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भारतीय मानक

विद्युत उपस्कर में प्रयोग हेतु तकनीकी ग्रेड सल्फर हेक्साफ्लोराइड (SF_6) की विशिष्टि

(पहला पुनरीक्षण)

Indian Standard

SPECIFICATION OF TECHNICAL GRADE SULFUR HEXAFLUORIDE (SF_6) FOR USE IN ELECTRICAL EQUIPMENT

(First Revision)

ICS 29.040.20/29.130

BUREAU OF INDIAN STANDARDS
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Price Group 4

NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with IEC 60376 : 2005 'Specification of technical grade sulfur hexafluoride (SF_6) for use in electrical equipment' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Fluids for Electrotechnical Applications Sectional Committee and approval of the Electrotechnical Division Council.

This standard was originally published in 1991 which was identical with IEC 60376 : 1971. The first revision of this standard has been undertaken to align it with the latest version of IEC 60376 : 2005.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60050 (191) International Electrotechnical Vocabulary (IEV) — Chapter 191: Dependability and quality of service	IS 1885 (Part 39) : 1999 Electrotechnical vocabulary: Part 39 Dependability of electronic and electrical items	Technically Equivalent
IEC 60050 (212) International Electrotechnical Vocabulary (IEV) — Chapter 212: Insulating solids, liquids and gases	IS 1885 (Part 62) : 1993 Electrotechnical vocabulary: Part 62 Insulating solids, liquids and gases (*first revision*)	Identical
IEC 60050 (441) International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses	IS 1885 (Part 17) : 1979 Electrotechnical vocabulary: Part 17 Switchgear and controlgear	Technically Equivalent
ISO 14040 Environmental management — Life cycle assessment — Principles and framework	IS/ISO 14040 : 2006 Environmental management — Life cycle assessment — Principles and framework	Identical

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60050 (826)	International Electrotechnical Vocabulary (IEV) — Chapter 826: Electrical installations

(*Continued on third cover*)

INTRODUCTION

Sulfur hexafluoride, SF_6, is an essential gas for electrical equipment.

The available commercial gas contains impurities.

It is necessary to define a high purity level sulfur hexafluoride, referred to as technical grade sulfur hexafluoride.

This International Standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of the standard to establish appropriate health and safety practices and to determine the applicability of regulatory limitations prior to use (see IEC 61634).

This International Standard gives rise to sulfur hexafluoride, chemicals, and used sample containers. The disposal of these items should be carried out according to local regulations with regard to the impact on the environment. Every precaution is taken to prevent the release into the environment of sulphur hexafluoride (see IEC 61634).

Indian Standard

SPECIFICATION OF TECHNICAL GRADE SULFUR HEXAFLUORIDE (SF_6) FOR USE IN ELECTRICAL EQUIPMENT

(First Revision)

1 Scope

This International Standard defines the quality requirements and properties for technical grade sulfur hexafluoride (SF_6) for use in electrical equipment. It covers the properties and methods of test applicable to SF_6 when this substance is supplied for use in connection with any electrical equipment.

NOTE Throughout this standard, the term SF_6 stands for technical grade sulfur hexafluoride.

2 Normative references

The following referenced documents are indispensable for the application 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(191), *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*

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

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

IEC 60050(826), *International Electrotechnical Vocabulary (IEV) – Chapter 826: Electrical installations*

IEC 60480, *Guidelines for the checking and treatment of sulfur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use*

IEC 61634, *High-voltage switchgear and controlgear – Use and handling of sulfur hexafluoride (SF_6) in high-voltage switchgear and controlgear*

ISO 14040, *Environmental management – Life cycle assessment – Principles and framework*

3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60050(191), IEC 60050(212), IEC 60050(441) and IEC 60050(826) apply.

Some of the more important ones are listed here for easy reference.

3.1
electrical equipment
item used for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as electric machines, transformers, switchgear and controlgear, measuring instruments, protective devices, wiring systems, current-using equipment

[IEV 826-16-01]

3.2
technical grade SF_6
SF_6 gas having a very low level of impurities in accordance with Table 1

3.3
container
any kind of cylinder suitable for pressurized SF_6

NOTE This general term will be used throughout the text.

4 General properties of SF_6

Sulfur hexafluoride is a compound having the formula SF_6. At normal room temperatures and pressures (20 °C and 100 kPa) [1][1] it is gaseous and has a density of 6,07 kg/m^3 (about five times the density of air). Since its critical temperature is 45,54 °C, it can be liquefied by compression [2]. The pressure/temperature/density curves are given in IEC 61634.

SF_6 is colourless, odourless and non-toxic. It is normally transported as a liquefied gas in containers

Caution Although the gas is non-toxic, it will not support life, and equipment containing sulfur hexafluoride must not be entered without adequate ventilation. Similarly, since the gas has a much greater density than air, low lying areas, e.g. trenches, may contain high concentrations of the gas and the necessary precautions shall be taken to avoid asphyxiation.

