

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fluids for electrotechnical applications – Recycled mineral insulating oils for transformers and switchgear

Fluides pour applications électrotechniques – Huiles minérales isolantes recyclées pour transformateurs et appareillages de connexion

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FLUIDS FOR ELECTROTECHNICAL APPLICATIONS –
RECYCLED MINERAL INSULATING OILS
FOR TRANSFORMERS AND SWITCHGEAR**

FOREWORD

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International Standard IEC 62701 has been prepared by IEC technical committee 10: Fluids for electro technical applications.

This International Standard is in line with IEC 60296 and IEC 60422.

The text of this standard is based on the following documents:

FDIS	Report on voting
10/908/FDIS	10/910/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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INTRODUCTION

Health and safety

This International Standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of the standard to establish appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.

The mineral insulating oils which are the subject of this standard should be handled with due regard to personal hygiene. Direct contact with the eyes may cause irritation. In the case of eye contact, irrigation with copious quantities of clean running water should be carried out and medical advice sought. Some of the tests specified in this standard involve the use of processes that could lead to a hazardous situation. Attention is drawn to the relevant standard for guidance.

Environment

This standard is applicable rise to mineral insulating oils, chemicals and used sample containers. The disposal of these items shall be carried out according to the local regulations with regard to the impact on the environment. Every precaution should be taken to prevent release of mineral insulating oil into the environment.

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FLUIDS FOR ELECTROTECHNICAL APPLICATIONS – RECYCLED MINERAL INSULATING OILS FOR TRANSFORMERS AND SWITCHGEAR

1 Scope

This International Standard specifies requirements for recycled mineral insulating oils intended for use in transformers, switchgear, and similar electrical equipment in which oil is required for insulation and heat transfer.

These oils are produced by processes employed offsite.

Oils treated and reconditioned on-site are not within the scope of this standard.

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

Such oils will have originally been supplied in compliance with a recognized unused mineral insulating oil specification.

This standard does not differentiate between the methods used to recycle mineral insulating oil.

This standard does not apply to mineral insulating oils used as impregnates in cables or capacitors.

For the purpose of this standard the following subclauses of IEC 60296:2012 apply:

- 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9;
- 4.1, 4.3, 4.4;
- 5.1, 5.5;
- 6.1, 6.2, 6.4, 6.5, 6.6, 6.8, 6.9, 6.10, 6.11.1, 6.11.3, 6.11.4, 6.12, 6.14, 6.15, 6.16;
- 7.1.

NOTE Some types of re-refined oils are equivalent to unused oils in terms of performance, in which case IEC 60296 is applicable. This should be stated by the manufacturer.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

IEC 60296:2012, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60422, *Mineral insulating oils in electrical equipment – Supervision and maintenance guidance*

IEC 60628, *Gassing of insulating liquids under electrical stress and ionization*

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

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

IEC 60970, *Insulating liquids – Method for counting and sizing particles*

IEC 61125:1992, *Unused hydrocarbon based insulating liquids – Test methods for evaluating the oxidation stability*
Amendment 1 (2004)

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

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

IEC 61620, *Insulating liquids – Determination of the dielectric dissipation factor by measurement of the conductance and capacitance – Test method*

IEC 61868, *Mineral insulating oils – Determination of kinematic viscosity at very low temperatures*

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

IEC 62021-2, *Insulating liquids – Determination of acidity – Part 2: Colorimetric titration*

IEC 62535, *Insulating liquids – Test method for detection of potentially corrosive sulphur in used and unused insulating oils*

IEC 62697-1, *Test methods for quantitative determination of corrosive sulfur compounds in unused and used insulating liquids – Part 1: Test method for quantitative determination of dibenzylsulfide (DBDS)*

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

ISO 3016, *Petroleum products – Determination of pour point*

ISO 3104, *Petroleum products – Transparent and opaque liquids – Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3675, *Crude petroleum and liquid petroleum products – Laboratory determination of density – Hydrometer method*

ISO 12185, *Crude petroleum and petroleum products – Determination of density – Oscillating U-tube method*

ISO 14596, *Petroleum products – Determination of sulfur content – Wavelength-dispersive X-ray fluorescence spectrometry*

ASTM D971, *Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method*

DIN 51353, *Testing of insulating oils; detection of corrosive sulfur; silver strip test*

EN 14210, *Surface active agents – Determination of interfacial tension of solutions of surface active agents by the stirrup or ring method*

IP 346, *Determination of polycyclic aromatics in unused lubricating base oils and asphaltene free petroleum fractions – Dimethylsulfoxide extraction refractive index method*

IP 373, *Petroleum products – Determination of sulphur content – Oxidative microcoulometry method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60296, as well as the following apply.

3.1

recycled mineral insulating oil

general term to encompass mineral insulating oils previously used in electrical equipment that has been subjected to re-refining or reclaiming (regeneration) off-site

Note 1 to entry: The characteristics of recycled oil are heavily dependent on the crude from which it was refined, the original refining technique, the service history and the type of recycling process. Natural antioxidants originally present in the oil might have been depleted in service or removed by the recycling process.

Note 2 to entry: Recycled oil is not appropriate for use in some applications.

Note 3 to entry: Such recycled oils are often produced from mixtures of mineral insulating oils of different origins.

Note 4 to entry: A blend of unused and recycled oils in any proportion is regarded as being recycled oil.

