

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Specifications for the re-use of sulphur hexafluoride (SF₆) and its mixtures
in electrical equipment**

**Spécifications pour la réutilisation de l'hexafluorure de soufre (SF₆)
et des mélanges contenant du SF₆ dans le matériel électrique**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2019 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 l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
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 corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) 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 IEC

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

Recherche de publications IEC - webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Specifications for the re-use of sulphur hexafluoride (SF₆) and its mixtures
in electrical equipment**

**Spécifications pour la réutilisation de l'hexafluorure de soufre (SF₆)
et des mélanges contenant du SF₆ dans le matériel électrique**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.040.20; 29.130.01

ISBN 978-2-8322-6697-7

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	8
4 Contaminants and their sources	9
4.1 General.....	9
4.2 Contaminants from handling and use	9
4.3 SF ₆ by-products in equipment that only have an insulating function.....	9
4.4 SF ₆ by-products in switching equipment	10
4.5 SF ₆ by-products from internal arcs	10
4.6 SF ₆ mixtures specific by-products.....	10
5 Specifications for re-use of SF ₆	10
6 Specifications for re-use of SF ₆ mixtures.....	11
7 Reclaiming of SF ₆ and SF ₆ mixtures	11
7.1 Feasibility and process	11
7.2 Detection techniques for checking the quality of the gases.....	14
7.2.1 General	14
7.2.2 On-site analysis.....	14
7.2.3 Laboratory analysis	15
8 Handling, storage and transportation (informative).....	16
9 Safety and first aid	16
9.1 General safety rules.....	16
9.1.1 General	16
9.1.2 Protection of personnel	17
9.1.3 Handling of contaminated safety equipment and tools.....	18
9.1.4 Pressurized equipment and tools or measuring devices	19
9.1.5 Personal safety and protective equipment.....	19
9.1.6 Facilities and services	20
9.2 Additional safety measures in case of abnormal release of SF ₆ due to external fire or internal arc fault	20
9.3 First aid equipment and treatment.....	21
9.3.1 General	21
9.3.2 Irritation of the skin.....	21
9.3.3 Irritation of the eyes.....	22
9.3.4 Breathing difficulty	22
10 Environmental aspects	22
Annex A (informative) Description of methods of analysis (on-site and laboratory).....	23
A.1 Sampling.....	23
A.1.1 General	23
A.1.2 On-site sampling connection.....	23
A.1.3 Sample cylinder for laboratory analysis.....	23
A.1.4 Sampling methods for laboratory analysis.....	24
A.2 On-site analysis	25
A.2.1 General	25
A.2.2 SF ₆ concentration meter.....	25

A.2.3	Hygrometers	25
A.3	Laboratory analysis	26
A.3.1	Gas chromatography	26
A.3.2	Infrared spectroscopy	28
Annex B (informative)	By-products of SF ₆ and its mixtures	31
B.1	Decomposition of SF ₆ and its mixtures	31
B.1.1	General	31
B.1.2	Behaviour of SF ₆ in an electric arc	31
B.1.3	SF ₆ decomposition with low current discharges	33
B.1.4	Catalytic decomposition of SF ₆ (high-temperature behaviour)	33
B.2	Corrosion behaviour of SF ₆ and its by-products	33
B.3	Measures for the removal of by-products	33
B.4	Physiological characteristics of by-products	34
Annex C (informative)	Procedures for evaluating the potential effects on health from by-products of SF ₆ and its mixtures	35
C.1	General	35
C.2	Formation and health effects of SF ₆ by-products	35
C.2.1	Formation of SF ₆ by-products	35
C.2.2	Effects of SF ₆ by-products on health	36
C.2.3	Quantitative estimation of gaseous by-products	37
C.2.4	Procedures for health risk evaluation	38
C.3	Conclusion	40
Annex D (informative)	Reclaiming recommendations	42
D.1	General	42
D.2	Filtering recommendations	42
D.3	Transport of used SF ₆ in gas cylinders and containers by road	42
Annex E (informative)	Cryogenic reclaiming of SF ₆	43
E.1	General	43
E.2	Applications	43
E.3	Physical background	43
E.4	Cryogenic processes	44
E.5	Description of a cryogenic reclaimer	44
Bibliography	47
Figure 1	– Decision flow chart for recovered SF ₆	13
Figure A.1	– One-sampling cylinder method set-up	24
Figure A.2	– Two-sampling cylinder method set-up	24
Figure A.3	– Example of a gas chromatogram in one print out showing the different possible by-products after decomposition	27
Figure A.4	– Typical GCMS chromatogram of decomposed SF ₆ /CF ₄ mixture	28
Figure A.5	– IR spectrum of contaminated SF ₆	30
Figure C.1	– Procedure for the evaluation of the potential effects on health due to arcing	39
Figure C.2	– Procedure for the evaluation of the potential effects on health due to low energy discharges	40
Figure D.1	– Saturated vapour pressure of various gases as a function of temperature	43
Figure D.2	– Typical cryogenic reclaimer for SF ₆ recovery on site	45
Figure D.3	– Typical cryogenic reclaimer for removing contaminants	45

