	Total sulphur content (BS 2000 part 373 or ISO 14596), %	0.15 %	
19	2-Furfural content (IEC 61198) , mg/kg, Maximum	0.1	
20	Gassing (IEC 60628 A)	No general requirement, however, negative gassing tendency is not acceptable	
NOTE: 1 Oil samples (One Composite and 8 individual) shall be tested at the works of transformer oil manufacturer)			
NOTE: 2 Test Results of 1 (One) Composite sample shall meet test requirement as per Item Nos. 1 to 20 above.			
NOTE: 3 Test Results of 8 Individual samples shall meet test requirement as per Item Nos. 9,10& 11 above.			
NOTE: 4 In case , test facilities of any test mentioned above are not available at the works of transformer oil manufacturer, the same test shall be conducted at any third party test lab Approved by CE(EP)/CE(ED) of NPCIL.			