

Method for the

Measurement of relative permittivity, dielectric dissipation factor and d.c. resistivity of insulating liquids

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- Associated Offices Technical Committee
- British Electrical and Allied Manufacturers' Association (BEAMA)
- British Radio Equipment Manufacturers' Association
- British Steel Corporation
- Department of Energy, Electricity
- Electric Cable Makers' Confederation*
- Electrical Contractors' Association
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- Engineering Equipment Users' Association
- Health and Safety Executive
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The 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:

- British Railways Board
- British Lubricants Federation Limited
- Electric Cable Makers Confederation — Supertension Cables Group
- Institute of Petroleum
- The Transmission and Distribution Association (BEAMA)

This British Standard, having been prepared under the direction of General Electrotechnical Engineering Standards Committee, was published under the authority of the Executive Board and comes into effect on 31 August 1979

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National foreword

This British Standard has been prepared under the direction of the General Electrotechnical Engineering Standards Committee. It is identical with IEC 247 “*Measurement of relative permittivity, dielectric dissipation factor and d.c. resistivity of insulating liquids*” published by the International Electrotechnical Commission (IEC).

Terminology and conventions. The text of the International Standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

Cross-references

International Standard	Corresponding British Standard
IEC 250:1969	BS 2067 <i>Determination of power-factor and permittivity of insulating materials (Hartshorn & Ward method)</i> (Related) BS 4542 <i>Method for the determination of loss tangent and permittivity of electrical insulating materials in sheet form (Lynch method)</i> (Related)
IEC 475:1974	BS 5263 <i>Method for sampling liquid dielectrics</i> (Related)

At present there is no corresponding British Standard for the following International Standard referred to in 4.5: IEC 93 “*Recommended methods of test for volume and surface resistivities of electrical insulating materials*”. The technical committee has reviewed the provisions of IEC Publication 93, and has decided that they are acceptable for use in conjunction with this standard.

NOTE *Textual error.* When adopting the text of the International Standard, the following errors were noticed.

In 2.3 line 3, the unit of resistivity should be read as “ohm metre (Ω m)”.

In 3.1 paragraph 8 line 4 and in 3.2 a) line 1, “1/K” should be read as “the inverse of the temperature, expressed in kelvins,”.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, 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.

1 Scope

This standard describes methods for the determination of dielectric dissipation factor, relative permittivity and d.c. resistivity of hydrocarbons and askarels¹⁾ which are liquid at the test temperature.

The methods are primarily intended for making reference tests on unused liquids but they may also be applied to liquids in service in transformers, cables and other electrical apparatus. However, when it is desired to make routine determinations, simplified procedures, as described in Appendix A, may be adopted.

The test procedures described may be used successfully with insulating liquids other than hydrocarbon liquids and askarels, though it is recognized that alternative cleaning procedures may be required.

2 Definitions

2.1 permittivity (relative)

the relative permittivity of an insulating material is the ratio of capacitance C_x of a capacitor in which the space between and around the electrodes is entirely and exclusively filled with the insulating material in question, to the capacitance C_0 of the same configuration of electrodes in vacuum

the capacitance C_a of the configuration of electrodes in air can normally be used instead of C_0 to determine the relative permittivity with sufficient accuracy

2.2 dielectric dissipation factor

the dielectric dissipation factor ($\tan \delta$) of an insulating material is the tangent of the loss angle the loss angle is the angle by which the phase difference between applied voltage and the resulting current deviates from $\pi/2$ rad when the dielectric of the capacitor consists exclusively of the insulating material

2.3 d.c. resistivity (volume)

the volume resistivity of an insulating material is the quotient of a d.c. electrical field strength and the steady state current density within the material the unit of resistivity is the ohm meter (Ωm)

3 General considerations

3.1 Permittivity and dielectric dissipation factor

The permittivity and the dielectric dissipation factor of electrical insulating liquids depend to a considerable extent on the test conditions under which they are measured, in particular on the temperature and on the frequency of the applied voltage. Permittivity and dissipation factor are the results of dielectric polarization and conductance of the material.

At power frequency and sufficiently high temperature, as recommended in these methods, the losses may exclusively be attributable to the conductance of the liquid, that is, to the presence of free charge carriers in the liquid. Measurements of the dielectric properties of high purity insulating liquids are therefore of value as an indication of the presence of ionizable contaminants.

The contribution to dielectric losses from the conductance of the liquid is inversely dependent on measuring frequency and varies with the viscosity of the medium. The value of the test voltage when measuring the dissipation factor is less important. It is often governed by the sensitivity of the measuring bridge. However, it must be borne in mind that too high a voltage stress results in secondary phenomena at the electrodes, dielectric heating, discharges, etc.

While relatively large amounts of impurities produce a comparatively small change in permittivity, the dissipation factor of insulating liquids may be strongly affected by traces of ionizable dissolved contaminants or colloidal particles. Askarels are much more sensitive to contamination than hydrocarbon liquids due to their higher polarity, which results in turn in higher solvent power and dissociation capability. Therefore they require comparatively greater care in handling than hydrocarbon liquids.

Unreliable results usually originate from contamination due to improper sampling or handling of liquid specimens, from incomplete cleaning of the cells or from the presence of undissolved water.

Long exposure to strong light during storage may lead to deterioration with high results. Standardized procedures for the storage and transfer of the liquid samples and for the construction and cleaning of test cells shall be recommended so that errors caused by contamination are minimized.

¹⁾ The term askarel describes a broad class of insulating liquids that, being totally or partly based on polychlorobiphenyls, can be persistent environmental contaminants. Care is needed in handling or disposing of them to prevent entry into the environment.