

BS 148:2020



BSI Standards Publication

**Recycled mineral insulating oil for
transformers and switchgear —
Specification**

bsi.

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Summary of pages

This document comprises a front cover, and inside front cover, pages i to ii, pages 1 to 8, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 March 2020. It was prepared by Technical Committee GEL/10, *Fluids for electrotechnical applications*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes [BS 148:2009](#), which is withdrawn.

Information about this document

The limits given in this British Standard are based on BS EN 60296. For ease of cross-reference, the clause numbering of this standard follows that of BS EN 60296 as far as possible. This standard differs from BS EN 60296 in specifying limits for total furans. The increasing use of total furfural/furans measurements as an in-service diagnostic tool has brought about the necessity to impose limits on reclaimed oil, which is continued in this edition. This British Standard acknowledges UK practice whereby the limiting values for reclaimed mineral insulating oils are based on those for unused mineral insulating oils for transformers and switchgear while having due regard for the variability of used oil feedstock from which reclaimed oil is produced.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause **G.1.1**, which states, “Requirements should be expressed using wording such as: ‘When tested as described in [Annex A](#), the product shall ...’”. This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies requirements for recycled oxidation inhibited and uninhibited mineral insulating oils, as delivered, for use in transformers, switchgear and similar electrical equipment in which oil is required as an insulant and/or for heat transfer.

Oils with and without additives are within the scope of this standard.

This standard does not differentiate between methods used to recycle used mineral insulating oil, thus reclaimed or regenerated oil, re-refined oil, dechlorinated oil and reconditioned oil are all considered recycled oil for the purposes of this standard.

This standard does not apply to mineral insulating oils used as impregnates in cables or capacitors, or to hydrocarbon insulating liquids obtained by synthesis.

NOTE Oils conforming to the requirements of this standard, and containing no additives, are considered to be compatible with one another and can be mixed in any proportion. This does not necessarily apply to oils containing additives, and where the user wishes to mix such oils a check should be made to ensure that the mixture conforms to the requirements of this standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document.¹⁾ For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM E1687-10, *Standard test method for determining carcinogenic potential of virgin base oils in metalworking fluids*

BS EN 60156, *Insulating liquids – Determination of the breakdown voltage at power frequency. Test method*

BS EN 60247, *Insulating liquids – Measurement of relative permittivity, dielectric dissipation factor ($\tan \delta$) and d.c. resistivity*

BS EN 60475, *Method for sampling liquid dielectrics*

BS EN 60666, *Detection and determination of specified additives in mineral insulating oils*

BS EN 60814, *Insulating liquids – Oil-impregnated paper and pressboard. Determination of water by automatic coulometric Karl Fischer titration*

[BS EN IEC 61125:2018](#), *Insulating liquids – Test methods for oxidation stability – Test method for evaluating the oxidation stability of insulating liquids in the delivered state*

BS EN 61198, *Mineral insulating oils – Methods for the determination of 2-furfural and related compounds*

BS EN 61619, *Insulating liquids – Contamination by polychlorinated biphenyls (PCBs) – Method of determination by capillary column gas chromatography*

BS EN 62021-1, *Insulating liquids – Determination of acidity – Part 1: Automatic potentiometric titration*

BS EN 62021-2, *Insulating liquids – Determination of acidity – Part 2: Colourimetric titration*

BS EN 62535, *Method for detection of potentially corrosive sulfur in used and unused mineral insulating oils*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

BS EN 62697-1, *Test methods for quantitative determination of corrosive sulphur compounds in unused and used insulating liquids – Test method for quantitative determination of dibenzyl disulfide (DBDS)*

[BS EN IEC 62961](#), *Insulating liquids – Test methods for the determination of interfacial tension of insulating liquids – Determination with the ring method*

BS EN ISO 2719, *Determination of flash point – Pensky-Martens closed cup method*

BS EN ISO 3104, *Petroleum products. Determination of kinematic viscosity and calculation of dynamic viscosity of transparent and opaque liquids*

BS EN ISO 3675, *Methods of test for petroleum and its products – BS 2000-160: Crude petroleum and liquid petroleum products. Laboratory determination of density – Hydrometer method*

