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INTERNATIONAL STANDARD



**Fluids for electrotechnical applications – Unused natural esters for transformers
and similar electrical equipment**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FLUIDS FOR ELECTROTECHNICAL APPLICATIONS –
UNUSED NATURAL ESTERS FOR TRANSFORMERS
AND SIMILAR ELECTRICAL EQUIPMENT****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
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- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

This commented version (CMV) of the official standard IEC 62770:2024 edition 2.0 allows the user to identify the changes made to the previous IEC 62770:2013 edition 1.0. Furthermore, comments from IEC TC 10 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 62770 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications. It is an International Standard.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: **1**

- a) Introduction of IEC 63012 which details other liquids not covered by this document. IEC 63012 was published in 2019 after the first edition of IEC 62770 (2013).
- b) New Table 1 inserted which clarifies definitions.
- c) Appearance and colour requirements now merged.
- d) Pour point: Introduction of the importance of LCSET with advice on cold temperature behaviour of natural esters.
- e) Additives: new agreed wording inserted on the declaration of additives
- f) Flash and fire points: now only determined by Cleveland Open Cup method, since the Pensky-Martens closed cup method was identified as problematic with natural esters.
- g) Toxicity: Aquatic toxicity now emphasized.
- h) Annex B removed as it is no longer needed since the publication of IEC 63012.

The text of this International Standard is based on the following documents:

Draft	Report on voting
10/1215/FDIS	10/1243/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
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- revised.

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INTRODUCTION

Because of their higher fire points and ~~better~~ lower environmental ~~compatibility~~ impact relative to hydrocarbon petroleum derived insulating mineral oil, the use of vegetable oils and other natural esters is on the rise as insulating and heat transfer fluids in electrical devices such as transformers.

This document sets performance criteria for unused natural esters earmarked for electrical applications. However, the use of natural esters is recommended only for equipment that is not open to the atmosphere, for example sealed transformers and reactors because these fluids liquids are ~~prone~~ susceptible to ~~rapid~~ oxidation.

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

Unused natural esters which are the subject of this document should be handled with due regard to personal hygiene. Direct contact with eyes should be avoided. In case of eye contact, irrigation with copious amounts of clean running water should be carried out and medical advice sought.

Performance of some of the tests mentioned in this document could lead to a hazardous situation. Attention is drawn to the relevant document test method for guidance.

~~The disposal of natural esters, chemicals and sample containers mentioned in this standard should be carried out in accordance with current national legislation with regard to the impact on the environment. Every precaution should be taken to prevent the release of natural esters into the environment.~~ **2**

FLUIDS FOR ELECTROTECHNICAL APPLICATIONS – UNUSED NATURAL ESTERS FOR TRANSFORMERS AND SIMILAR ELECTRICAL EQUIPMENT

1 Scope

This document describes specifications and test methods for unused natural esters in transformers and similar ~~oil-impregnated~~ liquid-immersed electrical equipment in which a liquid is required as an insulating and heat transfer medium. The exposure of natural ester to air leads to deterioration of the insulating liquid. Use of natural esters is ~~not recommended for electrical equipment that is open to the atmosphere~~ therefore restricted to sealed units, or with the conservator tank protected from the contact with atmosphere by a membrane or other suitable system. **3**

In this document the term "natural esters" applies to insulating ~~fluids~~ liquids for transformers and similar electrical equipment with suitable biodegradability and lower environmental ~~compatibility~~ impact. Such natural esters are vegetable oils obtained from seeds, and oils obtained from other suitable biological materials ~~and delivered to an agreed point, at a set time period~~. These oils are comprised of triglycerides.

Natural esters with additives are within the scope of this document. Because of their different chemical composition, natural esters differ from insulating mineral oils and other insulating ~~fluids~~ liquids that have high fire points, such as synthetic esters or silicone fluids.

Natural ester-derived insulating ~~fluids~~ liquids with low viscosity have been introduced but are not covered by this document. ~~Pertinent properties of such fluids are given in Annex B.~~ IEC 63012 covers these liquids. **4**

This document is applicable only to unused natural esters. Reclaimed natural esters and natural esters blended with ~~non-natural esters fluids~~ other insulating liquids are beyond the scope of this document.

