SLOVENSKI STANDARD
oSIST prEN IEC 60422:2023

01-junij-2023

Mineralna izolacijska olja v električni opremi - Napotki za nadzorovanje in vzdrževanje

Mineral insulating oils in electrical equipment - Supervision and maintenance guidance

Isolieröle auf Mineralölbasis in elektrischen Betriebsmitteln - Leitlinie zur Überwachung und Wartung

Huiles minérales isolantes dans les matériels électriques - Lignes directrices pour la maintenance et la surveillance

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Ta slovenski standard je istoveten z: **prEN IEC 60422:2023**

ICS:

29.040.10	Izolacijska olja	Insulating oils

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2003-01.Slovenski inštitut za standardizacijo. Razmnoževanje celote ali delov tega standarda ni dovoljeno.

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10/1194/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 60422 ED5**	
DATE OF CIRCULATION: **2023-04-07**	CLOSING DATE FOR VOTING: **2023-06-30**
SUPERSEDES DOCUMENTS: **10/1165/CD, 10/1183A/CC**	

IEC TC 10 : FLUIDS FOR ELECTROTECHNICAL APPLICATIONS

SECRETARIAT: Italy	SECRETARY: Mr Massimo Pompili
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 14, SC 17A, TC 20, SC 36A, TC 38, TC 99, TC 112	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☒ ENVIRONMENT ☒ QUALITY ASSURANCE ☒ SAFETY

☒ SUBMITTED FOR CENELEC PARALLEL VOTING	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING
Attention IEC-CENELEC parallel voting The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	

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Recipients of this document are invited to submit, with their comments, notification of

- any relevant patent rights of which they are aware and to provide supporting documentation,
- any relevant “in some countries” clauses to be included should this proposal proceed. Recipients are reminded that the enquiry stage is the final stage for submitting "in some countries" clauses. See AC/22/2007.

TITLE:

Mineral insulating oils in electrical equipment – Supervision and maintenance guidance

PROPOSED STABILITY DATE: 2026

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MINERAL INSULATING OILS – GUIDELINES FOR MAINTENANCE AND USE IN ELECTRICAL EQUIPMENT

FOREWORD

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International Standard IEC 60422 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

This fifth edition cancels and replaces the fourth edition, published in 2013, and constitutes a technical revision.

The main changes with respect to the previous edition are as follows:

This new edition represents a major revision of the fourth edition, bringing this standard in line with the latest developments in oil condition monitoring. New interpretation tables have been created, containing limits for oil parameters specific to plant type with suggested corrective actions in the tables and new test methods.

The action limits for all oil tests have been revised and changes made where necessary to enable users to use current methodology and comply with requirements and regulations affecting safety and environmental aspects.

Category O has been removed and is now incorporated within category A.

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In addition, this standard incorporates changes introduced in associated standards since the fourth edition was published.

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

FDIS	Report on voting
10/XXXX/FDIS	10/XXXX/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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Insulating mineral oils are used in electrical equipment employed in the generation, transmission, distribution and use of electrical energy.

Monitoring and maintaining oil quality is essential to ensure the reliable operation of oil-filled electrical equipment. Codes of practice for this purpose have been established by electrical power authorities, power companies and industries in many countries.

A review of current experience reveals a wide variation of procedures and guidance. It is possible, however, to compare the value and significance of standardized oil tests and to recommend uniform criteria for the evaluation of test data.

If a certain amount of oil deterioration (by degradation or contamination) is exceeded, there is inevitably some erosion of safety margins and the question of the risk of failure should be considered. While the quantification of the risk can be very difficult, a first step involves the identification of potential effects of increased deterioration. The philosophy underlying this standard is to furnish users with as broad a base of understanding of oil quality deterioration as is available, so that they can make informed decisions on inspection and maintenance practices.

Mineral oils are valuable resources and should be utilised accordingly. Used mineral oils are, by most regulations, deemed to be controlled waste. If spills occur, this may have a negative environmental impact especially if the oil is contaminated by persistent organic pollutants such as polychlorinated biphenyls (PCBs).

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This International Standard, whilst technically sound, is mainly intended to serve as a common basis for the preparation of more specific and complete codes of practice by users in the light of local circumstances. Sound engineering judgement will have to be exerted in seeking the best compromise between technical requirements and economic factors.

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Reference should also be made to instructions from the equipment manufacturer.

General caution

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

The mineral oils which are the subject of this document shall be handled in compliance with local regulations and supplier’s safety datasheets.

Environment, Health & Safety

This standard is applicable to mineral oils, chemicals and used sample containers. The disposal of these items should be carried out according to local regulations regarding their impact on the environment.