BS EN ISO 12185, *Methods of test for petroleum and its products – Crude petroleum and petroleum products. Determination of density. Oscillating U-tube method*

DIN 51353, *Testing of insulating oils; detection of corrosive sulfur; silver strip test (Foreign Standard)*

[ISO 2049](#), *Petroleum products. Determination of colour (ASTM scale)*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 mineral insulating oil

insulating liquid obtained by refining, modifying and blending of petroleum products

3.2 uninhibited oil

mineral insulating oil to which no anti-oxidants or metal deactivating agents have been added but which might contain other additives

3.3 inhibited oil

mineral insulating oil containing an anti-oxidant

3.4 passivated oil

mineral insulating oil containing a metal deactivating agent

3.5 unused oil

mineral insulating oil, obtained by refining, modifying and/or blending of petroleum products and other hydrocarbons.

NOTE Such an oil has not been used in, nor been in contact with electrical equipment or other equipment not required for manufacture, storage or transport.

3.6 recycled oil

mineral insulating oil previously used in electrical equipment that has been subjected to an off-site recycling process

NOTE A blend of unused and recycled oils in any proportion is regarded as being recycled oil.

3.7 reclaimed (regenerated) oil

recycled oil which has been subjected to chemical and physical processing to reduce soluble and insoluble contaminants

3.8 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

NOTE Such re-refined oils are often produced from mixtures of mineral insulating oils of different origins including processes such as distillation and hydrotreatment.

3.9 reconditioned oil

recycled oil which has been subjected to a physical process to remove insoluble contaminants and free water and to reduce the levels of dissolved moisture and gases

3.10 dechlorinated oil

recycled oil which has been subjected to decontamination from PCBs

3.11 additive

suitable substance added to an insulating liquid to improve certain characteristics

3.12 anti-oxidant

additive incorporated into an insulating liquid to reduce or delay its degradation by oxidation

3.13 metal deactivating agent

additive introduced to suppress catalytic activity of metals in insulating liquid; classified into two major groups, either passivators or chelating agents

NOTE In reducing the catalytic activity, metal deactivators might have an antioxidant effect.

3.14 passivator

metal deactivating agent incorporated into an insulating liquid to reduce the chemical reactivity of metallic surfaces within oil-filled equipment

3.15 pour point depressant

additive that enables the pour point of a mineral insulating oil to be lowered

4 Identification and delivery

- 4.1** Road or rail tank wagons and drums used for the delivery of oil shall be specially cleaned for this purpose.
- 4.2** Oil drums and containers shipped by the oil supplier shall carry at least the following markings:
- the supplier's designation;
 - the type of oil: whether inhibited (I), trace inhibited (T) or uninhibited (U); and
 - the number and date of this British Standard, i.e. BS 148.²⁾
- 4.3** Each oil delivery shall be covered by a document from the supplier declaring at least the following:
- the supplier's designation;
 - the function and chemical family of all additives present and their concentrations; and

²⁾ Marking BS 148:2020 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third party certification of conformity.

c) that the oil conforms to BS 148.

NOTE A pour point depressant should only be included in the oil formulation if this is agreed between supplier and purchaser.

4.4 Health and safety information, in line with current legislation, shall be available to the purchaser.

5 Sampling

Sampling shall be carried out in accordance with the relevant procedure described in BS EN 60475.

6 Properties, their significance and test methods

The properties of recycled oil shall be tested in accordance with [Table 1](#).

NOTE Informative comments about the significance of selected tests are given in [Annex A](#).

Table 1 — General specifications

Property	Test method	Limits
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 sulfur	DIN 51353	Not corrosive
Potentially corrosive sulfur	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

Table 1 (continued)

Property	Test method	Limits
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 500 h
- 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)
<p>^{A)} For bulk supply.</p> <p>^{B)} For delivery in drums and IBC (intermediate bulk container).</p> <p>^{C)} After laboratory treatment (see BS EN 60296, 6.4).</p> <p>^{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.</p> <p>^{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.</p> <p>^{F)} At the end of oxidation stability tests.</p> <p>^{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.</p>		

Annex A (informative)

Recycled oil properties, their significance and test methods

A.1 Water content

A low water content of mineral insulating oil is necessary to achieve adequate breakdown voltage and low dissipation losses. To avoid separation of free water, recycled mineral insulating oil should have limited water content. Before filling the electrical equipment, the oil should be treated to meet the requirements of BS EN 60422.