NOTE The chemical nomenclature and scientific notations used in the document are in accordance with the IUPAC handbook (Quantities, Units and Symbols in Physical Chemistry).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. **5**

~~IEC 60076-14, Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials~~

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* ~~of insulating fluids~~

~~IEC 60296, Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear~~

IEC 60475, *Method of sampling ~~liquid dielectrics~~ insulating liquids*

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

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

~~IEC 61100, Classification of insulating liquids according to fire point and net calorific value¹~~

IEC 61125:1992, ~~Unused hydrocarbon-based insulating fluids~~ *Insulating liquids – Test methods for oxidation stability – Test method for evaluating the oxidation stability of insulating liquids in the delivered state*

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 62021-3, *Insulating liquids – Determination of acidity – Part 3: Test methods for non-mineral insulating oils²*

IEC 62535:2008, *Insulating liquids – Test method for detection of potentially corrosive sulphur in used and unused insulating oil*

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 dibenzyldisulfide (DBDS)*

ISO 2049, *Petroleum products – Determination of colour (ASTM scale)*

ISO 2592, *Petroleum and related products – Determination of flash and fire points – Cleveland open cup method*

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

ISO 3016, *Petroleum and related products from natural or synthetic sources – Determination of pour point*

ISO 3104, *Petroleum products – Transparent and opaque fluids – 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*

¹ ~~Withdrawn in 2009 and partially replaced by IEC 61039.~~

² ~~To be published.~~

~~ASTM D 1275, Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils~~

ASTM D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

ASTM D7042, Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)

~~OECD 201-203, Test Guidelines for ecotoxicity~~

~~OECD 301, Guideline for testing of chemicals adopted by European Council on July 17th 1992~~

~~US EPA, Office of Prevention, Pesticides and Toxic Substances (OPPTS)~~

~~835.311, Fate, Transport and Transformation Test Guidelines~~

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fluids for electrotechnical applications – Unused natural esters for transformers and similar electrical equipment

Fluides pour applications électrotechniques – Esters naturels neufs pour transformateurs et matériels électriques analogues

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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IEC 60475, *Method of sampling insulating liquids*

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

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

IEC 61125, *Insulating liquids – Test methods for oxidation stability – Test method for evaluating the oxidation stability of insulating liquids in the delivered state*

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 62021-3, *Insulating liquids – Determination of acidity – Part 3: Test methods for non-mineral insulating oils*

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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 dibenzyl disulfide (DBDS)*

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ISO 2592, *Petroleum and related products – Determination of flash and fire points – Cleveland open cup method*

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

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

FLUIDES POUR APPLICATIONS ÉLECTROTECHNIQUES – ESTERS NATURELS NEUFS POUR TRANSFORMATEURS ET MATÉRIELS ÉLECTRIQUES ANALOGUES

AVANT-PROPOS

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L'IEC 62770 a été établie par le comité d'études 10 de l'IEC: Fluides pour applications électrotechniques. Il s'agit d'une Norme internationale.

Cette deuxième édition annule et remplace la première édition parue en 2013. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) l'IEC 63012, qui décrit les autres liquides non couverts par le présent document, a été introduite. L'IEC 63012 a été publiée en 2019, après la première édition de l'IEC 62770 (2013);
- b) un nouveau Tableau 1, qui clarifie les définitions, a été inséré;
- c) les exigences relatives à l'apparence et la couleur sont désormais fusionnées;
- d) point d'écoulement: l'importance de la TMDP a été introduite, avec des conseils relatifs au comportement à basse température des esters naturels;
- e) additifs: une nouvelle formulation fixée par accord a été insérée dans la déclaration des additifs;
- f) points d'éclair et de feu: désormais uniquement déterminés par la méthode Cleveland à vase ouvert, la méthode Pensky-Martens en vase clos ayant été identifiée comme problématique avec les esters naturels;
- g) toxicité: la toxicité aquatique est désormais soulignée;
- h) l'Annexe B a été supprimée, dans la mesure où elle n'est plus nécessaire depuis la publication de l'IEC 63012.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
10/1215/FDIS	10/1243/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

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- reconduit,
- supprimé, ou
- révisé.

INTRODUCTION

Du fait de leurs points de feu plus élevés et de leur impact moindre sur l'environnement par rapport à l'huile minérale isolante obtenue à partir des hydrocarbures pétroliers, l'utilisation des huiles végétales et d'autres esters naturels est en augmentation en tant que liquides isolants et fluides caloporteurs dans les appareils électriques tels que les transformateurs.

Le présent document établit des critères de performance pour les esters naturels neufs destinés aux applications électriques. Cependant, l'utilisation des esters naturels est recommandée uniquement pour les matériels sans contact avec l'air, par exemple les transformateurs et réacteurs scellés, car ces liquides sont susceptibles de s'oxyder.

Le présent document ne prétend pas couvrir tous les problèmes de sécurité liés à son utilisation. Il est de la responsabilité de l'utilisateur du présent document de mettre en place les pratiques d'hygiène et de sécurité adéquates et de déterminer avant utilisation si des contraintes réglementaires s'appliquent.

Il convient de manipuler les esters naturels neufs dont traite le présent document en respectant scrupuleusement l'hygiène personnelle. Il convient d'éviter tout contact direct avec les yeux. En cas de contact oculaire, il convient de laver les yeux abondamment à l'eau courante propre et de demander un avis médical.