SF_6 is used in electrical equipment for the transmission and distribution of electricity (gas insulated substations, ring main units, circuit breakers, transformers, cables, etc.). It is also used for non-electric purposes, such as metallurgy, electronics, scientific equipment, etc.

4.1 Electrical properties

The gas is strongly electronegative (i.e. tends to attract free electrons). It has a unique combination of physical properties: high dielectric strength 89 V/m/Pa at 20 °C (about three times higher than air), high interruption capabilities (about ten times higher than air) and high heat transfer characteristics (about two times higher than air) [2].

It has been successfully used for current interruption and insulation in both HV power transmission and MV distribution equipment since the 1960s.

1 Figures in square brackets refer to the bibliography.

4.2 Compatibility

Technical grade sulphur hexafluoride is chemically inert and thermally stable [2] at normal temperatures.

At temperatures up to about 180 °C the gas has a compatibility with metals used in electrical construction, similar to that of nitrogen. Operation at higher temperatures is possible, but SF_6 can decompose in these conditions, particularly in the presence of catalytic material and the by-products may be incompatible with some constructional materials. Individual cases need to be assessed separately.

5 Maximum acceptable impurity levels for technical grade SF_6

The available commercial gas contains impurities. The maximum impurity levels present in sulfur hexafluoride referred to in this standard as technical grade sulfur hexafluoride are given in Table 1. This table also lists appropriate analytical methods for the determination of impurity levels and the corresponding acceptable accuracy of measurement.

NOTE Further handling and storage of the gas and operation of equipment may introduce additional quantities of impurities. This situation is covered in IEC 60480.

Table 1 – Maximum acceptable impurity levels

Content	Specification	Analytical methods (for indication only, not exhaustive)	Precision
Air	2 g/kg [note 1]	Infrared absorption method	35 mg/kg
		Gas-chromatographic method	3 – 10 mg/kg
		Density method	10 mg/kg
CF_4	2 400 mg/kg [note 2]	Gas-chromatographic method	9 mg/kg
H_2O	25 mg/kg [note 3]	Gravimetric method	0,5 mg/kg[note 5]
		Electrolytic method	2 – 15 mg/kg
		Dew point method	1 °C
Mineral oil	10 mg/kg	Photometric method	< 2 mg/kg
		Gravimetric method	0,5 mg/kg [note 5]
Total acidity expressed in HF	1 mg/kg [note 4]	Titration	0,2 mg/kg

NOTE 1 2 g/kg is equivalent to 1 % vol under ambient conditions (100 kPa and 20 °C [1]).

NOTE 2 2 400 mg/kg is equivalent to 4 000 µl/l under ambient conditions (100 kPa and 20 °C [1]).

NOTE 3 25 mg/kg (25 mg/kg) is equivalent to 200 µl/l and to a dew point of –36 °C, measured at ambient conditions (100 kPa and 20 °C [1]).

NOTE 4 1 mg/kg is equivalent to 7,3 µl/l under ambient conditions (100 kPa and 20 °C [1]).

NOTE 5 Depending on the sample size.

Due to the maximum impurity levels that can be present in SF_6, the SF_6 amount in a container (measured in the liquid phase), shall be higher than 99,7 % in weight. There exist other methods giving this value, without separating the different impurities that cannot be considered as analytical methods (e.g. the measurement of the speed of sound).

6 Environmental, health and safety aspects

6.1 Environmental aspects

6.1.1 Introductory remarks

Human activities have an effect on the environment. The impact of a given activity depends on its scale and on the materials involved. SF_6 has certain environmental characteristics as described below. Due to these characteristics, SF_6 has to be used avoiding any deliberate release into the atmosphere, and in an environmentally compatible way.

Nevertheless the real impact of SF_6 used in electrical equipment shall be considered by taking into account the entire functionality of the electrical equipment, i.e. the full power system environmental load. This can be evaluated via life cycle assessment (see ISO 14040).

6.1.2 Environmental characteristics of SF_6

6.1.2.1 Impact on the ecosystem

SF_6 is an inert gas. As its solubility in water is very low, it presents no danger to surface and ground water or the soil. A biological accumulation in the nutrition cycle does not occur.

6.1.2.2 Ozone depletion

SF_6 does not contribute to the destruction of stratospheric ozone.

6.1.2.3 Greenhouse effect

SF_6 persists in the atmosphere for a long time and has a high global warming potential (GWP). The values reported are dependent on the evaluation methods. It is recommended that reference be made to IPCC (International panel for climate change) updated documents.

Due to these characteristics, SF_6 has to be used in a way so as to avoid any deliberate release into the atmosphere, and in an environmentally compatible way, during the development, designing, production, filling and refilling, servicing, maintenance, recovering and end of life.

