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NPS/003/019 – Technical Specification for Electrical Insulating Fluids for use in Plant & Switchgear

1. Purpose

This specification details the technical requirements for electrical insulating fluids for use in plant and switchgear on the Northern Powergrid electrical distribution networks.

This document supersedes the following document, all copies of which shall be destroyed:

Reference	Version	Date	Title
NPS/003/019	6.0	Feb 2019	Technical Specification for Electrical Insulating Fluids for use in Plant & Switchgear

2. Scope

This specification includes for unused and reclaimed electrical insulating oil and other fluids for use in ground mounted and pole mounted plant and switchgear on the Northern Powergrid electrical distribution networks.

Re-refined oil as defined in BS148 is not acceptable and therefore not included within this specification.

It will also be necessary to consider and include any project specific requirements as detailed in Appendix 4, Addendum to Supplier Requirements.

The following appendices form part of this technical specification.

- Appendix 1 - Technical Specification Sheet & Self Certification/Conformance Declarations
- Appendix 2 - Addendum to Supplier Requirements
- Appendix 3 - Technical Information Check List

This specification excludes insulating fluids for use in cables and insulating fluids for use in capacitors.

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3. Technical Requirements

3.1. Compliance with other Specifications and Standards

Technical documents referenced within this specification refer to the latest versions of the relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENA TS) current at the time of supply.

3.2. Insulating Fluids

Unused or reclaimed electrical insulating mineral oil shall be used for standard applications.

The oil shall be:

- naphthenic
- uninhibited (except for specific applications where following regeneration of the transformer insulating oil, inhibitor has previously been added)
- unpassivated

Northern Powergrid will consider alternative fluids for use as an electrical insulating and cooling fluid where the supplier can prove that the alternative product / material has equivalent; or improved critical properties *in addition* to a sound environmental, technical and/or commercial benefit that would justify the use of the alternative over unused or reclaimed electrical insulating mineral oil.

3.2.1. Unused oil

Unused oil shall be: Transformer Oil, U, -30°C in compliance with the requirements of BS EN IEC 60296: Fluids for electrotechnical applications — Mineral insulating oils for electrical equipment.

3.2.2. Reclaimed Oil

Reclaimed Oil shall be in accordance with BS148: Recycled mineral insulating oil for transformers and switchgear — Specification. Re-refined oil as defined in BS 148 is not acceptable.

The PCB content shall be non-detectable (<2mg/kg).

3.2.3. Other Fluids

Other fluids are sometimes required for special applications, such as situations where there is an unacceptable fire risk, or particular environmental sensitivity and/or environmental risk.

Other fluids may include synthetic oil or vegetable-based esters in accordance with BS EN 61099: Insulating liquids. Specifications for unused synthetic organic esters for electrical purposes; for example Midel 7131, Envirotemp FR3 or equivalent, or BS EN 60836: Specifications for unused silicone insulating liquids for electrotechnical purposes; for example Midel Dow Corning 561 or equivalent.

These fluids shall be segregated from mineral insulating oil and other insulating fluids.

Before use on the Northern Powergrid distribution networks any fluids must be assessed and their acceptability confirmed in writing by a Policy and Standards representative.

Details of insulating fluids approved by Northern Powergrid can be found on the Assessed Products Database.

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4. References

The products described within this specification shall comply with all current versions of the relevant International Standards, British Standards and all relevant Energy Networks Association Technical Specifications (ENATS) current at the time of supply.

4.1. External Documentation

Reference	Title
BS EN IEC 60296:2020	Fluids for electrotechnical applications — Mineral insulating oils for electrical equipment.
BS EN IEC 60475:2022	Method of sampling insulating liquids
BS EN 60836:2015	Specifications for unused silicone insulating liquids for electrotechnical purposes
BS EN 61099:2010	Insulating liquids — Specifications for unused synthetic organic esters for electrical purposes
BS148:2020	Recycled mineral insulating oil for transformers and switchgear - Specification

