

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Oil-filled electrical equipment – Sampling of gases and analysis of free and dissolved gases – Guidance

Matériels électriques immergés – Échantillonnage de gaz et analyse des gaz libres et dissous – Lignes directrices





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2011 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, 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 either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, 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 la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00



IEC 60567

Edition 4.0 2011-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Oil-filled electrical equipment – Sampling of gases and analysis of free and dissolved gases – Guidance

Matériels électriques immergés – Échantillonnage de gaz et analyse des gaz libres et dissous – Lignes directrices

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE **XA**
CODE PRIX

ICS 29.040

ISBN 978-2-88912-768-9

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	9
2 Normative references	9
3 Sampling of gases from gas-collecting (Buchholz) relays.....	10
3.1 General remarks.....	10
3.2 Sampling of free gases by syringe.....	10
3.2.1 Sampling equipment.....	10
3.2.2 Sampling procedure.....	11
3.3 Sampling of free gases by displacement of oil	12
3.4 Sampling of free gases by vacuum	13
3.5 Sampling of oil from oil filled equipment	14
4 Labelling of gas samples	14
5 Sampling, labelling and transferring of oil from oil-filled equipment.....	14
5.1 Sampling and labelling of oil.....	14
5.2 Transfer of oil for DGA analysis.....	14
5.2.1 Transfer from oil syringes	14
5.2.2 Transfer from ampoules.....	15
5.2.3 Transfer from flexible metal bottles.....	15
5.2.4 Transfer from glass and rigid metal bottles	15
6 Preparation of gas-in-oil standards	15
6.1 General remark	15
6.2 First method: preparation of a large volume of gas-in-oil standard.....	15
6.2.1 Equipment.....	15
6.2.2 Procedure.....	16
6.2.3 Calculation	18
6.3 Second method: preparation of gas-in-oil standards in a syringe or a vial.....	18
6.3.1 Equipment.....	19
6.3.2 Procedure.....	20
7 Extraction of gases from oil	20
7.1 General remarks.....	20
7.2 Multi-cycle vacuum extraction using Toepler pump apparatus	21
7.2.1 Toepler pump extraction apparatus.....	21
7.2.2 Extraction procedure	24
7.3 Vacuum extraction by partial degassing method	25
7.3.1 General remark	25
7.3.2 Partial degassing apparatus	25
7.3.3 Extraction procedure	26
7.4 Stripping extraction method.....	26
7.4.1 Stripping apparatus	26
7.4.2 Outline of procedure.....	29
7.5 Headspace method	30
7.5.1 Principle of the method.....	30
7.5.2 Symbols and abbreviations.....	30
7.5.3 Headspace extraction apparatus.....	31
7.5.4 Headspace extraction procedure	35

7.5.5	Calibration of the headspace extractor	39
8	Gas analysis by gas-solid chromatography	41
8.1	General remarks.....	41
8.2	Outline of suitable methods using Table 4	42
8.3	Apparatus.....	42
8.3.1	Gas chromatograph	42
8.3.2	Columns	44
8.3.3	Carrier gas	44
8.3.4	Detectors.....	44
8.3.5	Methanator	44
8.3.6	Cold trap	44
8.3.7	Integrator and recorder.....	44
8.4	Preparation of apparatus	45
8.5	Analysis	45
8.6	Calibration of the chromatograph.....	45
8.7	Calculations	46
9	Quality control	46
9.1	Verification of the entire analytical system.....	46
9.2	Limits of detection and quantification.....	47
9.3	Repeatability, reproducibility and accuracy.....	47
9.3.1	General remark	47
9.3.2	Repeatability	48
9.3.3	Reproducibility.....	48
9.3.4	Accuracy	48
10	Report of results	49
Annex A (informative)	Correction for incomplete gas extraction in partial degassing method by calculation	51
Annex B (informative)	Mercury-free and shake test versions of the standard extraction methods.....	53
Annex C (informative)	Preparation of air-saturated standards	55
Annex D (informative)	Correction for gas bubbles in syringes and air gap in rigid bottles	56
Annex E (informative)	Procedure for comparing gas monitor readings to laboratory results	57
Bibliography	58
Figure 1	– Sampling of gas by syringe	11
Figure 2	– Sampling of free gases by oil displacement.....	12
Figure 3	– Sampling of free gases by vacuum.....	13
Figure 4	– First method of preparing gas-in-oil standards	17
Figure 5	– Second method for preparing gas-in-oil standards.....	19
Figure 6	– Example of a Toepler pump extraction apparatus	23
Figure 7	– Types of glass strippers	27
Figure 8	– Stainless steel stripper.....	28
Figure 9	– Schematic arrangement for connecting an oil stripper to a gas chromatograph.....	29
Figure 10	– Schematic representation of headspace sampler.....	30

