IEC 63360

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fluids for electrotechnical application – Specification of gases alternative to SF6 to be used in electrical power equipment

Fluides pour applications électrotechniques – Spécifications des gaz alternatifs au SF6 destinés à être utilisés dans les matériels électriques

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FLUIDS FOR ELECTROTECHNICAL APPLICATION – SPECIFICATION OF GASES ALTERNATIVE TO SF_6 TO BE USED IN ELECTRICAL POWER EQUIPMENT

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

Draft	Report on voting
10/1219/FDIS	10/1257/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.

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

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

Considering the limited information for some of the data which appear in informative Annex A, the reader should be aware that the information related with possible gases alternative to SF_6 are still a matter of study.

FLUIDS FOR ELECTROTECHNICAL APPLICATION – SPECIFICATION OF GASES ALTERNATIVE TO SF_6 TO BE USED IN ELECTRICAL POWER EQUIPMENT

1 Scope

This document specifies the quality of gases alternative to SF_6 (subsequently referred to as gases) for use in electrical power equipment.

Detection techniques, applicable to the analysis of gases prior to their introduction into the electrical power equipment, are also described in this document.

Information about gases by-products and the procedure for evaluating the potential effects of gases and its by-products on human health are covered by IEC 63359[1][1] and IEC 62271-4.

It is the responsibility of the gas manufacturer to make available sufficient information for safe handling of gases and a risk assessment.

For gases not mentioned in this document, the electrical power equipment manufacturer and/or gas manufacturer provides 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. This document provides information to prepare risk assessment associated with the use of gases. It is the responsibility of the user of this document to establish appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.

NOTE 1 Throughout this document, the term "pressure" stands for "absolute pressure".

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 dependance of mole fraction and volume fraction is given in 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 [2] (available at https://std.iec.ch/iec62474 [viewed 2024-02-19]).

NOTE 4 Handling of gases is covered by IEC 62271-4:2022.

NOTE 5 Additional information is needed from gas manufacturer and/or electrical power equipment manufacturer to perform a full risk assessment.

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, *International Electrotechnical Vocabulary (IEV) – Part 212: Electrical insulating solids, liquids and gases* (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)

[1] Numbers in square brackets refer to the Bibliography.

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

IEC 62271-4:2022, *High-voltage switchgear and controlgear – Part 4: Handling procedures for gases for insulation and/or switching*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 60050-212, IEC 60050-441, IEC 60050-826 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 could contain contaminants.

EXAMPLE CO_2 (at standard atmospheric conditions) 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 could contain contaminants.

EXAMPLE CO_2/O_2 (at standard atmospheric conditions) is a typical example of a gas mixture of two single gases.

3.1.4
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.]

3.1.5
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]

3.1.6
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 [3], 3.2, modified − "gas" has been added to the term.]

3.1.7
compressed air
air suitable for electrical power equipment processed in accordance with Table 1

3.1.8
technical grade natural-origin gas
technical grade nitrogen (N_2), technical grade oxygen (O_2) or technical grade carbon dioxide (CO_2) or their mixtures in any combination

3.1.9
technical grade nitrogen
nitrogen (N_2) for electrical power equipment in accordance with Table 3

3.1.10
technical grade oxygen
oxygen (O_2) for electrical power equipment in accordance with Table 4

3.1.11
technical grade carbon dioxide
carbon dioxide (CO_2) for electrical power equipment in accordance with Table 5

3.1.12
technical grade synthetic air
gas mixture for electrical power equipment in accordance with Table 2

Note 1 to entry: Technical grade synthetic air is a fixed gas mixture of technical grade natural-origin gases.

3.1.13
technical grade C5-FK
C5-FK for electrical power equipment in accordance with Table 6

3.1.14
technical grade C4-FN
C4-FN for electrical power equipment in accordance with Table 7

3.2 Abbreviated terms

ppmv parts per million by volume

ppmw parts per million by weight

4 Requirements for gases

4.1 General

The technical specifications enclosed are based on achieving required technical performance with commercially available gases. Therefore, the level of impurity can vary for different gases.

The accuracy of the measuring devices/methods shall be considered when checking the quality of the gas.

NOTE Detection techniques applicable for on-site verification of concentrations and acceptable level of impurities are given in Annex B.

4.2 Compressed air

Compressed air shall fulfil the requirements given in Table 1.

The responsibilities of the manufacturer lie with the party compressing the air for use in electrical power equipment.

NOTE Table 1 is necessary to define requirements for compressed air for use in electrical power equipment because not all ambient air, when compressed, is suitable for this application.

Table 1 – Requirements for compressed air for electrical power equipment

Substance	Concentration/size
N_2	77 % to 80,5 %
O_2	19,5 % to 22 %
Ar	≤ 1 %
CO_2	≤ 5 000[a] µl/l (ppmv)
H_2O	≤ 450[b] µl/l (ppmv)
Other gases	≤ 100 µl/l (ppmv)
Mineral oil	< 10 mg/kg (ppmw)
Solid particles	≤ 1 µm[c]
The substance concentrations sum to 100 %.	
[a] The CO2 level corresponds to the maximum average workplace concentration and has a negligible impact on dielectric performance.	
[b] This value is equivalent to −28 °C frost point at 100 kPa and can be reduced with the use of drying agent.	
[c] This value can be achieved using a compressor equipped with suitable particle filters.	

