

CONFIRMED
NOVEMBER 1989

Code of practice for

The testing of sulphur hexafluoride taken from electrical equipment

UDC 621.31:546.226'161:543

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Co-operating organizations

The Electrical Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Associated Offices Technical Committee	Department of Energy
Association of Consulting Engineers*	Department of the Environment
Association of Manufacturers of Domestic Electrical Appliances	Department of Prices and Consumer Protection
Association of Mining Electrical and Mechanical Engineers	Electric Cable Makers' Confederation
Association of Supervisory and Executive Engineers	Electrical Contractors' Association
British Electrical and Allied Manufacturers' Association	Electrical Contractors' Association of Scotland
British Electrotechnical Approvals Board for Household Equipment	Electrical Research Association*
British Non-Ferrous Metals Federation	Electricity Supply Industry in England and Wales*
British Radio Equipment Manufacturers' Association	Electronic Engineering Association
British Railways Board*	Engineering Equipment Users' Association
British Steel Corporation	Institution of Electrical Engineers*
Crown Agents for Oversea Governments and Administrations	Institution of Electrical and Electronics Technician Engineers
Department of Employment (HM Factory Inspectorate)	Lighting Industry Federation Limited
	Ministry of Defence*
	National Inspection Council for Electrical Installation Contracting
	Oil Companies Materials Association
	Post Office
	South of Scotland Electricity Board

The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

BEAMA Transmission and Distribution Association	London Transport Executive
Chemical Industries Association	National Coal Board
Chemical Society	Department of Industry — National Engineering Laboratory
Institute of Petroleum	

This British Standard, having been approved by the Electrical Industry Standards Committee, was published under the authority of the Executive Board on 30 September 1975

© BSI 10-1999

The following BSI references relate to the work on this standard:
Committee references ELE 115 and ELE 115/3
Draft for comment 71/29897

ISBN 0 580 08713 1

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

	Page
Co-operating organizations	Inside front cover
Foreword	iii
Section 1. General	
1 Scope	1
2 References	1
3 Position of this code as compared to BS 5207 sulphur hexafluoride	1
Section 2. General information concerning sulphur hexafluoride	
4 General properties of unused material	1
5 Impurities, etc. arising during use	1
6 Safety precautions	3
Section 3. Frequency of testing	
7 General	3
8 Oxygen content	3
9 Dew point and acidity	3
10 Hydrolysable fluorides and oil content	3
Section 4. Sampling	
11 General	4
12 Sample line assembly	4
13 Preparation of sampling point and use of sample line	4
Section 5. Identification of gas	
14 General	4
15 Thermal conductivity detector	5
16 Method of use	6
Section 6. Determination of the oxygen content	
17 Reason for test	6
18 Magnetic susceptibility method	6
19 Gas chromatographic method	6
Section 7. Determination of the dew point of impurities	
20 Principle of method	6
21 Essential features of dew-point cell	7
22 Apparatus and material	7
23 Procedure	9
24 Calculation of dew point	10
25 Calculation of dew point at pressures other than atmospheric	11
Section 8. Determination of acidity	
26 Principle of method	11
27 Apparatus	11
28 Precautions	11
29 Preparation of reagents	11
30 Measuring procedure	12
31 Calculation	13
Section 9. Determination of hydrolysable fluorides	
32 General	13
33 Test method A (colorimetric determination)	13
34 Test method B (fluoride ion selective electrode)	15
Section 10. Determination of mineral oil in sulphur hexafluoride	
35 Principle of method	16
36 Apparatus	17

	Page
37 Reagents	17
38 Procedure	17
39 Calculation	19
Appendix A Hygrometric data for uncontaminated water vapour	20
Figure 1 — Saturated vapour pressure curve for sulphur hexafluoride	2
Figure 2 — Arrangement of sulphur hexafluoride acidity measuring equipment	5
Figure 3 — Main features of dew-point cell design	8
Figure 4 — Arrangement for measurement of dew point	10
Figure 5 — High speed washing bottle for acidity measurements	12
Figure 6 — Gas washing bottle for separation of oil from sulphur hexafluoride gas	18
Figure 7 — Apparatus for absorbing oil from sulphur hexafluoride gas	18
Publications referred to	Inside back cover

Foreword

This British Standard code of practice has been prepared under the authority of The Electrical Industry Standards Committee and is based on a draft IEC Recommendation “Guide to the checking of sulphur hexafluoride taken from electrical equipment”.

