

Insulating liquids — Measurement of relative permittivity, dielectric dissipation factor ($\tan \delta$) and d.c. resistivity

The European Standard EN 60247:2004 has the status of a
British Standard

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/10, Fluids for electrotechnical applications, which has the responsibility to:

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**Insulating liquids –
Measurement of relative permittivity,
dielectric dissipation factor ($\tan \delta$) and d.c. resistivity
(IEC 60247:2004)**

Liquides isolants –
Mesure de la permittivité relative,
du facteur de dissipation diélectrique
($\tan \delta$) et de la résistivité en courant
continu
(CEI 60247:2004)

Isolierflüssigkeiten –
Messung der Permittivitätszahl,
des dielektrischen Verlustfaktors ($\tan \delta$)
und des spezifischen Gleichstrom-
Widerstandes
(IEC 60247:2004)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-04-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60247:2004 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

Health and safety

General caution. 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 determine the applicability of regulatory limitations prior to use.

Environment

This standard gives rise to insulating liquids, chemicals, used sample containers and oil contaminated solids. The disposal of these items should be carried out according to local regulations with regard to their impact on the environment. Every precaution should be taken to prevent the release into the environment of these liquids.

INSULATING LIQUIDS – MEASUREMENT OF RELATIVE PERMITTIVITY, DIELECTRIC DISSIPATION FACTOR ($\tan \delta$) AND DC RESISTIVITY

1 Scope

This International standard describes methods for the determination of the dielectric dissipation factor ($\tan \delta$), relative permittivity and d.c. resistivity of any insulating liquid material at the test temperature.

The methods are primarily intended for making reference tests on unused liquids. They can also be applied to liquids in service in transformers, cables and other electrical apparatus. However the method is applicable to a single phase liquid only. When it is desired to make routine determinations, simplified procedures, as described in Annex C, may be adopted.

With insulating liquids other than hydrocarbons, alternative cleaning procedures may be required.

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 60093, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60250, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths*

IEC 60475, *Method of sampling liquid dielectrics*

IEC 61620, *Insulating liquids – Determination of the dielectric dissipation factor by measurement of the conductance and capacitance – Test method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

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

3.2

dielectric dissipation factor ($\tan \delta$) DDF

dielectric dissipation factor, DDF, ($\tan \delta$) 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

NOTE For practical purposes, measured values below 0,005 for $\tan \delta$ and power factor are essentially the same. A simple conversion can be used to convert one to the other. The power factor is the sine of the loss angle and the relationship between power factor and dielectric dissipation factor can be expressed as follows:

$$PF = \frac{DDF}{\sqrt{1 + (DDF)^2}} \quad (1)$$

3.3

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

NOTE The unit of resistivity is the ohmmetre (Ωm).

4 General

Permittivity, $\tan \delta$ and resistivity, either separately or together, are important indicators of the intrinsic quality and degree of contamination of an insulating fluid. These parameters may be used to interpret the deviation from desired dielectric characteristics and the potential influence on performance of equipment in which the fluid is used.

4.1 Permittivity and dielectric dissipation factor ($\tan \delta$)

The permittivity and the dielectric dissipation factor ($\tan \delta$) 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 measurements of dielectric polarization and conductivity of the material.

At power frequency and sufficiently high temperature, as recommended in these methods, the losses may be attributable exclusively to the conductivity 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 contaminants.

The dielectric loss factor is usually inversely proportional to the measuring frequency and varies with the viscosity of the medium. The value of the test voltage when measuring the dissipation factor is less important and 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 $\tan \delta$ of insulating liquids may be strongly affected by traces of dissolved contaminants or colloidal particles. Some liquids 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.