Table 1 – SF ₆ contaminants	9
Table 2 – Specifications for re-use of SF ₆	10
Table 3 – Specifications for re-use of SF ₆ /N ₂ mixtures	11
Table 4 – Specifications for re-use of SF ₆ /CF ₄ mixtures	11
Table 5 – General contaminants and methods for their removal	12
Table 6 – Typical adsorbents for various SF ₆ contaminants	12
Table 7 – On-site methods	15
Table 8 – Laboratory methods	16
Table 9 – Measures when working with SF ₆ electric power equipment	7
Table 10 – Safety measures when opening or accessing gas compartments	18
Table 11 – Neutralizing solutions	19
Table 12 – Additional safety measures	21
Table A.1 – Peak absorption of SF ₆ and contaminants	29
Table C.1 – OELs for SO ₂ , HF, and S ₂ F ₁₀	37
Table C.2 – SOF ₂ production rate	37

Currently in preview, click buy full version

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SPECIFICATIONS FOR THE RE-USE OF SULPHUR HEXAFLUORIDE (SF₆)
AND ITS MIXTURES IN 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.
- 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 60480 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

This third edition cancels and replaces the second edition, published in 2004. This edition constitutes a technical revision.

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

- specifications for the re-use of SF₆ have been confirmed;
- specifications for the re-use of SF₆ mixtures, namely SF₆/N₂ and SF₆/CF₄ mixtures are included;
- as a result of a new repartition of annexes in IEC 60376, IEC 60480 and IEC 62271-4, this new edition now contains the following five annexes:
 - Annex A: Description of methods of analysis (on-site and laboratory);
 - Annex B: By-products of SF₆ and its mixtures;

- Annex C: Procedure for evaluating the potential effects on health from by-products of SF₆ and its mixtures;
- Annex D: Reclaiming recommendations.
- Annex E: Cryogenic reclaiming of SF₆;

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

FDIS	Report on voting
10/1075/FDIS	10/1080/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

SPECIFICATIONS FOR THE RE-USE OF SULPHUR HEXAFLUORIDE (SF₆) AND ITS MIXTURES IN ELECTRICAL EQUIPMENT

1 Scope

This document provides criteria for the re-use of sulphur hexafluoride (SF₆) and its mixtures after recovery and reclaiming from electrical equipment (e.g. for maintenance, at the end-of-life).

Sulphur hexafluoride (SF₆), nitrogen (N₂) and carbon tetrafluoride (CF₄), are gases commonly used for electrical equipment. Taking into account environmental concerns, particular attention is paid to re-use criteria for SF₆ and its mixtures with N₂ and CF₄ in its use in electrical equipment. Procedures for recovering and reclaiming used SF₆ and its mixtures are outside the scope of this document and are described in IEC 62271-4.

This document provides several annexes on the description of the different methods of analysis, on by-products, on the procedure for evaluating the potential health effects from by-products, on cryogenic reclaiming of SF₆, and on reclaiming recommendations.

Storage, transportation and disposal of SF₆ and its mixtures are outside the scope of this document and are covered by IEC 62271-4. Procedures to determine SF₆ leakages are described in IEC 60068-2-17 [4]¹.

For the purposes of this document, the complementary gases used in SF₆ mixtures will be limited to N₂ or CF₄.

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.

IEC 60050-192, *International Electrotechnical Vocabulary – Part 192: Dependability* (available at <http://www.electropedia.org>)

IEC 60050-212, *International Electrotechnical Vocabulary – Part 212: Electrical insulating solids, liquids and gases* (available at <http://www.electropedia.org>)

IEC 60050-441, *International Electrotechnical Vocabulary – Part 441: Switchgear, controlgear and fuses* (available at <http://www.electropedia.org>)

IEC 60050-826, *International Electrotechnical Vocabulary – Part 826: Electrical installations* (available at <http://www.electropedia.org>)

IEC 62271-4:2013, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF₆) and its mixtures*

¹ Numbers in square brackets refer to the bibliography.