Sulphur hexafluoride complying with the requirements of BS 5207 is supplied for use as an insulant in electrical equipment but this insulant is subject to contamination by impurities from the time when it has been passed into the equipment. Additionally, the operation of the equipment may produce further impurities and corona discharge and high energy arcs will decompose the gas and produce gases and solid contaminants.

The nature of the impurities and resulting hazards to the reliable operation of the equipment are described in this document together with recommendations for routine methods for sampling and testing the insulant in order to assess its suitability for further service. The code has been prepared for the maintenance of sulphur hexafluoride in service and the tests recommended are as simple as possible.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This code is intended to give guidance to operational and maintenance personnel as to the tests required to check the condition of sulphur hexafluoride gas in electrical equipment and to enable a unified method of analysis to be used whenever possible.

It should be understood that this code can only give general guidance and that for specific items of equipment the maximum acceptable levels of impurity in the sulphur hexafluoride and the period between checking should be agreed between the manufacturer of the electrical equipment and the user.

This code applies to a gas which originally satisfied the specification for sulphur hexafluoride (BS 5207).

2 References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3 Position of this code as compared to BS 5207 sulphur hexafluoride

In order that these tests may be carried out without too much difficulty and if possible at the site of the installation, the operating methods set forth in this code are fairly simple so that the use of elaborate equipment and highly trained personnel is avoided.

Most of the test methods given in this code are not as precise as those given in BS 5207 for unused sulphur hexafluoride, but the level of accuracy is satisfactory for the purpose.

Section 2. General information concerning sulphur hexafluoride

4 General properties of unused material

Sulphur hexafluoride, SF_6 , is an inert, non-flammable non-toxic, odourless and colourless substance. At normal temperatures and pressures it is a gas but it may readily be liquefied by compression (below the critical temperature of 45.6°C) and it is normally transported as a compressed liquefied gas in steel cylinders. The saturated vapour pressure curve is shown in Figure 1.

The gas has a high electric strength (normally two to three times that of air) and it is used as an insulant in transformers, enclosed busbar systems, etc.; this electric strength is very little affected by moderately small quantities of nitrogen, air, or other impurities, and sometimes a sulphur hexafluoride nitrogen mixture is used as a dielectric. Sulphur hexafluoride also has excellent arc quenching properties, and for this reason is used as an interrupting medium in circuit breakers.

5 Impurities, etc. arising during use

Even as supplied by the manufacturer and before use in electrical equipment, some impurities are invariably present in sulphur hexafluoride, but provided the substance complies with the requirements of BS 5207 the operation of the equipment will not be adversely affected.

However, once it has been passed into equipment, extra impurities are almost unavoidably added (e.g. water from imperfectly dry insulation, oxygen and nitrogen from imperfect filling techniques, and perhaps acidic and other impurities remaining from previous use of the equipment). When the equipment is put into operation, further impurities may be gradually added; for instance solid insulation may dry out or degrade, producing water and other substances; any corona discharges will decompose the gas, producing gaseous and solid products; in the case of circuit breakers, where high energy arcs may be interrupted frequently, the quantities of these decomposition products can become very significant.

These impurities may constitute a hazard to the reliable operation of the equipment; for example, water, acidic products and oxygen, especially in combination, may promote corrosion leading to faulty mechanical operation; water in combination with any acidic impurities may condense at low operating temperatures and high operating pressures with danger to the electrical safety of the equipment. Thus it is necessary to ensure that the quantities of impurities present are within acceptable limits for the particular equipment concerned.