4.3 Technical grade synthetic air

Technical grade synthetic air shall fulfil the requirements given in Table 2.

Table 2 – Requirements for technical grade synthetic air

Substance	Concentration
O_2	20 % ± 2 %
N_2	80 % ± 2 %
Other gases	≤ 0,4 %
H_2O	≤ 200[a] µl/l (ppmv)
The substance concentrations sum to 100 %.	
[a] This value is equivalent to −36 °C frost point at 100 kPa.	

4.4 Technical grade natural-origin gases

Technical grade natural-origin gases (nitrogen (N_2), oxygen (O_2)) and carbon dioxide (CO_2) or any mixture of them shall fulfil the requirements given in Table 3, Table 4 and Table 5.

Table 3 – Requirements for technical grade nitrogen

Substance	Concentration
N_2	≥ 99,7 %
Other gases[a]	≤ 0,3 %
H_2O	≤ 200[b] µl/l (ppmv)

[a] Typically, the main other gas is O2.

[b] This value is equivalent to −36 °C frost point at 100 kPa.

Table 4 – Requirements for technical grade oxygen

Substance	Concentration
O_2	≥ 99,5 %
Other gases[a]	≤ 0,5 %
H_2O	≤ 200[b] µl/l (ppmv)

[a] Typically, the main other gas is N2.

[b] This value is equivalent to −36 °C frost point at 100 kPa

Table 5 – Requirements for technical grade carbon dioxide

Substance	Concentration
CO_2	≥ 99,5 %
Other gases[a]	≤ 0,5 %
H_2O	≤ 200[b] µl/l (ppmv)

NOTE The kind and quantities of specific contaminants depend on the production process.

[a] Typically, the main other gases are N_2 and O_2.

[b] This value is equivalent to −36 °C frost point at 100 kPa.

4.5 Technical grade $C_5F_{10}O$ (C5-FK)

Technical grade $C_5F_{10}O$ shall fulfil the requirements given in Table 6.

Technical grade $C_5F_{10}O$ is usually used in a mixture with one or more technical grade carrier gases (N_2, CO_2 and/or O_2).

NOTE 1,1,1,3,4,4,4-heptafluoro-3-(trifluoromethyl)-2-butanone, also described as CF_3-C(O)-CF-$(CF_3)_2$ or $C_5F_{10}O$ is a Fluoroketone. For easier naming, reference and identification, it is also named C5-FK (FK = Fluoroketone). There are other molecules with the same formula ($C_5F_{10}O$) which do not have the same spatial structure.

Table 6 – Requirements for technical grade C5-FK

Substance	Concentration
CF_3-C(O)-CF-$(CF_3)_2$	≥ 99,5 %
Other gases [a]	≤ 0,5 %
H_2O	≤ 270[b] µl/l (ppmv)

NOTE The kind and quantities of specific contaminants depend on the production process.

[a] Typically, another gas is 1,1,1,2,3,3,3-heptafluoropropane.

[b] This value is equivalent to −33 °C frost point at 100 kPa.

4.6 Technical grade C_4F_7N (C4-FN)

Technical grade C_4F_7N shall fulfil the requirements given in Table 7.

Technical grade C_4F_7N is usually used in a mixture with one or more technical grade carrier gases (N_2, CO_2 and/or O_2).

NOTE 2,3,3,3-tetrafluoro-2-(trifluoromethyl)-propanenitrile, also described as $(CF_3)_2$CFCN or C_4F_7N, is a Fluoronitrile. For easier naming, reference and identification, it is also named C4-FN (FN = Fluoronitrile). There are other molecules with the same formula (C_4F_7N) which do not have the same spatial structure.

Table 7 – Requirements for technical grade C4-FN

Substance	Concentration
$(CF_3)_2$-CF-CN	≥99,3 %
Other gases[a]	≤ 0,7 %
H_2O	≤ 270[b] µl/l (ppmv)

NOTE The kind and quantities of specific contaminants depend on the production process.

[a] Typically, another gas is 1,1,1,2,3,3,3-heptafluoropropane and/or CF_3-CF_2-CF_2-CN.

[b] This value is equivalent to −33 °C frost point at 100 kPa.

5 Mixing ratio and tolerances

Except for technical grade synthetic air and compressed air, additional information on the accuracy of the concentration of each component of the gas mixture is required. The tolerance of mixing ratio is specified by the electrical power equipment manufacturer. For gas mixtures used in electrical power equipment, the required concentration of each component of the mixture is based on:

- the minimum temperature, to avoid partial liquefaction,
- physical and chemical properties,
- the dielectric, thermal and/or switching performances.

The absolute tolerance on high concentrations can be larger than for low concentrations, which results in an impact of the mixing ratio in the achievable accuracy. In addition, for practical reasons, the achievable accuracy of the gas mixing equipment and of the gas analyser shall be considered, to avoid requirements which cannot be fulfilled with state-of-the-art equipment.