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TECHNICAL REPORT

RAPPORT TECHNIQUE

High-voltage switchgear and controlgear –
Part 303: Use and handling of sulphur hexafluoride (SF_6)

Appareillage à haute tension –
Partie 303: Utilisation et manipulation de l'hexafluorure de soufre (SF_6)

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

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

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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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.
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IEC 62271-303, which is a technical report, has been prepared by subcommittee 17A: High-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This first edition of IEC/TR 62271-303 cancels and replaces the first edition of IEC 61634 published in1995. This edition constitutes a technical revision.

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

IEC 62271-303 is a major revision of the old IEC 61634. The former sections of IEC 61634 are removed and replaced by the chapters of the CIGRE brochure n. 276.

IEC 61634 was issued in 1995 when the focus was on safety. In 2008, safety is a very well known and established concept and the focus is nowadays on the environmental compatibility. SF_6 must be kept in a closed cycle and any intentional release must be forbidden. The implementation of the SF_6 reuse concept suggested in the CIGRE brochure was updated with the most recent information. Today SF_6 can be recovered and reclaimed for either being reused on-site or given back to the gas supplier and reused as raw material for the production of "technical grade SF_6". Detailed procedures for appropriate SF_6 handling are given together with the description of the state-of-the-art equipments and measuring devices.

More in detail, clause by clause:

– The former Section 1 was removed and replaced with Clause 1 "Scope", Clause 2 "Normative references" and Clause 3 " Terms and Definitions".

– Clause 4 "Storage and transportation of SF_6", Clause 5 "Safety and first aid", Clause 6 "Training and certification", and Clause 11 "Description of SF_6 handling equipment" were taken from the CIGRE brochure and their content was revised.

– Clause 7 " SF_6 handling during installation and commissioning", Clause 8 " SF_6 handling during normal service life", Clause 9 " SF_6 recovery and reclaiming during maintenance", and Clause 10 "Dismantling of SF_6 electric power equipment at the end-of-life" were taken from the CIGRE brochure, their content was revised and replaces the former sections 2, 3, 4, 5, and 6.

– The former Annexes A, B, C, and D were revised while the Annexes E and F were dropped. The Bibliography replaces the former Annex G.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
17A/813/DTR	17A/817/RVC

Full information on the voting for the approval of this technical report 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.

A list of all parts of IEC 62271 series, under the general title *High-voltage switchgear and controlgear* can be found on the IEC website.

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.

INTRODUCTION

SF_6 technology is used in switchgear and controlgear, for more than 30 years. Its application is mainly in electric power equipment for rated voltages exceeding 1 kV up to the highest rated voltages for which switchgear and controlgear are manufactured. It is estimated that several millions of the different types of SF_6-filled units are currently in service.

Three methods for gas containment are technically available, according to IEC 62271-1:

- controlled pressure system;

NOTE 1 Controlled pressure systems are no longer used for new equipment, because of the unacceptable leakage rate (see IEC 62271-203).

- closed pressure system: modern high-voltage electric power equipments. The standardized values for leakage rates are 0,5 % and 1 % per year and per gas-filled compartment;
- sealed pressure system: modern medium-voltage electric power equipments (commercially designated as “sealed for life products” or “hermetically sealed systems”). The tightness of sealed pressure systems is specified by their expected operating life. The expected operating life with regard to leakage performance is specified by the manufacturer. Preferred values are 20, 30 and 40 years.

NOTE 2 To fulfil the expected operating life requirement the leakage rate of the SF_6 sealed pressure systems is considered to be less than 0,1 % per year.

The long experience with the use of SF_6 in switchgear and controlgear evidences that a certain number of elementary precautions and procedures should be adopted in order to achieve operational, safety at work and environmental benefits such as:

- safe operation of the equipment;
- optimisation of resources and tools required;
- minimisation of out-of-service time for equipment;
- standard training of personnel handling SF_6;
- reduction of the amount of gas released during handling operations down to the functional physical limit;
- avoidance of any deliberate release, for example flushing to the atmosphere;
- reduction of SF_6 losses and emissions during commissioning, service, operation and end-of-life treatment to a minimum.

Recently, the latest practical recommendations on the use of SF_6 technology applied to switchgear and controlgear have been published by WG B3.02 of CIGRE Study Committee B3 [1][1]. This information is used to revise IEC 61634 into the present technical report.

1 Figures in square brackets refer to the **Bibliography**.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 303: Use and handling of sulphur hexafluoride (SF_6)

1 Scope

The scope of this technical report is to address the procedures for safe and environmental compatible handling of SF_6 during installation, commissioning, normal and abnormal operations, disposal at the end-of-life of high-voltage switchgear and controlgear. Storage and transportation of SF_6 are also covered.

These procedures should be regarded as minimum requirements to ensure the safety of personnel working with SF_6 and to minimize the SF_6 emission to the environment.

