

---

---

**Mineralna izolacijska olja v električni opremi – Napotki za nadzorovanje in vzdrževanje (IEC 60422:2005)**

Mineral insulating oils in electrical equipment – Supervision and maintenance guidance (IEC 60422:2005)

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

[SIST EN 60422:2006](https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-09a7b0f191a7/sist-en-60422-2006)

<https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-09a7b0f191a7/sist-en-60422-2006>

# **iTeh STANDARD PREVIEW** **(standards.iteh.ai)**

SIST EN 60422:2006

<https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-09a7b0f191a7/sist-en-60422-2006>

**Mineral insulating oils in electrical equipment -  
Supervision and maintenance guidance  
(IEC 60422:2005)**

Huiles minérales isolantes  
dans les matériels électriques -  
Lignes directrices pour la maintenance  
et la surveillance  
(CEI 60422:2005)

Richtlinien zur Überwachung und Wartung  
von Isolierölen auf Mineralölbasis  
in elektrischen Betriebsmitteln  
(IEC 60422:2005)

**iTeh STANDARD PREVIEW**

This European Standard was approved by CENELEC on 2006-04-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

**CENELEC**

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

The text of document 10/636/FDIS, future edition 3 of IEC 60422, prepared by IEC TC 10, Fluids for electrotechnical applications, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60422 on 2006-04-04.

The following dates were fixed:

- latest date by which the EN has to be implemented  
at national level by publication of an identical  
national standard or by endorsement (dop) 2007-02-01
- latest date by which the national standards conflicting  
with the EN have to be withdrawn (dow) 2009-05-01

Annex ZA has been added by CENELEC.

---

## Endorsement notice

The text of the International Standard IEC 60422:2005 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60567	NOTE	Harmonized as EN 60567:2005 (not modified).
IEC 60599	NOTE	Harmonized as EN 60599:1999 (not modified).
IEC 61198	NOTE	Harmonized as EN 61198:1994 (not modified).

<https://standards.iteh.ai/catalog/standards/sist/60422-2006-50dc-464b-9576-09a7b0f191a7/sist-en-60422-2006>

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60156	- <sup>1)</sup>	Insulating liquids - Determination of the breakdown voltage at power frequency - Test method	EN 60156	1995 <sup>2)</sup>
IEC 60247	- <sup>1)</sup>	Insulating liquids - Measurement of relative permittivity, dielectric dissipation factor (tan d) and d.c. resistivity	EN 60247	2004 <sup>2)</sup>
IEC 60296	- <sup>1)</sup>	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear	EN 60296 + corr. September	2004 <sup>2)</sup> 2004
IEC 60475	- <sup>1)</sup>	Method of sampling liquid dielectrics	-	-
IEC 60666	- <sup>1)</sup>	Detection and determination of specified anti-oxidant additives in insulating oils	HD 415 S1	1981 <sup>2)</sup>
IEC 60814	- <sup>1)</sup>	Insulating liquids - Oil-impregnated paper and pressboard - Determination of water by automatic coulometric Karl Fischer titration	EN 60814	1997 <sup>2)</sup>
IEC 60970	- <sup>1)</sup>	Methods for counting and sizing particles in insulating liquids	-	-
IEC 61125	- <sup>1)</sup>	Unused hydrocarbon-based insulating liquids - Test methods for evaluating the oxidation stability	-	-
IEC 61619	- <sup>1)</sup>	Insulating liquids - Contamination by polychlorinated biphenyls (PCBs) - Method of determination by capillary column gas chromatography	EN 61619	1997 <sup>2)</sup>
IEC 62021-1	- <sup>1)</sup>	Insulating liquids - Determination of acidity Part 1: Automatic potentiometric titration	EN 62021-1	2003 <sup>2)</sup>
ISO 2049	- <sup>1)</sup>	Petroleum products - Determination of colour (ASTM scale)	EN 12049	1996 <sup>2)</sup>
ISO 2719	- <sup>1)</sup>	Petroleum products and lubricants - Determination of Flash Point Pensky-Martens closed cup method	EN ISO 2719	2002 <sup>2)</sup>
ISO 3016	- <sup>1)</sup>	Petroleum Oils - Determination of pour point	-	-

<sup>1)</sup> Undated reference.

<sup>2)</sup> Valid edition at date of issue.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
ISO 3104	- <sup>1)</sup>	Petroleum products - Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity	EN ISO 3104	1996 <sup>2)</sup>
ISO 3675	- <sup>1)</sup>	Crude petroleum and liquid petroleum products - Laboratory determination of density - Hydrometer method	ISO 3675	1998 <sup>2)</sup>
ASTM D971-99a	2004	Standard test method for interfacial tension of oil against water by the ring method		-

## iTeh STANDARD PREVIEW (standards.iteh.ai)

SIST EN 60422:2006

<https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-09a7b0f191a7/sist-en-60422-2006>

NORME  
INTERNATIONALE  
INTERNATIONAL  
STANDARD

CEI  
IEC

60422

Troisième édition  
Third edition  
2005-10

---

---

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

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**  
**Mineral insulating oils in electrical equipment –  
Supervision and maintenance guidance**

SIST EN 60422:2006

<https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-09a7b0f191a7/sist-en-60422-2006>

© IEC 2005 Droits de reproduction réservés — Copyright - all rights reserved

Aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'éditeur.