The major part of this code describes test methods which may be used to determine the concentrations of important impurities. It is not possible to lay down general rules as to the concentrations of impurities that are acceptable, because these depend on: the design and location of the equipment; the minimum flashover distances and lengths of leakage paths within the equipment; whether or not arcing or corona occur in the gas; and the constructional materials in contact with the gas.

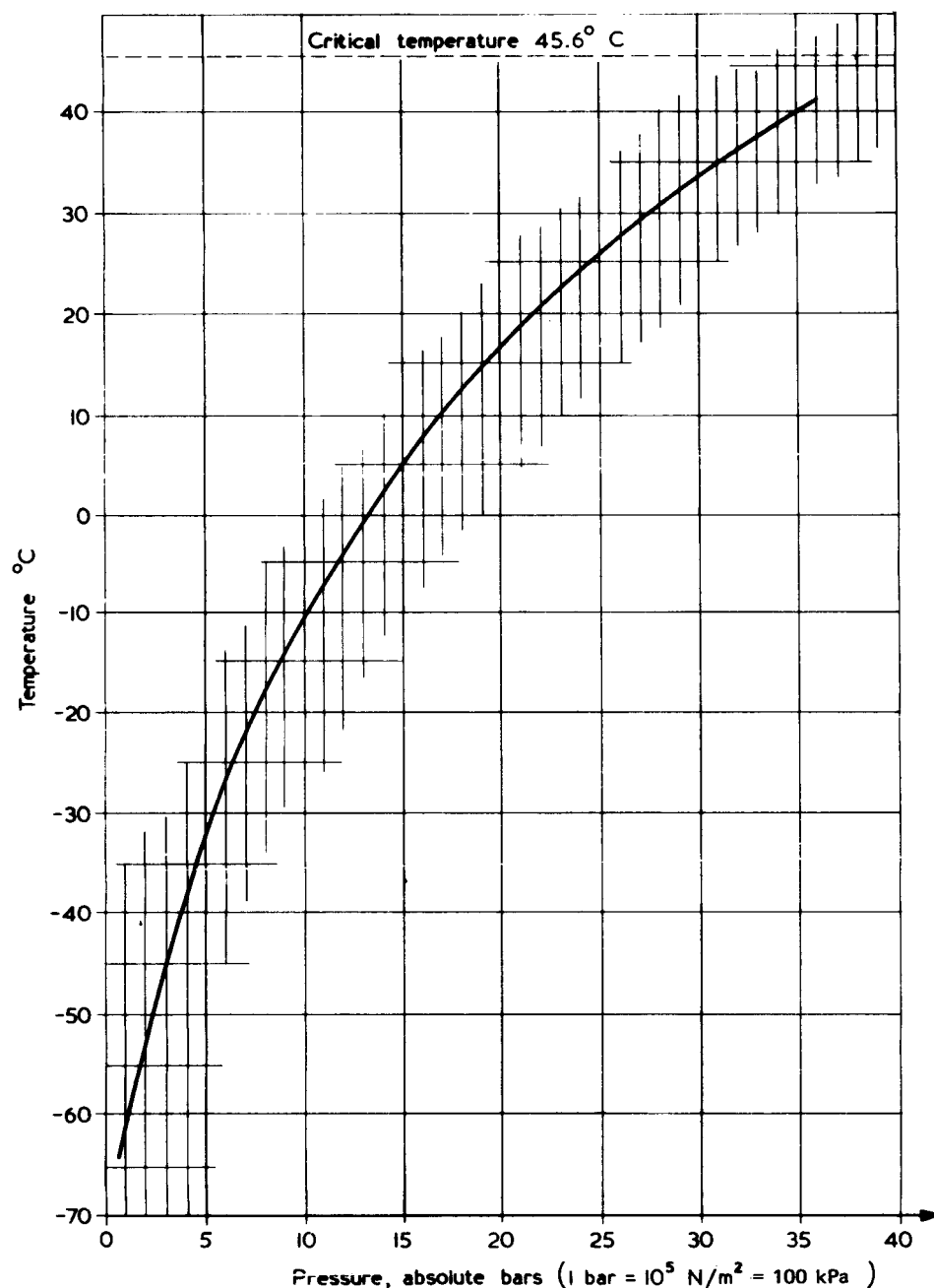


Figure 1 — Saturated vapour pressure curve for sulphur hexafluoride

The equipment manufacturer should be consulted to ascertain, for each piece of equipment, the levels of impurity at which the gas should be reconditioned or replaced.

