

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis

Matériels électriques imprégnés d'huile minérale en service – Guide pour l'interprétation de l'analyse des gaz dissous et des gaz libres



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 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 It also gives information on projects, withdrawn and replaced publications.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

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis

Matériels électriques imprégnés d'huile minérale en service – Guide pour l'interprétation de l'analyse des gaz dissous et des gaz libres

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

CG

CONTENTS

FOREWORD.....	3
INTRODUCTION.....	4
1 Scope.....	5
2 Normative references	5
3 Definitions and abbreviations	5
4 Mechanisms of gas formation	8
5 Identification of faults.....	9
6 Conditions for calculating ratios	14
7 Application to free gases in gas relays	15
8 Gas concentration levels in service	16
9 Recommended method of DGA interpretation (figure 1).....	19
10 Report of results	19
Annex A (informative) Equipment application notes	22
Annex B (informative) Graphical representation of gas ratios (see 5.9)	32
Annex C (informative) Bibliography	35
Figure 1 – Flow chart	21
Figure B.1 – Graphical representation 1 of gas ratios	32
Figure B.2 – Graphical representation 2 of gas ratios	33
Figure B.3 – Graphical representation 3 of gas ratios – Duval's triangle	34

generated by EVS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MINERAL OIL-IMPREGNATED ELECTRICAL EQUIPMENT IN SERVICE –
GUIDE TO THE INTERPRETATION OF DISSOLVED AND
FREE GASES ANALYSIS**

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 60599 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

This consolidated version of IEC 60599 consists of the second edition (1999) [documents 10/450/FDIS and 10/460/RVD] and its amendment 1 (2007) [documents 10/685/FDIS and 10/693/RVD].

The technical content is therefore identical to the base edition and its amendment(s) and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

Annexes A, B and C are for information only.

INTRODUCTION

Dissolved and free gas analysis (DGA) is one of the most widely used diagnostic tools for detecting and evaluating faults in electrical equipment. However, interpretation of DGA results is often complex and should always be done with care, involving experienced insulation maintenance personnel.

This guide gives information for facilitating this interpretation. The first edition, published in 1978, has served the industry well, but had its limitations, such as the absence of a diagnosis in some cases, the absence of concentration levels and the fact that it was based mainly on experience gained from power transformers. This second edition attempts to address some of these shortcomings. Interpretation schemes are based on observations made after inspection of a large number of faulty oil-filled equipment in service and concentrations levels deduced from analyses collected worldwide.

MINERAL OIL-IMPREGNATED ELECTRICAL EQUIPMENT IN SERVICE – GUIDE TO THE INTERPRETATION OF DISSOLVED AND FREE GASES ANALYSIS

1 Scope

This International Standard is a guide describing how the concentrations of dissolved gases or free gases may be interpreted to diagnose the condition of oil-filled electrical equipment in service and suggest future action.

This guide is applicable to electrical equipment filled with mineral insulating oil and insulated with cellulosic paper or pressboard-based solid insulation. Information about specific types of equipment such as transformers (power, instrument, industrial, railways, distribution), reactors, bushings, switchgear and oil-filled cables is given only as an indication in the application notes (see annex A).

The Guide may be applied only with caution to other liquid-solid insulating systems.

In any case, the indications obtained should be viewed only as guidance and any resulting action should be undertaken only with proper engineering judgment.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(191):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*

IEC 60050(212):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 212: Insulating solids, liquids and gases*

IEC 60050(604):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*

IEC 60567:1992, *Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases*

IEC 61198:1993, *Mineral insulating oils – Methods for the determination of 2-furfural and related compounds*

3 Definitions and abbreviations

3.1 Definitions

For the purpose of this International Standard, the following definitions, some of them based on IEC 60050(191), IEC 60050(212) and IEC 60050(604) apply:

3.1.1

fault

an unplanned occurrence or defect in an item which may result in one or more failures of the item itself or of other associated equipment [IEV 604-02-01]

NOTE In electrical equipment, a fault may or may not result in damage to the insulation and failure of the equipment.