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: [inmail@iec.ch](mailto:inmail@iec.ch) Web: [www.iec.ch](http://www.iec.ch)



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

CODE PRIX  
PRICE CODE

X

Pour prix, voir catalogue en vigueur  
For price, see current catalogue

## CONTENTS

FOREWORD.....	7
INTRODUCTION.....	11
1 Scope.....	13
2 Normative references .....	13
3 Terms and definitions .....	15
4 General remarks.....	17
4.1 General caution.....	17
4.2 Environment.....	17
5 Properties and deterioration/degradation of oil .....	19
6 Oil tests and their significance.....	19
6.1 General.....	19
6.2 Colour and appearance .....	21
6.3 Breakdown voltage.....	21
6.4 Water content.....	23
6.5 Acidity.....	29
6.6 Dielectric Dissipation Factor (DDF) and resistivity.....	29
6.7 Inhibitor content and oxidation stability.....	35
6.8 Sediment and sludge.....	37
6.9 Interfacial tension (IFT) .....	37
6.10 Particle count.....	37
6.11 Flash-point.....	39
6.12 Compatibility of insulating oils.....	39
6.13 Pour-point .....	41
6.14 Density.....	41
6.15 Viscosity.....	41
6.16 Polychlorinated biphenyls (PCBs).....	41
6.17 Corrosive sulphur .....	41
7 Sampling of oil from equipment .....	43
8 Categories of equipment.....	43
9 Evaluation of mineral insulating oil in new equipment .....	45
10 Evaluation of oil in service.....	47
10.1 General.....	47
10.2 Frequency of examination of oils in service .....	47
10.3 Testing procedures.....	51
10.4 Classification of the condition of oils in service.....	51
10.5 Corrective action .....	53
11 Handling and storage .....	63
12 Treatment.....	65
12.1 General.....	65
12.2 Reconditioning .....	65
12.3 Reclaiming .....	73
12.4 Decontamination of oils containing PCB .....	75



13 Replacement of oil in electrical equipment.....	77
13.1 Replacement of oil in transformers rated below 72,5 kV and in switchgear and associated equipment.....	77
13.2 Replacement of oil in transformers rated 72,5 kV and above .....	77
13.3 Replacement of oil in electrical equipment contaminated with PCB.....	77
Annex A (informative) Sampling temperature below 20 °C.....	79
Annex B (informative) Particles.....	81
Annex C (informative) Test method for determination of sediment and sludge.....	83
Bibliography.....	85
Figure 1 – Example of the variation in saturation water content with oil temperature and acidity for insulating oil originally conforming to IEC 60296 .....	25
Figure 2 – Typical correction factors .....	29
Figure 3 – Example of variation of resistivity with temperature for insulating oils.....	33
Table 1 – Tests for mineral insulating oils .....	21
Table 2 – Categories of equipment .....	43
Table 3 – Recommended limits for mineral insulating oils after filling in new electrical equipment prior to energization.....	45
Table 4 – Recommended frequency of testing <sup>(1)</sup> .....	49
Table 5 – Application and interpretation of tests.....	55
Table 6 – Corrective actions.....	63
Table 7 – Conditions for processing inhibited mineral insulating oils .....	67
Table A.1 – Guidelines for interpreting data expressed in percent saturation .....	79
Table B.1 – Examples of contamination levels (particles) encountered on power transformer insulating oil as measured by laser counting (ISO 4406) .....	81

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MINERAL INSULATING OILS IN ELECTRICAL EQUIPMENT –  
SUPERVISION AND MAINTENANCE GUIDANCE**

## 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.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

This third edition cancels and replaces the second edition, published in 1989, and constitutes a technical revision.

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

This standard has been revised to take into account changes in oil and equipment technology and to have due regard for the best practices currently in use world-wide.

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.

This guidance incorporates changes introduced in associated standards since the publication of the second edition.

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

FDIS	Report on voting
10/636/FDIS	10/641/RVD

Full information on the voting for the approval of this guide 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 maintenance result 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.

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 60422:2006

<https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-09a7b0f191a7/sist-en-60422-2006>

## INTRODUCTION

Insulating mineral oils are used in electrical equipment employed in the generation, transmission, distribution and use of electrical energy, so that the amount of oil in service, worldwide, amounts to hundreds of millions of kilograms.

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 criteria. 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 premature failure should then 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.

Unused mineral oils are limited resources and should be handled with this in mind. 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 (PCB).

The guidelines given in this standard, whilst technically sound, are 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.

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

## MINERAL INSULATING OILS IN ELECTRICAL EQUIPMENT – SUPERVISION AND MAINTENANCE GUIDANCE

### 1 Scope

This International Standard gives guidance on the supervision and maintenance of the quality of the insulating oil in electrical equipment.

This standard is applicable to mineral insulating oils, originally supplied conforming to IEC 60296, and used 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 assists 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.

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

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.

### 2 Normative references

[SIST EN 60422:2006](https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-03d7b0191a77/sist-en-60422-2006)

[https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-](https://standards.iteh.ai/catalog/standards/sist/c0462fbb-5bd6-464b-9576-03d7b0191a77/sist-en-60422-2006)

The following referenced documents are indispensable for the application 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.

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: *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60475: *Method of sampling liquid dielectrics*

IEC 60666: *Detection and determination of specified anti-oxidant additives in insulating oils*

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

IEC 60970: *Methods for counting and sizing particles in insulating liquids*