Attention is drawn to the fact that, at the time of writing this standard, some mineral oils in service are known to be contaminated to some degree with other liquids, for example, silicone oils and PCBs.

Because of this, safety countermeasures should be taken to avoid risks to workers, the public and the environment during the life of the equipment, by strictly controlling spills and emissions. Disposal or decontamination of these oils should be carried out strictly according to local

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regulations. Every precaution should be taken to prevent release of mineral oil into the environment.

Typically, each country has specific regulations around health and safety. Safety Data Sheets (SDS) are normally used by the industry internationally and are usually written in accordance with an international regulation set (such as REACH). Please consult the SDS from the suppliers of the insulating product that is used. These documents provide essential information regarding health, safety, and environmental impacts.

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MINERAL INSULATING OILS – GUIDELINES FOR MAINTENANCE AND USE IN ELECTRICAL EQUIPMENT

1 Scope

This standard provides monitoring guidance and procedures that are required for the use and maintenance of mineral insulating oils and other hydrocarbon-based liquids in transformers and other electrical equipment.

This standard is applicable to mineral insulating oils, originally supplied conforming to IEC 60296, in transformers, switchgear and other electrical apparatus where oil sampling is reasonably practicable and where the normal operating conditions specified in the equipment specifications apply.

This standard is also intended to assist the power equipment operator to evaluate the condition of the oil and maintain it in a serviceable condition. It also provides a common basis for the preparation of more specific and complete local codes of practice.

The standard includes recommendations on tests and evaluation procedures and outlines methods for reconditioning and reclaiming oil and the decontamination of oil contaminated with PCBs.

NOTE: The condition monitoring of electrical equipment, for example by analysis of dissolved gases, furanic compounds or other means, is outside the scope of this standard.

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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.

EN 12766-2, *Petroleum products and used oils - Determination of PCBs and related products - Part 2: Calculation of polychlorinated biphenyl (PCB) content*

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 δ) and d.c. resistivity*

IEC 60296, *Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment*

IEC 60475, *Method of sampling liquid dielectrics*

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 – Methods for counting and sizing particles*

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

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

IEC 62021-2, *Insulating liquids – Determination of acidity – Part 2: Colourimetric 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 dibenzyldisulfide (DBDS)*

IEC 62961, *Insulating liquids – Test methods for the determination of interfacial tension of insulating liquids - Determination with the ring method*

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

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 4406, *Hydraulic fluid power – Fluids – Method for coding level of contamination by solid particles*

ISO 6247, Petroleum products — Determination of foaming characteristics of lubricating oils

ISO 9120, Petroleum and related products — Determination of air-release properties of steam turbine and other oils — Impinger method

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

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

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)*

DIN 51353: *Testing of insulating oils; Detection of corrosive sulphur; Silver strip test*

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Regulation (EC) No 1907/2006, Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

3 Terms and definitions

For the purposes of this document, the following definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org.obp

Note 1 to entry: ASTM and IEEE terminologies are available on:

- ASTM D2864: Standard Terminology Relating to Electrical Insulating Liquids and Gases [1]
- IEEE C57.12.80 Standard Terminology for Power and Distribution Transformers [2]

3.1
local regulations
regulations pertinent to the particular process in the country concerned

Note 1 to entry: Such regulations may be defined by local, regional or national legislation or even the owner or operator of the equipment itself. They are always to be considered as the most stringent of any combination thereof. It is the responsibility of each user of this standard to familiarize themselves with the regulations applicable to their situation. Such regulations may refer to operational, environmental or health and safety issues. A detailed risk assessment will usually be required.

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3.2
routine tests (Group 1)
minimum tests required to monitor the oil and to ensure that it is suitable for continued service

Note 1 to entry: If the results obtained from these tests do not exceed recommended action limits, usually no further tests are considered necessary until the next regular period for inspection but, under certain perceived conditions, complementary tests may be deemed prudent.

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3.3
complementary tests (Group 2)
additional tests, which may be used to obtain further specific information about the quality of the oil, and may be used to assist in the evaluation of the oil for continued use in service

3.4
special investigative tests (Group 3)
tests used mainly to determine the suitability of the oil for the type of equipment in use and to ensure compliance with environmental and operational considerations

3.5
reconditioning
process that eliminates or reduces gases, water, solid particles, and contaminants by physical processing only

3.6
reclamation
process that eliminates or reduces soluble and insoluble polar contaminants from the oil by chemical and physical processing

3.7
PCBs decontamination
process that eliminates or reduces PCBs contamination from mineral oil

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4 Properties and deterioration/degradation of oil

The reliable performance of mineral insulating oil in an insulation system depends upon certain basic oil characteristics that can affect the overall performance of the electrical equipment.

