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Fluids for electrotechnical application: Specifications for the re-use of mixtures of gases alternative to SF₆

Fluides pour applications électrotechniques : Spécifications pour la réutilisation des mélanges de gaz alternatifs au SF₆



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

Fluids for electrotechnical application - Specifications for the re-use of mixtures of gases alternative to SF₆

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

Draft	Report on voting
10/1296/FDIS	10/1298/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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1 Scope

This document provides the quality of gases alternative to SF₆ (subsequently referred to as gases) for their re-use in electrical power equipment after recovery and if applicable reclaiming (e.g., during maintenance, repair, overhaul or at the end-of-life). The re-use criteria consider technical and environmental concerns.

This document covers the same gases as listed in IEC 63360. For gases not mentioned in this document, the electrical power equipment manufacturer and/or the gas manufacturer provide the information indicated in this document. It is the intention of this document to include such gases in a next edition or in amendments to this edition.

Procedures for recovering and reclaiming of used gases are described in IEC 62271-4:2022.

NOTE 1 Reclaiming procedures of gases can be done by either reclaiming the complete gas or by separating the most valuable components from the gas.

Gas analysis techniques for checking the quality of the gas are described in this document.

It is the responsibility of the gas manufacturer and/or the electrical power equipment manufacturer to provide sufficient information for safe handling of gases and to provide a risk assessment. It is the responsibility of the user of the electrical power equipment to establish appropriate health and safety practices and to determine the applicability of regulatory limitations prior to use.

NOTE 2 If not otherwise specified in this document, concentration values (e.g. %, ppmv, µl/l) of gas components or contaminants are given in volume fraction at 20 °C and 100 kPa. More information on temperature and pressure dependence of mole fraction and volume fraction is given in IEC 63360:2025, Annex C.

NOTE 3 If gases for electrical power equipment are regulated, their designation and regulation origin can be found in the IEC 62474 database [1]¹ (available at <https://std.iec.ch/iec62474>).

NOTE 4 Information about storage, transportation and disposal of gases, gas properties, safety and first aid, environmental impact, training and certification, handling equipment, by-products, and procedures to evaluate the potential effects on health are covered by IEC 62271-4:2022.

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 60050-212:2010, *International Electrotechnical Vocabulary (IEV) - Part 212: Electrical insulating solids, liquids and gases* (available at <http://www.electropedia.org>)

IEC 60050-426:2020, *International Electrotechnical Vocabulary (IEV) - Part 826: Explosive atmospheres* (available at <http://www.electropedia.org>)

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

IEC 63360:2025, *Fluids for electrotechnical application - Specification of gases alternative to SF₆ to be used in electrical power equipment*

¹ Numbers in square brackets refer to the Bibliography.

3 Terms and definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 60050-212, IEC 60050-441 and IEC 60050-426 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

electrical power equipment

any high-voltage or medium-voltage equipment containing gas for insulation and/or switching, e.g. switchgear and controlgear, gas-insulated lines, transformers, instrument transformers, etc.

3.1.2

single gas

gas made up of identical atoms or molecules

Note 1 to entry: A single gas can contain contaminants.

EXAMPLE CO₂ is a typical example of a single gas.

3.1.3

gas mixture

gas made up of a minimum of two single gases

Note 1 to entry: A gas mixture can contain contaminants.

EXAMPLE CO₂/O₂ is a typical example of a gas mixture of two single gases.

3.1.4

gas container

vessel (cylinder) suitable for the containment of pressurized gases either in gaseous or liquid phase, according to local and/or international safety and transportation regulations

[SOURCE: IEC 60480:2019 [2], 3.2, modified – “gas” has been added to the term.]

3.1.5

reclaiming of a gas

process of removing contaminants from a gas

[SOURCE: IEC 62271-4:2022 [3], 3.1.15]

3.1.6

recovery of a gas

process of transferring a gas from a gas compartment into an alternate container (recovery container)

Note 1 to entry: The operation is normally performed utilising a recovery equipment.

[SOURCE: IEC 62271-4:2022, 3.1.13]

3.1.7

contaminant

foreign substance or material in an insulating liquid, gas or solid

[SOURCE: IEC 60050-212:2010, 212-17-27, modified – "which usually has deleterious effect on one or more properties" has been deleted.]