Figure 11 – Vial filled with water 32

Figure 12 – Revolving table 34

Figure 13 – Schematic arrangement for gas chromatography 43

Figure B.1 – Schematic representation of methods in Annex B 54

Table 1 – Information required for gas samples 14

Table 2 – Examples of headspace operating conditions 35

Table 3 – Headspace partition coefficients at 70 °C in mineral insulating oil 40

Table 4 – Examples of gas chromatographic operating conditions..... 41

Table 5 – Required limits of detection in oil..... 47

Table 6 – Examples of accuracy of extraction methods 49

Table A.1 – Examples of solubility coefficients a_i (at 25 °C) reported by CIGRE TF
D1.01.15..... 51

Table C.1 – Examples of solubility values of air for different oil types 55

Table C.2 – Examples of temperature variations for oxygen and nitrogen solubility in
mineral oil..... 55

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**OIL-FILLED ELECTRICAL EQUIPMENT –
SAMPLING OF GASES AND ANALYSIS
OF FREE AND DISSOLVED GASES –
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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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 60567 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

This fourth edition cancels and replaces the third edition, published in 2005, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

Since the publication of the third edition, CIGRE TF.D1.01.15 has made progress in several areas of dissolved gas analysis (DGA), notably

- a) oil sampling,
- b) laboratory analysis and solubility coefficients of gases in non-mineral oils,
- c) calibration of the headspace gas extraction method,

- d) more sensitive detectors for chromatography,
- e) preparation of air-saturated standards and
- f) evaluation of gas monitor readings.

These advances are included in this fourth edition.

Sampling of oil for DGA from oil-filled equipment has been moved from IEC 60567 to IEC 60475 as reflected in the revised title of this standard.

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

FDIS	Report on voting
10/849/FDIS	10/872/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.

INTRODUCTION

Gases may be formed in oil-filled electrical equipment due to natural ageing but also, to a much greater extent, as a result of faults.

Operation with a fault may seriously damage the equipment, and it is valuable to be able to detect the fault at an early stage of development.

Where a fault is not severe, the gases formed will normally dissolve in the oil, with a small proportion eventually diffusing from the liquid into any gas phase above it. Extracting dissolved gas from a sample of the oil and determining the amount and composition of this gas is a means of detecting such faults, and the type and severity of any fault may often be inferred from the composition of the gas and the rate at which it is formed.

In the case of a sufficiently severe fault, free gas will pass through the oil and collect in the gas-collecting (Buchholz) relay if fitted; if necessary, this gas may be analysed to assist in determining the type of fault that has generated it. The composition of gases within the bubbles changes as they move through the oil towards the gas-collecting relay.

This can be put to good use, as information on the rate of gas production may often be inferred by comparing the composition of the free gases collected with the concentrations remaining dissolved in the liquid.

The interpretation of the gas analyses is the subject of IEC 60599.

These techniques are valuable at all stages in the life of oil-filled equipment. During acceptance tests on transformers in the factory, comparison of gas-in-oil analyses before, during and after a heat run test can show if any hot-spots are present, and similarly analysis after dielectric testing can add to information regarding the presence of partial discharges or sparking. During operation in the field, the periodic removal of an oil sample and analysis of the gas content serve to monitor the condition of transformers and other oil-filled equipment.

The importance of these techniques has led to the preparation of this standard, to the procedures to be used for the sampling, from oil-filled electrical equipment, of gases and oils containing gases, and for subsequent analysis.

NOTE Methods described in this standard apply to insulating oils, since experience to date has been almost entirely with such oils. The methods may also be applied to other insulating liquids, in some cases with modifications.

General caution, health, safety and environmental protection

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 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.

Mercury presents an environmental and health hazard. Any spillage should immediately be removed and be properly disposed of. Consult local regulations for mercury use and handling. Mercury-free methods may be requested in some countries.

Environment

This standard is applicable to insulating oils, chemicals and used sample containers.

Attention is drawn to the fact that, at the time of writing of this standard, many insulating oils in service are known to be contaminated to some degree by PCBs. If this is the case, 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 regulations. Every precaution should be taken to prevent release of insulating oil into the environment.