4.2. Internal Documentation

Reference	Title
None	

4.3. Amendments from Previous Version

Reference	Amendments
2. Scope	Reconditioned oil was previously not included within the specification but is now judged to be acceptable, i.e. oil previously used in electrical equipment that has been subject to a physical process to remove insoluble contaminants and water.
3.2.1	BS EN IEC 60296 title updated
3.2.2	Clarification that re-refined oil as defined in BS148 is not acceptable.
3.2.2	BS 148 title updated. This standard now covers all recycled oil, not just reclaimed. It also includes re-refined oil which is not acceptable to NPg.
3.2.2	PCB content reduced from 5ppm to non-detectable (<2mg/kg)
3.2.3	BS EN 61099 and BS EN 60836 titles updated and examples of each clarified.
4.1	All references updated.
Appendix 1a	Updated to reflect the revised BS148
Appendix 1b	Updated to reflect the revised BS EN IEC 60296

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5. Definitions

Term	Definition
Naphthenic	Mineral oil derived from naphthenic base oil. Naphthenic base oils have a very low aromatic content and a low paraffin (Wax) content.
Reclaimed (regenerated) oil	Mineral insulating oil used in electrical equipment which has been subjected to chemical and/or physical processing to eliminate soluble and insoluble contaminants
Re-refined oil	Recycled oil which has been subjected to a process similar to that used for the production of unused oil from virgin feedstock to reduce the level of undesired compounds
Uninhibited	mineral insulating oil containing no added anti-oxidant but which may contain other additives
Unpassivated	Mineral oil that does not contain a passivator - any additive to reduce the chemical reactivity of <u>metallic surfaces within oil-filled equipment</u>
Unused oil	Mineral insulating which has not been used in, or been in contact with, electrical equipment or other equipment not required for manufacture, storage or transport

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6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	31/05/2023

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
No	Period: 5 years	Reason: Update will be dictated by contract renewal date or any significant changes in the specification or documents referenced
Should this document be displayed on the Northern Powergrid external website?		Yes
		Date
Joe Helm	Senior Policy & Standards Engineer	01/06/2023

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Paul McAdoo	Senior Policy & Standards Engineer	05/06/2023

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	Head of System Engineering	24/07/2023

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Appendix 1a – Recycled Oil: Self Certification Conformance Declaration to BS148

BS148:2009 Clause	Requirement	Conformance and Details
3.1 - additive	List any additives and quantities/proportions. Provide details of benefits / reasons for additive	
3.4 – passivator	Unpassivated as defined	
3.8 – Re-refined oil	Re-refined oil is not acceptable	
3.10 – uninhibited oil	Uninhibited as defined	
4.1 Tanker wagons and drums cleanliness	List vessels used and detail cleaning procedures for each	
4.2 – Marking of vessels	List vessels used and detail vessel marking for each: Mandatory markings per BS148	
4.3 – Accompanying documentation	Provide samples of documentation: Mandatory requirements per BS148 2009	
4.4 - Health & Safety information	Provide COSHH data sheets, etc.	
5 - Sampling (Procedure per BS EN 60475)	Top AND bottom samples shall be taken and analysed and results supplied.	

Property	Test method	Limits	Conformance and Details
1 – Function			
Viscosity at 40 °C	BS EN ISO 3104	Max. 12 mm ² /s	
Viscosity at –30 °C	BS EN ISO 3104	Max. 1800 mm ² /s	
Pour point	ISO 3016	Max. -40 °C	
Water content	BS EN 60814	Max. 30 mg/kg A)/ 40 mg/kg B)	
Breakdown voltage	BS EN 60156	Min. 30 kV / 70 kV C)	
Density at 20 °C	BS EN ISO 3675 or BS EN ISO 12185	Max. 0.895 g/ml D)	
DDF (Dielectric Dissipation Factor) at 90 °C	BS EN 60247	Max. 0.005	
2 – Refining/stability			
Appearance	–	Clear, free from sediment and suspended matter	
Colour	ISO 2049	Max 1.5	
Acidity	BS EN 62021-1 BS EN 62021-2	Max. 0.01 mg KOH/g	
Interfacial tension	BS EN IEC 62961	40 mN/m	
Corrosive sulphur	DIN 51353	Not corrosive	

