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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Test procedure for thermal endurance of insulating resins and varnishes for impregnation purposes – Electric breakdown methods

Méthode d'essai pour l'évaluation de l'endurance thermique des résines et vernis isolants d'imprégnation – Méthodes de claquage électrique

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TEST PROCEDURE FOR THERMAL ENDURANCE OF INSULATING RESINS AND VARNISHES FOR IMPREGNATION PURPOSES – ELECTRIC BREAKDOWN METHODS

FOREWORD

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International Standard IEC 60370 has been prepared by IEC technical committee 15: Solid electrical insulating materials.

This second edition cancels and replaces the first edition published in 1971. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) this document is now describing two methods, the existing one, following ASTM D1932 and new a method following the requirements of IEC 60455-2 and IEC 60464-2;
b) the theoretical background and way of calculation were removed, and replaced by reference to IEC 60216;
c) the layout and numbering system was updated;
d) for better understanding and illustration purposes examples were added.

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
15/812/FDIS	15/819/RVD

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

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

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INTRODUCTION

This document describes methods for thermal endurance testing. The methods described are in line with IEC 60216 (all parts). More information about the theory of thermal endurance, calculation methods and other possible methods can be found in IEC 60216 (all parts).

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TEST PROCEDURE FOR THERMAL ENDURANCE OF INSULATING RESINS AND VARNISHES FOR IMPREGNATION PURPOSES – ELECTRIC BREAKDOWN METHODS

1 Scope

This International Standard covers methods of test for the determination of thermal endurance (temperature index) of electrical insulating resins and varnishes for impregnation purposes.

It is done by means of impregnating glass cloth and measuring electric strength or breakdown voltage before and after heat ageing.

It covers the materials described in IEC 60455-3-5 and IEC 60464-3-2 and similar materials.

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 60212, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*

IEC 60216 (all parts), *Electrical insulating materials – Thermal endurance properties*

IEC 60216-4-1, *Electrical insulating materials – Thermal endurance properties – Part 4-1: Ageing ovens – Single-chamber ovens*

IEC 60216-4-2, *Electrical insulating materials – Thermal endurance properties – Part 4-2: Ageing ovens – Precision ovens for use up to 300 °C*

IEC 60216-4-3, *Electrical insulating materials – Thermal endurance properties – Part 4-3: Ageing ovens – Multi-chamber ovens*

IEC 60243-1, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60455-3-5, *Resin based reactive compounds used for electrical insulation – Part 3: Specifications for individual materials – Sheet 5: Unsaturated polyester based impregnating resins*

IEC 60464-3-2, *Varnishes used for electrical insulation – Part 3: Specifications for individual materials – Sheet 2: Hot curing impregnating varnishes*

IEC 60641-3-1, *Pressboard and presspaper for electrical purposes – Part 3: Specifications for individual materials – Sheet 1: Requirements for pressboard, types B.0.1, B.0.3, B.2.1, B.2.3, B.3.1, B.3.3, B.4.1, B.4.3, B.5.1, B.5.3 and B.6.1*

ISO 2078, *Textile glass – Yarns – Designation*

ISO 2113, *Reinforcement fibers – Woven fabrics – Basis for a specification*

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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
resin
mixture of a reactive polymer with other reactive components such as hardener accelerator, inhibitor or reactive diluent, and with or without filler and additives, whereby virtually no volatile matter is released during the subsequent curing reaction

Note 1 to entry: Resins are solvent free.

Note 2 to entry: Small quantities of by-products can be evolved during the cure of selected resins. In the case where a reactive diluent is used, small quantities of monomeric diluent can evaporate during cure manly due to the application conditions used.

3.2
varnish
solution or emulsion of one or more resins in a solvent or carrier liquid

Note 1 to entry: Other components may be present, such as driers, catalysts, reactive diluents, dyestuffs, pigments or co-solvents.

Note 2 to entry: The solvents and by-products are released during the drying/curing process and at the same time the active components are polymerized and/or cross-linked forming a solid product.

4 Methods of test

4.1 General

In these test procedures, specimens are aged in ovens at elevated temperatures for specified periods. The specimens are then removed from the oven, cooled and tested electrically. At each temperature the thermal life is determined as the ageing time necessary for the electric property to decrease to a preselected value. This value may be selected on the basis of some functional characteristic of the material for the intended application. The thermal endurance is then determined as a curve showing the relationship between ageing temperature and thermal life.

Two alternative methods are given:

– Method 1: a curved electrode system designed to elongate the outer surface of the varnish specimen of approximately 2 %. This simulates flexing to which the varnish may be subjected in service.

  The property measured is electric strength, the end point criterion is 12 kV/mm.

– Method 2: a ball to plate electrode arrangement is used to avoid mechanical stress. In many cases, the specimens are no longer plan after ageing and a curved electrode system or a plate to plate arrangement is causing additional undefined mechanical stress.

  The property measured is breakdown voltage, the end point criterion is 3 kV.