A.2 Acidity

Mineral insulating oil produces acids and other oxidation by-products when in service. These should be removed from the oil to an acceptable level by a recycling process before it can be reused in electrical equipment to achieve suitable resistance to oxidation.

A.3 Anti-oxidants

Antioxidants in inhibited oil slow down the oxidation of oil and therefore the formation of degradation products such as acidity and other oxidation by-products. It is necessary to know the concentration of antioxidants for the correct classification of the oil. Additionally, periodic measurement of the concentration is required to prevent premature ageing of the oil.

Anti-oxidants include:

- a) inhibitors such as phenols and amines. The most widely used inhibitors are di-tert-butyl-para-cresol (DBPC) and di-tert-butyl-phenol (DBP). Standard test methods are not available for other types of inhibitors; and
 - b) other antioxidant additives such as sulfur- and phosphor-containing compounds, e.g. organic polysulfides and dithiophosphates. An antioxidant additive of this type is dibenzyl disulfide DBDS. DBDS should not be present in recycled oils as it is known to be corrosive to copper and can generate copper sulfide in service in electrical equipment.
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A.4 Gassing tendency

The gas absorbing property of oil when subjected to corona partial discharges is only necessary and important for special equipment like HV (high voltage) instrument transformers and bushings. It is a measure of the rate of absorption or evolution of hydrogen into oil under prescribed laboratory conditions. Gas absorption properties could be related to oil aromatic content.

NOTE Additives such as 1,2,3,4 tetrahydronaphthalene (tetralin), mono or dibenzyltoluene and others have been proposed to reduce the gassing tendency of some oils, but are not described in BS EN 60666. Mono and dibenzyltoluene are described in BS EN 60867.

A.5 Polycyclic aromatic hydrocarbon (PCAs) content

Some PCAs are classified to be carcinogens and therefore need to be controlled to an acceptable level in mineral insulating oil. Suppliers are therefore required to demonstrate the non-carcinogenicity of their products.

A.6 Polychlorinated biphenyl content (PCBs)

PCBs are sometimes found as residual contamination in used oil. They are subject to regulation; recycled mineral insulating oil should be free from PCBs.

NOTE Acceptable limits of total or individual PCBs are specified in national and local regulations. Further European specifications are described in PCB Council Directive 96/59/EC [1].

A.7 Furfural (2-FAL) and related compounds content

2-FAL and related compounds in recycled oil can result from improper redistillation after solvent extraction, from cellulose degradation within equipment that previously contained the oil or from contamination with used oil.

Recycled mineral insulating oils should have a non-detectable level of 2-FAL and related compounds.

- a) The “related compounds” are: 5-hydroxymethyl-2-furfural (5HMF), 2-furfuryl alcohol (2FOL), 2-acetylfuran (2ACF) and 5-methyl-2-furfural (5MEF).
 - b) Trace levels of furanic compounds might be detectable in recycled oil using modified methods in accordance with [IEC 61198](#). The limit of 0.05 mg/kg should still be applied.
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A.8 Appearance

Appearance may be evaluated by examining a representative sample of the oil in transmitted light under an oil depth of approximately 100 mm and at ambient temperature. Under these conditions, the requirements of [Table 1](#) may be met.

A.9 Density

Density can be measured by any recognized test method or, in the event of a dispute, the method given in BS EN ISO 3675 should be used. Density may be measured at 20 °C or converted to 20 °C using Table 59 D of Petroleum measurement paper No.3 [2].

Bibliography

- [1] COUNCIL OF THE EUROPEAN UNION. 96/59/EC. Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT).
- [2] Petroleum measurement paper No. 3: Computer implementation procedures for correcting densities and volumes to 20 °C, October 1988, The Institute of Petroleum, 61 New Cavendish St, London W1M 8AR.

Further reading

[BS 2000-15](#), *Methods of test for petroleum and its products — Part 15: Petroleum products — Determination of pour point*

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