However, one general rule can be stated, i.e. it is undesirable that the gas is used when condensable impurities have reached a level such that condensation may occur within the equipment at the lowest operating temperatures. The liability to condensation cannot be assessed by chemical analysis but has to be determined by measuring the temperature at which condensation occurs in a sample of the gas at a known pressure, i.e. the dew point of the impurities; methods to be used are described in section 7.

6 Safety precautions

Although uncontaminated sulphur hexafluoride is non-toxic, some of the gaseous impurities produced by electrical breakdowns in the gas are toxic if inhaled in sufficient quantity, and the solid fluoride powders also produced by breakdown may produce skin irritation. Care should thus be taken during maintenance, particularly with circuit breakers, or equipment known to have sustained a severe interior flashover. However, present experience shows that if personnel are exposed to significant amounts of breakdown products, definite warning indications will very quickly appear, such as a pungent or unpleasant odour, or irritation of the nose, mouth, and eyes. These warning signs will occur within seconds and well before any significant toxic effects can take place. If a pungent or unpleasant odour appears, personnel should quickly get into fresh air. If it is necessary to remain in such an atmosphere, self-contained compressed air breathing apparatus or air line breathing apparatus should be worn.

On first opening up equipment for inspection of the interior, personnel should take particular care to avoid exposure to possible breakdown products, and suitable protective equipment should be worn. This would include suitable coveralls, thin rubber gloves, chemical type box goggles and a respirator incorporating a dust filter and activated charcoal. When any dust and decomposition products have been removed from the interior of the apparatus the respirator and goggles can be taken off. Manufacturers or users should lay down a code of practice covering these operations and this should be adhered to.

Special filters are fitted in certain sulphur hexafluoride filled equipment to absorb gaseous breakdown products. Before attempting to remove any such gas filters the operator should be familiar with the manufacturer's instructions for doing this, together with his instructions for disposing of the used filter material, cleaning the container and re-charging it with new material.

Also, sulphur hexafluoride is a very heavy gas, about five times as dense as air. This gives rise to a serious potential danger; equipment, trenches, and similar enclosed spaces may remain full of the gas, which if pure has no colour or odour which might warn personnel of this fact.

Although sulphur hexafluoride is non-toxic, it will not support life, and personnel entering a sulphur hexafluoride filled enclosure, trench etc., will be asphyxiated. It is essential that personnel are made aware of this danger, and equipment, etc., should be adequately ventilated if it is to be entered without breathing apparatus. If there is any doubt, it is essential to verify the presence of sufficient oxygen, using, e.g. a portable oxygen analyser (see section 6).

Section 3. Frequency of testing

7 General

Later sections of this code give test methods for verifying that the gas is sulphur hexafluoride and for determining its oxygen content, dew point, acidity, hydrolysable fluorides and oil content. As well as giving limiting values of impurity contents, the equipment manufacturer will often give advice as to how frequently tests should be made, but the following general guidance, given in clauses 8, 9 and 10, may be kept in mind.

8 Oxygen content

This measurement is of most value immediately after filling or topping up the equipment to ensure that no air has been accidentally admitted. For equipment in which the sulphur hexafluoride is always above atmospheric pressure, there is, in general, no necessity to repeat this measurement during normal service.

9 Dew point and acidity

The dew point is measured after filling or topping up the equipment to verify that the equipment is properly dry. Both dew point and acidity are measured periodically to check that any deterioration in service of these parameters remains within acceptable limits. The frequency of these determinations depends almost entirely on the nature and loading of the equipment.

10 Hydrolysable fluorides and oil content

Only rarely will determination of either of these impurities be required on site. Hydrolysable fluorides will generally only be assessed if acidity is found to be high; oil content only if there is particular reason to suspect an abnormally high value may exist.