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4.2 Method 1 – Curved electrode system

4.2.1 Specimen

The specimens shall consist of panels of continuous filament, woven glass cloth impregnated with the material under test by dipping.

The glass cloth panels shall be cut from continuous filament, woven glass 0,1 mm to 0,18 mm thick with a weight per unit area of 90 g/m^2 to 140 g/m^2 and with 20 to 26 ends and 16 to 24 picks per centimetre. (Where glass cloth having the specified picks and ends is not available in the country making the test, the nearest standard cloth of that country shall be used.)

The dimensions of the curved electrode were designed to give an approximate 2 % elongation to the outer surface of a 0,1 mm thick glass cloth impregnated to 0,175 mm to 0,185 mm total thickness. It should be noted, therefore, that greater thicknesses will increase the elongation which, in turn, can significantly affect the ageing results.

The glass cloth shall be heat cleaned to remove binders.

NOTE A suggested heat cleaning procedure consists of heating the cloth 24 h at 250 °C and 24 h at 400 °C. Caution: heating above 450 °C can damage the cloth.

Each panel of glass cloth shall be 15 cm x 30 cm with the 30 cm dimension parallel to the warp threads of the cloth. Each panel shall be mounted and fastened in a suitable specimen-holding frame.

A set of twelve or more panels is required for each ageing temperature. A suitable fixture shall be used for holding the specimen frames in the oven in a vertical position with a minimum spacing of 2,5 cm.

4.2.2 Impregnation process

4.2.2.1 General

Test specimens shall be prepared by dipping the mounted glass cloth panels in the resin or varnish. The specimen shall be prepared at room atmosphere or preferably at standard atmosphere B according to IEC 60212 (23 °C ± 2 K and 50 % ± 10 % relative humidity).

4.2.2.2 Varnishes

The consistency of a varnish shall be adjusted by trial, using the recommended thinner so that two or more impregnations will give an overall increase in thickness of 0,08 mm ± 0,005 mm over the cloth thickness. The panel shall be immersed in the varnish in the direction of the 30 cm length until bubbling stops. It shall be mechanically withdrawn at a uniform rate of 10 cm/min, and allowed to drain for 1 h.

Specimens shall be reversed endwise between subsequent dips to provide a more uniform impregnation. After each dip, the specimens shall be cured in the same vertical position as the last dip and at the temperature and time specified by the manufacturer.

4.2.2.3 Resins

The consistency of a resin shall be adjusted by trial using reactive diluent so that the impregnation will give an overall thickness of 0,180 mm ± 0,005 mm. One impregnation process may be sufficient. The panel shall be immersed in the resin in the direction of the 30 cm length until bubbling stops. It shall be mechanically withdrawn at a uniform rate of 10 cm/min, and allowed to drain for 1 h. If the unadjusted resin leads to specimens below 0,180 mm thickness, a second or more impregnations may be necessary.

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Specimens shall be reversed endwise between subsequent dips to provide a more uniform impregnation. After each dip, the specimens shall be cured in the same vertical position as the last dip and at the temperature and time specified by the resin manufacturer.

4.2.3 Curved electrode system

The curved electrode system shall be in accordance with the dimensions shown in Figure 1. The electrodes shall be of polished brass. The upper (movable) electrode shall have a total mass of 1,8 kg. Provisions shall be made to allow sufficient movement of the upper electrode or lower electrode so that intimate contact between the specimen and both electrodes is assured. This may be done by placing a soft rubber pad under the lower electrode.

The fixture shall be in accordance with the dimensions shown in Figure 1.