However, the GWP of SF_6 alone is not adequate to measure the environmental impact of electric power equipment based on SF_6 technology. The environmental impact has to be evaluated from the global point of view, accounting for all components as well as the system design solutions (ISO 14040).

6.1.2.4 End of life of SF_6

At its end of life (i.e. when it is no longer technically and economically recyclable), SF_6 can be destroyed by incineration in compliance with local regulations.

6.1.3 Environmentally compatible use of SF_6

6.1.3.1 Handling

Proper handling procedures shall be defined and implemented to limit any release of SF_6 into the environment wherever possible (see IEC 61634).

6.1.3.2 Tightness of the equipment

Gas tightness of equipment shall be proven according to the relevant IEC product standards.

6.1.3.3 Reclaiming/recycling

Reclaiming and recycling of sulfur hexafluoride shall be carried out according to IEC 60480 and IEC 61634.

6.1.3.4 End of life of equipment

Refer to IEC 61634 (Clause 6).

6.2 Health and safety

6.2.1 Introductory remark

SF_6 is odourless, tasteless, colourless and non-toxic. It is chemically stable at room temperature and is non-flammable.

A material safety data sheet (MSDS) shall be provided by the supplier.

6.2.2 Toxicity

It is the supplier's responsibility to guarantee that the SF_6 supplied is non-toxic, taking into account the local regulations and state-of-the-art knowledge.

6.2.3 Oxygen depletion

SF_6 gas is about five times heavier than air and, if released in large quantities into the working environment may accumulate in low-lying areas. In doing so the air is displaced and consequently, the quantity of available oxygen will fall.

If the oxygen concentration falls below 16 % (IEC 61634), a danger of asphyxiation will exist for any personnel working in these areas. Particularly sensitive areas are those below ground level, poorly or not ventilated, such as cable ducts, trenches, inspection pits and drainage systems.

However, after a period of time, depending upon air movement and ventilation, the SF_6 will become mixed with the working environment air and its local concentration will fall to acceptable levels.

6.2.4 Mechanical

In many electrical applications the pressure of SF_6 gas employed is above atmospheric pressure. This implies that special precautions have to be taken when handling the equipment, to avoid exposing workers to the risks associated with mechanical failure. Local safety regulation of pressure vessels shall be applied.

6.2.5 Freezing

If compressed SF_6 is released rapidly, the sudden expansion reduces its temperature. The gas temperature may fall to well below 0 °C. A worker accidentally subjected to a jet of gas during equipment filling, for example, runs a risk of serious freezing burns, if he is not equipped with protective clothing such as overalls, boots and gloves as well as goggles for eye protection.

7 Handling, storage and transportation

7.1 Gas handling procedures

The need to handle SF_6 arises when

a) the gas is introduced in an electrical equipment,

b) the gas pressure is topped up in closed pressure systems,

c) a sample is taken for analysis.

When the gas has to be removed from an enclosure, a proper handling procedure shall be defined and implemented to limit any release of SF_6 into the environment wherever possible (see IEC 61634).

7.2 Gas handling

A particular care shall be paid to prevent contamination of SF_6 when it is transferred to the electrical equipment.

7.3 Storage

Containers are used for storage and transportation of the SF_6. It is the responsibility of the supplier to provide gas in the appropriate containers, according to local regulations and international transport regulations.

Nevertheless, containers shall have valves properly protected. The mass of sulfur hexafluoride (in kg) has to be stated on each cylinder.

Gas containers shall be stored in cool and well ventilated areas. Attention shall be paid to the filling factor of the containers, taking into account their design pressure and the maximum ambient temperature to which they will be subjected.

7.4 Transportation

Transport of SF_6 shall be carried out in accordance with national and international regulations. Nevertheless it is recommended to legibly mark the containers at the valve end and preferably on the cylindrical part of the body.

Specific labelling of containers shall be effected in accordance with the mode of transport and the national and international regulations.

Bibliography

[1] Gas encyclopaedia, Elsevier editor, pp. 7, 8

[2] Gmelin handbook of inorganic chemistry, 8th Edition, Behrendt *et al.*, Springer-verlag Berlin 1978

[3] IEC 60694, *Common specifications for high-voltage switchgear and controlgear standards*

[4] ISO 14050:2002, *Environmental management – Vocabulary*

(*Continued from second cover*)

International Standard	*Title*
IEC 60480	Guidelines for the checking and treatment of sulfur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use
IEC 61634	High-voltage switchgear and controlgear — Use and handling of sulfur hexafluoride (SF_6) in high-voltage switchgear and controlgear

Only the English language text has been retained while adopting it in this Indian Standard and as such the page numbers given here are not the same as in the IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc No.: ETD 03 (6361).

Amendments Issued Since Publication

Amendment No.	Date of Issue	Text Affected

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