To accomplish its multiple roles of dielectric insulation, cooling, arc-quenching and lubrication, oil needs to possess certain properties, in particular:

- high dielectric strength to withstand the electric stresses imposed in service
- sufficiently low viscosity so that its ability to circulate and transfer heat is not impaired
- adequate viscosity range and lubricity to ensure fault-free operation and endurance of mechanical equipment, such as tap-changers, over the whole temperature range
- adequate low-temperature properties down to the lowest temperature expected at the installation site
- resistance to oxidation and pyrolytic degradation (by switching arcs) to maximize service life
- non-corrosive or detrimental to electrical plant construction materials that it is in contact with

In service, mineral oil degrades due to the conditions of use. In many applications, insulating oil is in contact with air and is therefore subject to oxidation. Elevated temperatures accelerate degradation. The presence of metals, organo-metallic compounds or both may act as a catalyst for oxidation. Changes in colour, the formation of acidic compounds and, at an advanced stage of oxidation, precipitation of sludge may occur. Dielectric and, in extreme cases, thermal properties may be impaired.

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In addition to oxidation products, many other undesirable contaminants, such as water, solid particles and oil-soluble polar compounds can accumulate in the oil during service and affect its electrical properties. The presence of such contaminants and any oil degradation products are indicated by a change in one or more properties as described in Table 2.

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Deterioration of other constructional materials, which may interfere with the proper functioning of the electrical equipment and shorten its working life, may also be indicated by changes in oil properties.

The decision on when to carry out an intervention is normally the responsibility of the asset owner and is usually part of a wider asset management strategy. When making intervention decisions, consideration should not only be given to the condition of the oil but also to the age and general condition of the plant item and its operational environment and duty. Carrying out an expensive intervention on an asset that is reaching end of life may not be cost effective, alternatively not carrying out an intervention on a relatively new plant item even when certain intervention limits may not yet have been reached may contribute to accelerated ageing and reduction in the projected asset life.

5 Categories of equipment

In order to take account of different user requirements, equipment has been placed in various categories as shown in Table 1 below.

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209 **Table 1 – Categories of equipment**

Category	Transformers and Reactors
Category A	Power transformers/reactors with an U_m above 170 kV. Power transformers of any rated voltage where continuity of supply is vital and similar equipment for special applications operating under onerous condition
Category B	Power transformers/reactors with an U_m above 72,5 kV and up to and including 170 kV (other than those in Category A)
Category C	Power transformers/reactors for MV/LV application, e.g. U_m up to and including 72,5 kV (distribution transformers) and traction transformers (other than those in Category A).
	Instrument Protection Transformers
Category D	Instrument/protection transformers with an U_m above 170 kV
Category E	Instrument/protection transformers with an U_m up to and including 170 kV
	Tap-changers
Category F	Diverter tanks of on-load tap-changers, including combined selector/diverter tanks
	Circuit Breakers and Switchgear
Category G	Oil-filled circuit breakers, oil-filled switches, a.c. metal-enclosed switchgear and control gear with an U_m exceeding 72,5 kV
Category H	Oil-filled circuit breakers, oil-filled switches, a.c. metal-enclosed switchgear and control gear with an U_m up to and including 72,5 kV
	Oil Filled and OIP Bushings
Category K	Bushings with an U_m above 170 kV
Category L	Bushings with an U_m up to and including 170 kV
NOTE 1: Separated selector tanks of on-load tap-changers belong to the same category as the associated transformer. NOTE 2: Regardless of size or voltage, a risk assessment may justify condition-monitoring techniques usually appropriate to a higher classification. NOTE 3: For practical and economic reasons, some electrical utilities may decide that their small transformers up to 1 MVA and 36 kV are not included in this classification. Routine monitoring programmes may not be considered economical for this type of equipment. Where a monitoring programme is required for these transformers, the guidelines given for category C should be adequate. NOTE 4: U_m is the highest voltage for equipment. This was referred to as “nominal system voltage” in previous editions.	

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211 6 Sampling of oil from equipment

212 Sampling in accordance with IEC 60475, shall be performed by an experienced person with
213 adequate training, using approved sample containers/devices. Whenever possible, sampling
214 from equipment shall be at normal operating conditions or very shortly after de-energisation.
215 Whenever possible, Oil Directed or Oil Forced Air Forced (ODAF or OFAF) transformers should
216 have their samples taken with pumps running.

217 Where available, manufacturer’s instructions should be followed, and designated sample valves
218 or points used.

219 It is essential that every effort is made to ensure that samples are representative of the oil in
220 the equipment. Careless sampling procedures or contamination of the sample container will

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