Certains des essais mentionnés dans le présent document sont susceptibles d'entraîner une situation dangereuse. L'attention est attirée sur la méthode d'essai du document applicable à titre de recommandation.

FLUIDES POUR APPLICATIONS ÉLECTROTECHNIQUES – ESTERS NATURELS NEUFS POUR TRANSFORMATEURS ET MATÉRIELS ÉLECTRIQUES ANALOGUES

1 Domaine d'application

Le présent document décrit les spécifications et méthodes d'essai applicables aux esters naturels neufs dans les transformateurs et matériels électriques immergés dans du liquide analogues qui nécessitent un liquide en tant que milieu isolant et caloporteur. L'exposition de l'ester naturel à l'air entraîne une détérioration du liquide isolant. L'utilisation des esters naturels est donc limitée à des unités scellées, ou avec le conservateur protégé du contact atmosphérique par une membrane ou tout autre système approprié.

Dans le présent document, le terme "esters naturels" s'applique aux liquides isolants pour transformateurs et matériels électriques analogues qui présentent une biodégradabilité convenable et un impact moindre sur l'environnement. Ces esters naturels sont des huiles végétales obtenues à partir de graines et des huiles obtenues à partir d'autres matériaux biologiques appropriés. Ces huiles sont composées de triglycérides.

Les esters naturels avec additifs entrent dans le domaine d'application du présent document. En raison de leur composition chimique différente, les esters naturels se distinguent des huiles minérales isolantes et d'autres liquides isolants qui possèdent des points de feu élevés, tels que les esters synthétiques ou les fluides silicones.

Les liquides isolants obtenus à partir d'esters naturels qui présentent une faible viscosité ont été introduits, mais ne sont pas couverts par le présent document. L'IEC 63012 couvre ces liquides.

Le présent document ne s'applique qu'aux esters naturels neufs. Les esters naturels régénérés et les esters naturels mélangés à d'autres liquides isolants n'entrent pas dans le domaine d'application du présent document.

NOTE La nomenclature chimique et les notations scientifiques utilisées dans le présent document sont conformes au manuel de l'IUPAC (Grandeurs, unités et symboles de la chimie physique).

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60156, *Isolants liquides – Détermination de la tension de claquage à fréquence industrielle – Méthode d'essai*

IEC 60247, *Liquides isolants – Mesure de la permittivité relative, du facteur de dissipation diélectrique ($\tan \delta$) et de la résistivité en courant continu*

IEC 60475, *Méthode d'échantillonnage des liquides isolants*

IEC 60666, *Détection et dosage d'additifs spécifiques présents dans les huiles minérales isolantes*

IEC 60814, *Isolants liquides – Cartons et papiers imprégnés d'huile – Détermination de la teneur en eau par titrage coulométrique de Karl Fischer automatique*

IEC 61125, *Isolants liquides – Méthodes d'essai de la stabilité à l'oxydation – Méthode d'essai pour évaluer la stabilité à l'oxydation des isolants liquides tels que livrés*

IEC 61198, *Huiles minérales isolantes – Méthodes pour la détermination du 2-furfural et ses dérivés*

IEC 61619, *Isolants liquides – Contamination par les polychlorobiphényles (PCB) – Méthode de détermination par chromatographie en phase gazeuse sur colonne capillaire*

IEC 61620, *Isolants liquides – Détermination du facteur de dissipation diélectrique par la mesure de la conductance et de la capacité – Méthode d'essai*

IEC 62021-3, *Liquides isolants – Détermination de l'acidité – Partie 3: Méthodes d'essai pour les huiles non minérales isolantes*

IEC 62535, *Liquides isolants – Méthode d'essai pour la détection du soufre potentiellement corrosif dans les huiles usagées et neuves*

IEC 62697-1, *Méthodes d'essai pour la détermination quantitative des composés de soufre corrosif dans les liquides isolants usagés et neufs – Partie 1: Méthode d'essai pour la détermination quantitative du disulfure de dibenzyle (DBDS)*

ISO 2049, *Produits pétroliers – Détermination de la couleur (échelle ASTM)*

ISO 2592, *Pétrole et produits connexes – Détermination des points d'éclair et de feu – Méthode Cleveland à vase ouvert*

ISO 3016, *Produits pétroliers et connexes d'origine naturelle ou synthétique – Détermination du point d'écoulement*

ISO 3104, *Produits pétroliers – Liquides opaques et transparents – Détermination de la viscosité cinématique et calcul de la viscosité dynamique*

ISO 3675, *Pétrole brut et produits pétroliers liquides – Détermination en laboratoire de la masse volumique – Méthode à l'aréomètre*

ISO 12185, *Pétroles bruts et produits pétroliers – Détermination de la masse volumique – Méthode du tube en U oscillant*

ASTM D1500, *Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)*

ASTM D7042, *Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)*