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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Dielectric and resistive properties of solid insulating materials – Part 3-11: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity – Method for impregnation and coating materials

Propriétés diélectriques et résistives des matériaux isolants solides – Partie 3-11: Détermination des propriétés résistives (méthodes en courant continu) – Résistance volumique et résistivité volumique – Méthode pour matériaux d'imprégnation et de revêtement

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International Standard IEC 62631-3-11 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.

The text of this standard is based on the following documents:

FDIS	Report on voting
112/409/FDIS	112/415/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 62631 series, published under the general title *Dielectric and resistive properties of solid insulating materials*, can be found on the IEC website.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Many segments of the electrotechnical industry need volume resistance and volume resistivity data of solid insulating materials. This part of IEC 62631 is focused on the method for impregnation and coating materials. Clear guidelines are important to give the user of this document a uniform approach to sample preparation and test procedures.

DIELECTRIC AND RESISTIVE PROPERTIES OF SOLID INSULATING MATERIALS –

Part 3-11: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity – Method for impregnation and coating materials

1 Scope

This part of IEC 62631 covers a method of test for the determination of volume resistance and volume resistivity of electrical insulation materials by applying DC voltage. It covers the materials described in IEC 60455-3-5, IEC 60464-3-1, IEC 60464-3-2 and similar products.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 62631-3-1, *Dielectric and resistive properties of solid insulating materials – Part 3-1: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity – General method*

ISO 1514, *Paints and varnishes – Standard panels for testing*

ISO 2808, *Paints and varnishes – Determination of film thickness*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
volume resistance
part of the insulation resistance which is due to conduction through the volume

Note 1 to entry: Volume resistance is expressed in Ω.

3.2
volume resistivity
volume resistance of a material related to its volume

Note 1 to entry: Volume resistivity is expressed in Ωm.

Note 2 to entry: For insulating materials the volume resistivity is usually determined by means of measuring electrodes arranged on a sheet of the material.

Note 3 to entry: According to IEC 60050-121:1998, 121-12-03, “conductivity” is defined as “scalar or tensor quantity the product of which by the electric field strength in a medium is equal to the electric current density” and according to IEC 60050-121:1998, 121-12-04 “resistivity” is the "inverse of the conductivity when this inverse exists”. Measured in this way, the volume resistivity is an average of the resistivity over possible heterogeneities in the volume incorporated in the measurement; it includes the effect of possible polarization phenomena at the level of the electrodes.

3.3
stray current
leakage current in the earth or in metallic structures buried in the ground and resulting from their intended or unintended earthing

4 Significance

The materials applicable to this test are used to impregnate or coat coils made from enamelled copper or aluminium wire to fix the coils, protect them from humidity, dirt and other environmental influence. The main field applications are electric motors, transformers and similar appliances.

Additional electrical insulation is desirable but not essential. In many cases mechanical support, thermal and chemical resistance are more important. In particular, the changes in resistivity with regard to temperature and/or humidity are of great importance and need to be known when designing a motor for operation conditions.

When a direct voltage is applied between electrodes in contact with a specimen, the current through it decreases asymptotically towards a steady-state value. The decrease of current with time may be due to dielectric polarisation and the sweep of mobile ions to the electrodes. For materials having volume resistivity less than about 10^{10} Ωm the steady state is generally reached within 1 min and the resistance is determined after this time of electrification. For materials with higher volume resistivity the current may continue decreasing for several minutes, hours, days or even weeks. However, the results are taken after 1 min.

NOTE For very high electric field strengths different behaviour can occur.

5 Method of test

5.1 General

The method described in this document is used for impregnation and coating materials. For other specific types of materials other documents or the general method described in IEC 62631-3-1 may be more suitable.

For an impregnation or coating material the absolute value of volume resistance or resistivity is of minor interest. More important is the change of this value as a function of temperature or after immersion into water.

5.2 Power supply (voltage)

A source of very steady direct voltage is required. This may be provided either by batteries or by rectified and stabilized power supply. The degree of stability required is such that the change in current due to any change in voltage is negligible compared with the current to be measured.

NOTE The ripple of the voltage source is important. A typical value for 100 V is $< 5 \times 10^{-5}$ peak to peak.

If not otherwise stipulated, a voltage of 500 V is to be used. Other test voltages may be 10 V, 100 V or 1 000 V.

