

Methods for

Measurement of gassing of insulating liquids under electrical stress and ionization

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The preparation of this British Standard was entrusted by the General Electrotechnical Engineering Standards Committee (GEL/-) to Technical Committee GEL/115, upon which the following bodies were represented:

- Association of Consulting Engineers
- ERA Technology Ltd.
- Electricity Supply Industry in England and Wales
- Institute of Petroleum
- Institution of Electrical Engineers
- London Regional Transport
- Transmission and Distribution Association (BEAMA Ltd.)

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Lubricants Federation Limited
- Electric Cable Makers' Confederation
- Electric Cable Makers' Confederation (Supertension Cables Group)

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National foreword

This British Standard has been prepared under the direction of the General Electrotechnical Engineering Standards Committee and supersedes BS 5797:1979 which is withdrawn. It is identical with IEC Publication 628:1985 “*Gassing of insulating liquids under electrical stress and ionization*” published by the International Electrotechnical Commission (IEC) as amended by the corrigendum dated October 1986.

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards. The comma has been used in the figures as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Cross-references

International Standards	Corresponding British Standards
ISO 383:1976	BS 572:1985 <i>Specification for interchangeable conical ground glass joints</i> (Technically equivalent)
ISO 653:1980	BS 5074:1974 <i>Short and long solid-stem thermometers for precision use</i> (Technically equivalent)
ISO 4803:1978	BS 5895:1980 <i>Specification for borosilicate glass tubing for laboratory apparatus</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 683/XIII, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to ISO 683/XIII is BS 1449-2:1983 “*Specification for stainless and heat resisting steel plate, sheet and strip*” in which grade 304S31 is equivalent to No. 11 tubing mentioned in the text.

WARNING. This British Standard calls for the use of substances that may be injurious to health if adequate precautions are not taken. It refers only to the technical suitability and does not absolve the user from legal obligations relating to health and safety at any state. Attention is especially drawn to the warning note in clause 1 of the standard.

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 and ii, pages 1 to 16, 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 standard describes two procedures each using different apparatus to measure the tendency of insulating liquids to evolve or absorb gas when subjected, in cells having specific geometries, to electrical stress of sufficient intensity to cause an electric discharge through a gas phase in which a gas-oil interface is located.

The methods described in this standard are suitable for purchase specifications, general selection of insulating liquids, product development and quality assurance.

WARNING! Attention is called to national regulations associated with the use of high voltage, hydrogen and solvents.

2 General notes on the methods

2.1 These methods indicate whether insulating liquids are gas absorbing or gas evolving under the test conditions. The gassing behaviour of any one insulating liquid is primarily a function of its chemistry but changes in certain test parameters can modify the results significantly.

2.2 These methods can operate under a variety of gas phase, temperature and voltage stress conditions. In order to establish uniform criteria of measurement, specific test conditions are specified which experience has shown to be most informative of the general performance expected from the liquid dielectric in electrical equipment should ionization occur.

At present, however, though it is generally agreed that gas absorbency of the impregnant has a positive effect in minimizing ionization problems in impregnated insulation systems used at high electrical stress, correlation of gassing-cell test results with equipment performance is limited. Engineering judgement is necessary in interpreting the test results in relation to any intended application.

2.3 Both methods, have been originally designed for the range of gassing rates characteristic of mineral insulating liquids. The use of these methods with other liquids may require some adaptations in the dimensions of the test cell.

Section 2. Method A

3 Outline of method

This method determines the gassing tendency of an insulating liquid under a hydrogen atmosphere and expresses the results in terms of gassing rate over a relatively short test period.

After being dried and saturated with hydrogen gas, the insulating liquid and the hydrogen pocket above the liquid are subjected in the specified cell to a radial electrical stress under the following experimental conditions:

- voltage: 10 kV;
- frequency: 50 Hz or 60 Hz;
- temperature: 80 °C;
- test duration: 120 min at 50 Hz or 100 min at 60 Hz.

The rate of evolution or absorption of gas resulting from reactions at the gas-oil interface, is calculated as volume per unit of time from changes in pressure with time.

4 Apparatus

4.1 Gassing-cell and gas-burette assembly

The gassing-cell illustrated in Figure 1, page 9, with dimensions given in Figure 2, page 10, consists of the following components:

- Cell made of borosilicate glass with a relative permittivity of 5 ± 0.2 at 80 °C measured at a stated frequency (50 Hz or 60 Hz). The part under stress is constructed of 16 ± 0.2 mm inside diameter and 18 ± 0.2 mm outside diameter precision selected lightwall tubing according to ISO Standard 4803. This cell has an outer electrode (earth) 60 mm high made of solvent-resistant silver paint with a vertical slit for observing the oil level and a copper band for earth connection.
- Hollow high-voltage electrode made of 10 ± 0.1 mm outside diameter centreless-ground and polished stainless steel seamless tubing No. 11 according to ISO Standard 683/XIII and containing a 1.0 mm stainless steel capillary tubing as a gas passage.