Note 5 to entry: Due to local legislation, in some countries, it is advisable to categorize used electrical oil as waste oil and complete separation of handling of unused and used oils is required

3.2

Reclaimed (regenerated) mineral insulating oil

mineral insulating oil used in electrical equipment, which has been subjected to chemical and physical processing to eliminate soluble and insoluble contaminants

Note 1 to entry: Where these processes are performed on oil contained in equipment in service, so called “on-site reclamation”, such treated oils are beyond the scope of this standard.

3.3

reconditioned mineral insulating oil

mineral insulating oil used in electrical equipment, 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

3.4

re-refined mineral insulating oil

mineral insulating oil used in electrical equipment that has been removed from service and subjected to a process similar to that used for the production of unused mineral insulating oil from virgin feedstock, including distillation and hydrogenation, in order to reduce the level of unwanted compounds

Note 1 to entry: Such re-refined oils are often produced from mixtures of mineral insulating oils of different origins.

4 Properties of oil – Refining and stability

Properties of oil are influenced by quality and type of the original oil refining, used oil recycling and additives.

NOTE These properties can include appearance, interfacial tension, sulphur content, acidity, corrosive sulphur, 2-furfural and related compounds content and stray gassing.

5 Classification, identification, general delivery requirements

5.1 Classification

For the purposes of this standard, recycled mineral insulating oils are classified as in 5.1 of IEC 60296:2012.

5.2 Requirements

The general requirements of this standard are given in Table 1.

5.3 Miscibility

Recycled mineral insulating oils of the same class (see 5.1.1 of IEC 60296:2012), the same group (see 5.1.2 of IEC 60296:2012), the same LCSET (see 5.1.3 of IEC 60296:2012) and containing the same types of additives are considered to be miscible and compatible with each other (see also IEC 60422).

5.4 Identification and general delivery requirements

The following applies:

- a) Oil is normally delivered in bulk, rail tank cars, tank containers or packed in drums or IBC (intermediate bulk containers). These shall be clean and suitable for this purpose to avoid any contamination.
- b) Oil drums and IBC containers shall carry at least the following markings:
 - supplier's designation;
 - classification (see 5.1 of IEC 60296:2012);
 - oil quantity;
 - recycled oil compliant with IEC 62701.
- c) As agreed between the supplier and purchaser, each oil delivery shall be accompanied by a document specifying the supplier's designation, oil classification, compliance certificate and process of recycling.
- d) The supplier shall declare the generic type of all additives, and their concentrations in the cases of inhibitors and passivators.

NOTE This document is intended to be traceable to a specific batch of oil produced.

6 Properties, their significance and test methods

6.1 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 shall have limited water content. Before filling the electrical equipment, the oil should be treated to meet the requirements of IEC 60422. Water content shall be measured in accordance with IEC 60814.

6.2 Acidity

Recycled mineral insulating oil should have been treated to remove acidity and oxidation by-products. Acidity shall be measured according to IEC 62021-1 or IEC 62021-2.

6.3 Antioxidant additives

Antioxidants (see 3.5 of IEC 60296:2012) slow down the oxidation of oil and therefore the formation of degradation products such as oil sludge and acidity. It is necessary to know the concentration of antioxidants for the correct classification of the oil. Additionally, the actual concentration is required to monitor ageing of the oil.

Additives that slow down the oxidation of mineral insulating oils include:

- inhibitors such as phenols and amines (see 3.5.1 of IEC 60296:2012). The most widely used inhibitors are di-tert-butyl-para-cresol (DBPC) and di-tert-butyl-phenol (DBP). Detection and measurement of DBPC and DBP shall be carried out in accordance with IEC 60666. IEC test methods are not available for other types of inhibitors;
- other antioxidant additives such as sulphur- and phosphor-containing compounds, e.g. organic polysulphides and dithiophosphates (see 3.5.2 of IEC 60296:2012). An antioxidant additive of this type is dibenzyl disulphide (DBDS) (see 6.10 of IEC 60296:2012), but it is not accepted in recycled oils as it is known to be corrosive to copper and will likely result in the oil failing the potentially corrosive sulphur test IEC 62535. The IEC 62697-1 test method was prepared only for DBDS (see 6.9 below) and not for the other antioxidant additives of this type;
- metal passivators (see 3.5.3 and 6.11.3 of IEC 60296:2012).

6.4 Gassing tendency

Gassing tendency of mineral insulating oil, i.e. 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 gas into oil under prescribed laboratory conditions. Gas absorption properties could be related to oil aromatic content. Gassing tendency shall be measured using method A of IEC 60628.

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

6.5 Polycyclic aromatics content (PCAs)

Some PCAs are classified to be carcinogens and therefore need to be controlled to an acceptable level in mineral insulating oil. The total amount of PCAs can be measured by extraction with DMSO (dimethylsulfoxide) under the conditions of IP 346.

NOTE 1 Acceptable limits of total or individual PCAs are specified in national and local regulations.

NOTE 2 Values and limits as given in IP 346 are substantiated for virgin base oils only.

6.6 Polychlorinated biphenyl content (PCBs)

Recycled mineral insulating oil shall be free from PCBs. The reference test method shall be IEC 61619.

NOTE Acceptable limits of total or individual PCBs are specified in national and local regulations. Further European specifications are described in Directive CE/59/96 [2].

¹ References in square brackets refer to the Bibliography.