5.3 Equipment

5.3.1 Accuracy

Any suitable equipment may be used. The measuring device should be capable of determining the unknown resistance with an overall accuracy of at least:

- ±10 % for resistances below 10^{10} Ω
- ±20 % for resistances between 10^{10} Ω and 10^{14} Ω
- ±50 % for values higher than 10^{14} Ω

5.3.2 Guarding

For routine measurements, especially in production control to determine the specified minimum values, guarding is not necessary. This allows smaller and simplified specimens.

If the exact absolute value is of interest, or the value is above 10^{12} Ω, or in case of doubt, then guarding is recommended. Further information related to guarding can be found in IEC 62631-3-1.

5.3.3 Electrodes

For simple measurements a permanent electrode (e.g. conductive silver paint) may be used.

In case of measurements before and after a treatment (e.g. immersion into water) a removable electrode shall be used. Further information related to electrodes can be found in IEC 62631-3-1.

5.3.4 Calibration

The equipment shall be calibrated in the magnitude of the volume resistance measured.

NOTE Calibration resistors in the range up to 100 TΩ are commercially available.

5.3.5 Test specimen

Unless otherwise specified, a steel panel according to ISO 1514 but of a thickness of (0,125 ± 0,025) mm, a length of at least 100 mm and a width at least 60 mm shall be used. The preparation and cleaning of the panel shall be in accordance with the measures proposed in ISO 1514.

Unless otherwise specified, the steel panel shall be immersed in the resin or varnish in a vertical position and at a speed sufficiently low to prevent voids of air adhering to the surface of the panel. The panel shall be kept in the resin or varnish for at least 5 min and shall then be removed from the varnish at a uniform speed of not more than 5 mm/s.

The specimen shall then be drained for 10 min to 15 min and dried and/or cured in accordance with the agreed schedule. It shall be drained in a vertical position. For drying and/or curing, the oven applied shall be specially designed for drying painted or varnished parts, which may have large surfaces and substantial amounts of solvent evaporation. Drying and curing temperature conditions shall comply with the requirements of the product datasheet.

For varnishes the coating process shall be repeated by dipping, draining and drying and/or curing the panel in the reverse direction. For resins a single coating is sufficient.

The thickness of the coating after drying and/or curing shall be determined by one of the procedures specified in ISO 2808. The coating on the steel panel shall be between 0,04 mm and 0,10 mm on either side of the panel.

NOTE Increasing the speed by which the panel is removed from the resin or varnish increases the thickness of the coating; reducing the speed reduces the thickness of the coating. It also can be necessary to reduce the viscosity of varnishes using the recommended thinner.

5.4 Procedure for volume resistivity as function of temperature

5.4.1 General

The following procedure describes an established method. Any other method in line with the general requirements may be used.

5.4.2 Equipment

The following equipment shall be used:

- any suitable tera-ohmmeter with an accuracy of ±10 %;
- metal cylinder to be used as voltage electrode (top electrode) of at least 40 mm diameter and having a mass to provide a pressure of about 0,015 MPa;
- conductive silver paint.

5.4.3 Test set-up

Three specimens shall be tested. The thickness of the coating shall be measured at five points at least within the test area before application of the electrodes. Conductive silver paint is applied on the test area and dried according to the paint manufacturer's recommendations.

The steel panel shall be placed on a flat solid surface in an oven. The steel panel itself is grounded and used as an electrode.

The metal cylinder is placed on the test area on top of the silver paint and used as the other electrode.

5.4.4 Procedure

The volume resistivity at room temperature is measured in accordance with IEC 62631-3-1 using an electrification of 1 min and a voltage not higher than 500 V.

The oven is turned on and adjusted to the first temperature. After the temperature has stabilized the measurement of the volume resistivity is repeated and recorded along with the temperature.

The necessary time for temperature stabilization is for example influenced by the construction and tolerances of the oven, the electrode arrangement specimen and other technical details. However care should be taken that the specimen has stabilized. The time characteristics of the individual oven should be determined or extrapolated from experience.

The oven is set to the second temperature and the process is repeated until the maximum temperature is reached. The maximum temperature shall be at least the thermal class temperature.

5.4.5 Calculation

The calculation of the volume resistivity shall be in accordance with IEC 62631-3-1. A graph using a logarithmic scale of the volume resistivity versus temperature has been found useful.