3.1.8

by-product

contaminant which is formed by the degradation of the gas by electrical arcs, corona effect or sparks, or formed by chemical reaction with other substances or materials

[SOURCE: IEC 62271-4:2022, 3.1.6]

3.1.9

ambient air

normal atmosphere surrounding the equipment

[SOURCE: IEC 60050-426:2020, 426-24-05]

3.1.10

non-arc'd gas

gas within a gas compartment or gas-cylinder that never experienced arcing and contains no relevant gas decomposition and no relevant solid by-products, but where small quantities of gaseous by-products can be present

Note 1 to entry: Small quantities of by-products can be present for example when partial discharges have occurred in the gas.

Note 2 to entry: Typical electrical power equipment having non-arc'd gases are: gas-insulated lines, gas-insulated busbars, gas-insulated voltage and current transformers, cable box, gas compartment around a vacuum circuit-breaker.

[SOURCE: IEC 62271-4:2022, 3.1.22]

3.1.11

normally arc'd gas

gas within a gas compartment or a gas-cylinder that experienced arcing during load current or fault current switching operations

Note 1 to entry: Overheating, for example due to bad contacts, or heavy partial discharge can also lead to decomposition of the gas.

Note 2 to entry: Details on normally arc'd gases depend on the design of the switchgear and the gas.

Note 3 to entry: Typical electrical power equipment having normally arc'd gases are: any gas compartment containing switching equipment, like earthing switch, disconnecter, load-break switch and circuit-breaker.

[SOURCE: IEC 62271-4:2022, 3.1.23]

3.1.12

heavily arc'd gas

gas within a gas compartment or a gas-cylinder that experienced an internal arc fault or arcing within a circuit-breaker after interruption failure or arcing within a switch after interruption failure or arcing within a circuit-breaker during successful interruption of several short-circuits

Note 1 to entry: Details on heavily arc'd gases depend on the design of the switchgear and the gas.

[SOURCE: IEC 62271-4:2022, 3.1.24]

3.1.13**used gas**

insulation gas that has been introduced into electrical power equipment

3.1.14**used gas suitable for reuse**

used gas having a maximum level of contaminants in accordance with Table 2 to Table 8

3.2 Abbreviated terms

ppmv parts per million by volume

4 Contaminants and their sources**4.1 General**

Gas recovered from electrical power equipment in operation contains several kinds of contaminants. Contaminants in recovered gases come both from gas handling and from use.

Table 1 summarizes the most common contaminants and their sources. For each gas, additional information is available in IEC 62271-4:2022, Clause C.8, Clause D.8, Clause E.8 or Clause F.8.

Table 1 – Most common contaminants of gases

Gas condition	Origin	Most common contaminants
Non-arced gas	<ul style="list-style-type: none"> – Residual gas after recovery of the gas – Permeation of ambient gas and/or humidity to inside – Desorption of humidity from materials – Chemical reaction of gas with materials – Residual dust in the gas – Residual oil from compressors or vacuum pumps 	<p>For natural-origin gases: Air, H₂O</p> <p>For fluorinated gas mixture: Air, H₂O.</p>
Normally arced gas	<p>Above, plus</p> <ul style="list-style-type: none"> – Arcing in switches and circuit-breakers – Partial discharges – Short-circuit making (earthing switches) – Disconnecter operation on energised lines 	<p>For natural-origin gases: Air, H₂O, CO₂, CO, O₃, NO_x, CF₄, C (solid)</p> <p>For fluorinated gas mixture: Air, H₂O and by-products (see IEC 62271-4:2022, Annexes E and F).</p>
Heavily arced gas	<p>Above, plus</p> <ul style="list-style-type: none"> – Multiple short-circuit breaking – Multiple short-circuit making – Failed breaking – Internal arc failure 	<p>For natural-origin gases: Air, H₂O, CO₂, CO, O₃, NO_x, CF₄, C (solid)</p> <p>For fluorinated gas mixture: Air, H₂O and by-products (see IEC 62271-4:2022, Annexes E and F).</p>

4.2 Contaminants from handling and use

Filling and recovery of the gas can lead to the additional contamination with ambient air including humidity.

Humidity also desorbs from internal surfaces of the electrical power equipment and from polymeric parts. Oil from handling equipment (pumps and compressors) can also be inadvertently introduced.