This technical report generally applies also to gas mixtures containing SF_6.

NOTE 1 For the use of this technical report, the term " high voltage" (reference IEV 601-01-27) is the rated voltage above 1 000 V. However, the term " medium voltage" (reference IEV 601-01-28) is commonly used for distribution systems with voltages above 1 kV and generally applied up to and including 52 kV.

NOTE 2 Throughout this technical report, the term "electric power equipment" stands for "high-voltage and medium voltage switchgear and/or controlgear".

2 Normative references

The following referenced documents are indispensable for the application of this technical report. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF_6) for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specifications for its reuse*

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

3 Terms and definitions

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

NOTE There are many different types of electric power equipment which use SF_6 as a dielectric and/or arc-quenching medium.

3.1
abnormal release of sulphur hexafluoride (SF_6)
release from equipment in service due to a failure in the pressure system

NOTE An abnormal SF_6 release is usually an un-wanted and continuous emission of gas. As soon as an abnormal SF_6 leakage is detected, appropriate measures to locate and eliminate the leak should be immediately arranged.

3.2
handling of sulphur hexafluoride (SF_6)
any process which might involve transfer of SF_6

3.3
evacuation
transfer of a gas different from SF_6 (for example air or N_2) from the gas compartment to the atmosphere. The operation is performed utilising a vacuum pump

3.4
recovery of sulphur hexafluoride (SF_6)
transfer of SF_6 from the gas compartment into a reclaimer or storage container. The operation is normally performed utilising a recovery compressor

3.5
topping-up with sulphur hexafluoride (SF_6)
filling with SF_6 a pre-filled compartment to the SF_6 rated filling pressure

NOTE Pre-filled compartments are closed pressure systems filled in the factory prior to shipment. They contain SF_6 at a typical pressure between 0,12 MPa to 0,15 MPa allowing for a faster and easier commissioning on-site.

3.6
reclaim of sulphur hexafluoride (SF_6)
a series of SF_6 handling including recovery and minimum SF_6 refining process such as filtering dust, by-products, moisture, oil, etc.

NOTE 1 A standard reclaimer is described in 11.1.

NOTE 2 Sometimes the words "reclaiming" or "reclamation" may be used with the same meaning as "reclaim".

3.7
metal-enclosed switchgear and controlgear
switchgear and controlgear assemblies with an external metal enclosure intended to be earthed, and complete except for external connections
[IEV 441-12-04]

3.8
insulation-enclosed switchgear and controlgear
switchgear and controlgear assemblies with an external insulation enclosure and completely assembled, except for external connections

NOTE The external insulation may be supplied with a (semi-) conducting layer.

[IEV 441-12-06, modified]

3.9
gas-insulated metal-enclosed switchgear
metal-enclosed switchgear in which the insulation is obtained, at least partly, by an insulating gas other than air at atmospheric pressure

NOTE This term generally applies to high-voltage switchgear and controlgear.

[IEV 441-12-05]

3.10
gas-filled compartment
compartment of switchgear and controlgear in which the gas pressure is maintained by one of the following systems:

- controlled pressure system;
- closed pressure system;
- sealed pressure system.

NOTE 1 Several gas-filled compartments may be permanently interconnected to form a common gas-system (gas-tight assembly).

NOTE 2 This definition reproduces 3.6.6.1 of IEC 62271-1.

3.11
controlled pressure system for gas
volume which is automatically replenished from an external compressed gas supply or internal gas source

NOTE 1 Examples of controlled pressure systems are air-blast circuit-breakers or pneumatic operating mechanisms.

NOTE 2 A volume may consist of several permanently connected gas-filled compartments.

NOTE 3 This definition reproduces 3.6.6.2 of IEC 62271-1.

3.12
closed pressure system for gas
volume which is replenished only periodically by manual connection to an external gas source

NOTE 1 Example of closed pressure systems are SF_6 single pressure circuit-breakers.

NOTE 2 This definition reproduces 3.6.6.3 of IEC 62271-1.

3.13
sealed pressure system
volume for which no further gas or vacuum processing is required during its expected operating life

NOTE 1 Examples of sealed pressure systems are tubes of vacuum circuit-breakers or some SF_6 circuit-breakers.

NOTE 2 Sealed pressure systems are completely assembled and tested in the factory.

NOTE 3 This definition reproduces 3.6.6.4 of IEC 62271-1.

3.14
technical grade sulphur hexafluoride (SF_6)
SF_6 gas having a very low level of impurities in accordance with IEC 60376

3.15
used sulphur hexafluoride (SF_6)
gas removed from an electrical equipment, initially filled with SF_6 according to IEC 60376 or IEC 60480. If after filling, the gas is removed for any purpose during the life of the equipment, for example repair, service, maintenance, the gas will be transferred and is considered as used gas

NOTE Annex C provides information regarding the by-products of used SF_6, which occur as gaseous and solid.