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Potentially corrosive sulphur	BS EN 62535	Not corrosive	
DBDS	BS EN 62697-1	Not detectable (<5 mg/kg)	
Anti-oxidants of BS EN 60666	BS EN 60666	(U) uninhibited oil: not detectable (< 0.1 g/kg) (T) trace inhibited oil: < 0.8 g/kg (I) inhibited oil: 0.8 – 4 g/kg	
Metal passivator additives of BS EN 60666	BS EN 60666	Not detectable (< 5 mg/kg) or as agreed upon with the purchaser E)	
2-Furfural and related compounds content	BS EN 61198	Not detectable (<0.05 mg/kg) for each individual compound	

Property	Test method	Limits	Conformance and Details
3 – Performance			
Oxidation stability	BS EN IEC 61125:2018 Method C Test duration (U) Uninhibited oil: 164h (T) Trace inhibited oil: 332h (I) Inhibited oil: 500h	Oils with other antioxidant additives and/ or metal passivator additives shall be tested at 500h	
-Total acidity F)	BS EN IEC 61125:2018 4.8.4	Max. 1.2 mg KOH/g	
-Sludge F)	BS EN IEC 61125:2018 4.8.1	Max. 0.8 mg KOH/g	
-DDF at 90 °C F) G)	BS EN IEC 61125:2018 4.8.5	Max. 0.500	
4 – Health, safety and environment (HSE)			
Flash point	BS EN ISO 2719	Min. 135 °C	
Carcinogenicity	ASTM E1687-10	Non-carcinogenic	
PCB content	BS EN 61619	Not detectable (<2 mg/kg)	
A) For bulk supply. B) For delivery in drums and IBC (intermediate bulk container). C) After laboratory treatment (see BS EN 60296, 6.4).			

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D) A maximum limit for density is specified to minimize the risk of ice crystals floating in the oil where oil insulated equipment is exposed to very low temperatures.

E) Subject to agreement between purchaser and supplier, passivator may be incorporated in the oil to a maximum concentration of 100 mg/kg as measured by the method given in BS EN 60666. The oil shall then be considered a passivated oil.

F) At the end of oxidation stability tests.

G) A DDF of max. 0.020 after 2 h of oxidation (see BS EN IEC 61125:2018, Method C) is recommended for application in EHV (Extra-High Voltage) instrument transformers and bushings.

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Appendix 1b – Unused Oil: Self Cert Conformance Declaration to BS EN IEC 60296

IEC60296 Clause	Requirement	Conformance and Details
1 - Unused oil	Confirm oil is 'Unused oil'	
3.3 - Additives	Northern Powergrid require additive free oil. List any additives and quantities/proportions	
5.1.1 Class	Transformer oil Type B	
5.1.2 - Inhibitor content	Uninhibited: U	
5.1.3 – Lowest cold start energising temperature (LCSET)	-30°C	
5.4 – Identification and delivery		
a) vessels clean and suitable	a) List vessels used and detail cleaning procedures for each	
b) vessel marking	b) List vessels used and detail vessel marking for each	
c) accompanying documentation	c) Provide samples of documentation	
d) declaration of chemical family, function and concentration of additives	d) Full declaration required	
e) traceability	e) demonstrate traceability to a manufactured batch	
5.5 - Sampling	Top AND bottom samples shall be taken (procedure per BS EN IEC 60475) and analysed and results supplied to Northern Powergrid.	
6 – Properties of the oil	Oil shall be additive-free uninhibited, unpassivated and within limiting values per Tables 4 General Specifications, Type B of BS EN 60296: 2020	
Viscosity test at 40 °C ISO 3104	Max. 12 mm ² /s	
Viscosity test at –30 °C ISO 3104	Max. 1 800 mm ² /s	