The electrode shall be supported and centred by a precision machined 24/29 recessed polytetrafluoroethylene plug.

A 3.0 mm needle valve (E) with gas inlet is on top of the electrode.

NOTE After repeated tests at 80 °C, the shape of the polytetrafluoroethylene plug should be checked because it may deform and no longer be leak-tight.

- Gas burette (Figure 1) made of 7 mm outside diameter borosilicate glass tubing with an etched scale (mm), tapered glass joint 10/19 (G) for connecting to the gassing-cell, a by-pass stopcock (D) and three glass bulbs (A, B and C). The correlation between the reading (mm) and the volume (mm³) must be known.

NOTE Increased capacity of gas-burette is required for highly gas absorbing liquids.

4.2 Heating device

A transparent oil bath, preferably filled with silicone liquid, with thermostatic control and liquid circulating system to maintain the bath medium at 80 ± 0.5 °C. The bath may be equipped with suitable supports for holding the gassing-cell and gas burette.

NOTE If the level of the oil filling drops below a defined minimum, the high voltage should be disconnected automatically by safety switches. The bath may be provided with an effective circulating cooling system to allow rapid cooling after the test.

4.3 Transparent safety shield

Fitted with safety electrical interlock switches to protect the operator from parts under high voltage.

4.4 High-voltage transformer

The transformer and its controlling equipment shall be of such size and design that, with a filled gassing-cell in the circuit, the peak factor (ratio of peak value to r.m.s. value) of the test voltage shall not differ by more than ± 5 % from that of a sinusoidal wave while maintaining $10 \text{ kV} \pm 2$ %.

4.5 Thermometer

Any convenient thermometer for measuring a temperature of 80 ± 0.1 °C (e.g. ISO Standard 653 – STL/0.1/60/85).

4.6 Syringe

A convenient glass syringe, volume 10 cm³.

5 Reagents

5.1 Hydrogen with oxygen content less than 10 mm³/dm³ and water content less than 2 mm³/dm³ from a cylinder with two-stage pressure reducer and a fine flow regulator.

5.2 *Dibutyl phthalate*, technical grade.

5.3 *1,1,1-trichloroethane*, technical grade.

5.4 *n-heptane*, analytical grade.

5.5 *Silicone vacuum grease*

6 Preparation of the apparatus

General remark:

As the gassing tendency of liquids may be strongly influenced by solvents, it is important that no traces of solvent remain after the cleaning procedure.

6.1 Clean the glass cell by first rinsing it inside and outside with 1,1,1-trichloroethane then with n-heptane. Then, refill the cell with n-heptane and scrub with a stiff brush of polyamide fibres to remove deposits from previous test.

Insert a smaller brush into the tapered joint (G) and scrub out silicone grease, taking care that none of the grease enters the cell. Again rinse with n-heptane and blow dry with clean compressed air.

Check the painted-on silver electrode, and touch up if necessary.

6.2 Clean the hollow electrode by blowing out the capillary tube with clean compressed air, rinsing the oil off the entire electrode with 1,1,1-trichloroethane and wiping off any deposit with tissue paper.

Polish the surface of the stainless steel shaft of the electrode with a suitable device, such as a buffing wheel; wipe off the buffing compound carefully with tissue paper moistened with 1,1,1-trichloroethane. Rinse again first with 1,1,1-trichloroethane, then with n-heptane. Blow dry with clean compressed air and complete drying in an oven at 80 °C.

6.3 Apply a light coat of silicone vacuum grease to the stopcock (D) and the standard tapered joint (G) and assemble the glass cell and burette, but do not insert the electrode into the glass cell.

6.4 Fill the burette to the half-full mark with dibutyl phthalate.

6.5 Clean the syringe with n-heptane then blow dry with compressed air.

7 Procedure

7.1 Filter about 10 cm³ of the oil sample through a previously dried filter paper and rapidly introduce 5 ± 0.1 cm³ of the filtered oil into the glass cell by means of the hypodermic syringe.

7.2 Lightly coat the polytetrafluoroethylene plug of the electrode with the test liquid (to act as a gas-seal) and insert the electrode into the glass cell.

7.3 Check the bath temperature, which shall be maintained at 80 ± 0.5 °C during the test.

7.4 Suspend the gassing-cell and gas burette assembly in the oil bath at the level indicated in Figure 1, page 9, and connect the lead from the outside electrode to earth.

7.5 Attach the gas inlet and outlet connections. The gas outlet should lead outside the building, either directly or through a fume hood.

7.6 Close the stopcock (D) and open the valve (E) to allow the saturating gas to bubble through the test oil and the burette liquid at a steady rate of 3 dm³/h for 60 min.

7.7 Open the stopcock (D) and continue bubbling the saturating gas through the test oil for an additional 5 min.

7.8 After a total of 65 min of gas bubbling, first close the valve (E) and then the stopcock (D), making certain the liquid levels in the two legs of the burette are equal.

7.9 Connect the high-voltage lead to the centre electrode.