Dimensions in millimetres

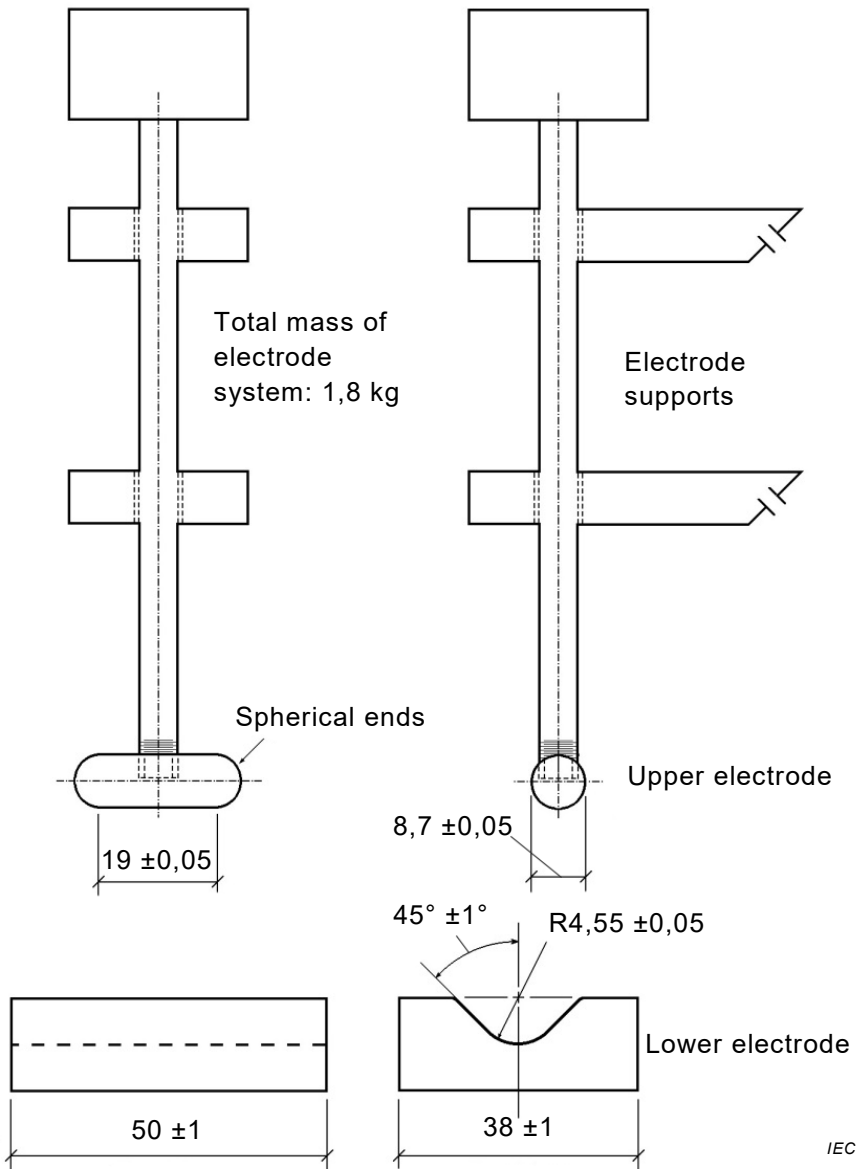

Figure 1 – Curved electrode fixture

4.2.4 Ageing ovens and ageing temperatures

Ovens according to IEC 60216-4-1, IEC 60216-4-2 and IEC 60216-4-3 shall be used.

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At least three ageing temperatures shall be used, preferably more. The ageing temperatures shall differ by 10 K to 20 K. The lowest ageing temperature shall give a thermal life of at least 5 000 h. An ageing temperature giving a thermal life of less than 100 h shall not be used.

4.2.5 Test procedure

4.2.5.1 Specimen thickness

The thickness shall be measured with a screw-type micrometer or a device with similar accuracy prior to heat ageing. At least five measurements evenly distributed across the specimen shall be done and the mean shall be used.

4.2.5.2 Electric strength testing

The electric strength test set shall be in accordance with IEC 60243-1, but using the curved electrode system.

The rate of voltage rise shall be 500 V/s. The electric strength testing shall be done 40 mm apart from the edge of the specimen and 45 mm apart from a previous measurement. The specimen shall be inserted in the curved electrode fixture (see Figure 1) so that the warp threads are bent; the electrode is lowered slowly taking care to avoid injury to the specimen. Six breakdown voltage measurements have to be done. The mean shall be used. For electrical strength, divide the mean breakdown voltage by the mean thickness.

4.2.5.3 Ageing and sequence of testing

One specimen shall be conditioned for at least 4 h at standard atmosphere B according to IEC 60212 (23 °C ± 2 K and 50 % ± 10 % relative humidity) and then tested for electric strength.

Five specimens shall be tagged with aluminium foil or otherwise permanently identified and placed in the specimen holding frames. The fixture containing the specimen frames shall then be placed in the ageing oven and positioned so that it is at least 10 cm from the walls at any point and the specimens are held parallel to the direction of the air flow. One specimen shall be removed at the end of each of three ageing times equal to 25 %, 50 % and 100 % of the estimated thermal life at the selected ageing temperature. After removal, the specimens shall be conditioned for at least 4 h at standard atmosphere B according to IEC 60212 (23 °C ± 2 K and 50 % ± 10 % relative humidity) and then tested for electric strength.

At the time of 50 % of estimated thermal life, five additional specimens shall be tagged and placed in the oven. Similarly, at the time of 75 % of thermal life, the remaining specimens shall be placed in the oven. Plot a graph of the electric strength of each specimen as the ordinate, corresponding to the ageing time as the abscissa. If the thermal life has been underestimated, one specimen of the first group remaining in the oven shall be removed at 150 % of the estimated thermal life and tested. With information now available on aged specimens, each of the remaining specimens shall be removed at chosen intervals so as to establish a curve of electric strength versus exposure time.

This may require filling in between established points or extending beyond if necessary. This procedure assures that sufficient specimens are available to complete the ageing process. The ageing shall be continued until an average electric strength of < 8 kV/mm (based on original average thickness) is reached or heat ageing has progressed to 10 000 h.

Repeat the same procedure with all temperatures.

4.2.5.4 Calculations

The end point criterion is 12 kV/mm. The selection of this end point is arbitrary and based upon experience showing that this value correlates with actual service life. However, when

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