3.16
used sulphur hexafluoride (SF_6) suitable for reuse on site
used SF_6 complying with the maximum acceptable impurity level in IEC 60480

NOTE If necessary, service units with appropriate filters and adsorber materials should be used.

3.17
used sulphur hexafluoride (SF_6) suitable for reuse at the gas manufacturer
used SF_6 exceeding the maximum acceptable impurity level in IEC 60480, but complying with the specification for gas reuse given by the gas manufacturer

NOTE If necessary to meet the specification, service units with appropriate filters and adsorber materials should be used.

3.18
used sulphur hexafluoride (SF_6) not suitable for reuse
gas complying with 3.15 but not complying with 3.16, and/or 3.17.

NOTE Used sulphur hexafluoride not suitable for reuse is disposed according to local or international regulations on waste management.

3.19
non-arced sulphur hexafluoride (SF_6)
used sulphur hexafluoride (SF_6) having less than approx. 0,1 % by volume of gaseous by-products

NOTE Non-arced sulphur hexafluoride is typically expected to be in any compartment after filling and prior to energising and/or after insulation testing and/or in insulation compartments which never experienced arcing.

3.20
normally arced sulphur hexafluoride (SF_6)
used sulphur hexafluoride (SF_6) having between approx. 0,1 % by volume and approx. 5 % by vol. of gaseous by-products

NOTE 1 Normally arced sulphur hexafluoride is typically expected to be in circuit breakers/load break switches after normal (load or fault) operations.

NOTE 2 A small amount of solid by-products, mainly metal fluorides and tungsten oxifluorides, may be present as well.

3.21
heavily arced sulphur hexafluoride (SF_6)
used sulphur hexafluoride (SF_6) having more than approx. 5 % by vol. of gaseous by-products

NOTE 1 Heavily arced sulphur hexafluoride is typically expected to be in any gas compartments after internal arc fault and/or circuit breakers/load break switches after interruption failure and/or circuit breakers after successful interruptions of several short circuits at high amplitude in relation with its ratings.

NOTE 2 A large amount of solid by-products, mainly metal fluorides and tungsten oxifluorides, is expected as well.

4 Storage and transportation of SF_6

Storage and transportation of SF_6, either in containers or in electric power equipment is always carried out in accordance with local and international regulations.

NOTE An empty SF_6 container may still contain a residual amount of SF_6. It should be stored and transported in the same way as for a filled container.

4.1 Storage of containers filled with SF_6

In general, SF_6 can be stored in two ways either as a gas at less than 2 MPa or as a liquid up to 5 MPa. Gaseous storage has the advantage of reducing the recovery and filling times but requires large storage volumes and is therefore generally restricted to small volume equipment or used in fixed location gas handling facilities. Liquid storage gives the ability to reduce storage volumes and economically transport large quantities of SF_6.

Containers are handled carefully and stored in a cool, dry, well ventilated area away from flammable or explosive material. They should be protected from direct sunlight, mounted clear of wet ground and secured to prevent falling over. Special valve protections should be adopted to avoid any potential damage on the valve itself.

Containers are refillable (non refillable containers are banned) and clearly labelled to identify their contents; containers containing technical grade SF_6 and used SF_6 suitable for reuse on site should be physically separated from those containing used SF_6 suitable for reuse at the gas manufacturer or used SF_6 not suitable for reuse.

Table 1 gives an overview of all possible storage methods on which a storage container may be based.

Table 1 – Methods for storage of SF_6

Method	Requirements	Features
Gaseous	Typical pressure lower than 2 MPa. SF_6 remains in the gaseous state	Requires relatively small recovery pressure differential (typically 100:1) but needs larger storage volumes. Gas cannot be liquefied in containers for transportation. Therefore it is limited to small quantities (typically 200 kg) and stationary use
Liquid-cooling assisted	Typical pressure equal to 3 MPa. Employs additional cooling system to cool SF_6 after compression, which allows SF_6 to be stored in liquid form	Requires relatively small recovery pressure differential (typically 700:1) but needs cooling aggregate. Performance of cooling aggregate can influence processing speed. Additional maintenance requirements. Limited storage volume required and generally not suitable for transportation
Liquid-pressure only	Typical pressure equal to 5 MPa. SF_6 compressed to 5 MPa liquefies by pressure only	Requires recovery differential of typically 1000:1 but eliminates the need of additional aggregates. Can be used with any storage vessel rated 5 MPa or higher

When used SF_6 is stored on-site, the storage containers comply with local and international regulations on pressurised vessels. Container labelling should be done according to local and international regulations, as well.

NOTE International regulations are published and periodically revised by the Committee of Experts on the Transport of Dangerous Goods (TDG) and on the Globally Harmonized System of Classification and Labelling (GHS) of the Economic Commission for Europe of the United Nations

Table 2 gives an overview of container types and required labelling. For practical reasons it is recommended to preferentially use transportable storage containers, wherever possible.