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IEC60296 Clause	Requirement	Conformance and Details
Pour point test ISO 3016	Max. -40 °C	
Water content test IEC 60814	=< 30 mg/kg (bulk supply) =< 40 mg/kg (drums)	
Breakdown voltage test IEC60156	Min. 30 kV / 70 kV	
Density test at 20 °C ISO 3675 or ISO12185	Max. 0,895 g/ml	
DDF Test at 90°C ISO 60247 or IEC 61620	Max. 0,005	
Appearance	Clear, free from sediment and suspended matter	
Acidity test IEC 62021-1	Max. 0,01 mgKOH/g	
Interfacial tension test ISO 6295	Min. 40mN/m	
Total sulphur content test BS 2000 part 373 or ISO 14596	No general requirement	
Corrosive sulphur test DIN 51353	Not corrosive	
Potentially corrosive sulphur IEC 62535	Not corrosive	
DBDS IEC 62697-1	Not detectable (<5 mg/kg)	
Antioxidant additive test IEC 60666	(U) uninhibited oil: not detectable	
2-Furfural content test IEC 61198	Not detectable (<0.05mg/kg) for each individual compound	
Oxidation stability test IEC 61125 (method C)	(U) Uninhibited oil: 164 h	
Total acidity	Max. 1,2 mg KOH/g	
Sludge	Max. 0,8 %	
DDF at 90 °C test IEC60247	Max. 0,500	
Flash point test ISO 2719	Min. 135 °C	
PCA content test BS2000 part 346	Max. 3 %	
PCB content test IEC 61619	Not detectable (<2mg/kg)	

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Appendix 1c – Unused Organic Esters: Self Cert Declaration to BS EN 61099

IEC61099 Property	Requirement / Test Method	Conformance and Details
Physical Properties		
Colour	Max. 200 Hazen to ISO 2211	
Appearance	Visually Clear, free from water and suspended matter and sediment	
Density at 20 °C (kg/dm ³)	Max. 1 000 to ISO 3675 or ISO 12185	
Kinematic viscosity at: 40 °C (mm²/s) –20 °C (mm²/s)	To ISO 3104 Max. 35 Max. 3 000	
Flash-point (°C)	Min. 250 to ISO 2719	
Fire-point (°C)	Min. 300 to ISO 2592	
Pour-point (°C)	Max. –45 to ISO 3016	
Chemical Properties		
Water content (mg/kg)	Max. 200* to IEC 60814	
Acidity (mg KOH/g)	Max. 0,03 to IEC 62021-1 or 62021-2	
Oxidation stability**	IEC 61125, Method C	
Test duration 164 h		
Total acidity (mg KOH/g)	Max. 0,3	
Total sludge (% mass)	Max. 0,01	
Electrical Properties		
Breakdown voltage (kV)	Min. 45a to IEC 60156 (See Clause 8)	
Dielectric dissipation factor, tan δ at 90 °C and 50 Hz	Max. 0,03*, *** to IEC 60247 or IEC 61620	
DC resistivity at 90 °C (GΩ × m)	Min. 2 to IEC 60247	
* For untreated liquid, as received. ** Oxidation stability (IEC 61125, Method C) at 500 h is an optional extra test. No requirement in this standard. *** For frequencies (f (Hz)) in the range of 48 Hz to 62 Hz, convert values as follows: $\tan\delta[f (50 \text{ Hz})] = \frac{f (Hz)}{50} \times \tan\delta [f (Hz)]$		

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Appendix 2 – Addendum to Supplier Requirements

Delivery of oil shall be by either bulk delivery to onsite storage tanks or by 205l barrels.

Pallet loads shall be limited to 4 barrels on a standard pallet such that the combined weight is < 1000Kg.

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Appendix 3 – Technical Information Checklist

The following information shall be provided by the supplier where applicable for technical review by Northern Powergrid. Additional information shall be provided if requested.

Requirement	Provided (Y/N)
Full product descriptions and part number/reference	
Appendix 1a – completed self certification conformance declaration for reclaimed oil	
Appendix 1b – completed self certification conformance declaration for unused oil	
Appendix 1c – completed self-certification conformance declaration for unused organic esters	
Appendix 2 – details	
Technical data sheets	
COSHH Data sheets	
Test evidence	
Routine sampling test plan	
Packaging/delivery information	