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Electrical insulating materials - Thermal endurance properties -
Part 1: Ageing procedures and evaluation of test results

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Electrical insulating materials - Thermal endurance properties - Part 1: Ageing procedures and evaluation of test results

FOREWORD

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IEC 60216-1 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is an International Standard.

This seventh edition cancels and replaces the sixth edition published in 2013. This edition constitutes a technical revision.

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

a) the definition for temperature index (TI) has been updated;
b) requirements for selection of related materials used, e.g. in different colours (5.1.2), have been added;
c) test procedure for thickness sensitivity (5.5 and 6.6) has been added;
d) Annex C "Concepts in earlier editions" has been deleted.

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

Draft	Report on voting
112/698/FDIS	112/706/RVD

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

The language used for the development of this International Standard is English.

A list of all parts in the IEC 60216 series [1], published under the general title *Electrical insulating materials – Thermal endurance properties*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

– reconfirmed,
– withdrawn, or
– revised.

INTRODUCTION

The listing of the thermal capabilities of electrical insulating materials, based on service experience, was found to be impractical, owing to the rapid development of polymer and insulation technologies and the long time necessary to acquire appropriate service experience. Accelerated ageing and test procedures were therefore needed to obtain the necessary information. The IEC 60216 series [1] has been developed to formalize these procedures and the interpretation of their results.

Physico-chemical models postulated for the ageing processes led to the almost universal assumption of the Arrhenius equations to describe the rate of ageing. Out of this arose the concept of the temperature index (TI) as a single-point characteristic based upon accelerated ageing data. This is the numerical value of the temperature in degrees Celsius at which the time taken for deterioration of a selected property to reach an accepted end-point is that specified (usually 20 000 h).

NOTE The term Arrhenius is widely used (and understood) to indicate a linear relationship between the logarithm of a time and the reciprocal of the thermodynamic (absolute or kelvin) temperature. The correct usage is restricted to such a relationship between a reaction rate constant and the thermodynamic temperature. The common usage is employed throughout this document.

The large statistical scatter of test data which was found, together with the frequent occurrence of substantial deviations from the ideal behaviour, demonstrated the need for tests to assess the validity of the basic physico-chemical model. The application of conventional statistical tests, as set out in IEC 60493-1:2011 [2], fulfilled this requirement, resulting in the confidence limit (TC) of TI, but the simple, single-point TI was found inadequate to describe the capabilities of materials. This led to the concept of the thermal endurance profile (TEP), incorporating the temperature index, its variation with specified ageing time, and a confidence limit.

A complicating factor is that the properties of a material subjected to thermal ageing possibly do not all deteriorate at the same rate, and different end-points can be relevant for different applications. Consequently, a material can be assigned more than one temperature index, derived, for example, from the measurement of different properties and the use of different end-point times.

It was subsequently found that the statistical confidence index included in the TEP was not widely understood or used. However, the statistical tests were considered essential, particularly after minor modifications to make them relate better to practical circumstances: the concept of the halving interval (HIC) was introduced to indicate the rate of change of ageing time with temperature. TEP was then abandoned, with the TI and HIC being reported in a way which indicated whether or not the statistical tests had been fully satisfied. At the same time, the calculation procedures were made more comprehensive, enabling full statistical testing of data obtained using a diagnostic property of any type, including the particular case of partially incomplete data. Simultaneously with the development of the IEC 60216 series [1], other standards were being developed in ISO, intended to satisfy a similar requirement for plastics and rubber materials. These are ISO 2578:1993 [3] and ISO 11346 [4], respectively, which use less rigorous statistical procedures and more restricted experimental techniques. A simplified calculation procedure is defined in IEC 60216-8 [5].

1 Scope

This part of IEC 60216 specifies the general ageing conditions and procedures to be used for deriving thermal endurance characteristics and gives guidance in using the detailed instructions and guidelines in the other parts of IEC 60216.

Although originally developed for use with electrical insulating materials and simple combinations of such materials, the procedures are considered to be of more general applicability and are widely used in the assessment of materials not intended for use as electrical insulation.

In the application of this document, it is assumed that a practically linear relationship exists between the logarithm of the time required to cause the predetermined property change and the reciprocal of the corresponding absolute temperature (Arrhenius relationship).

For the valid application of this document, no transition, in particular no first-order transition, is expected to occur in the temperature range under study.

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 60216-3:2021, *Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics*

IEC 60216-3, *Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics*

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

IEC 60493-1:2011, *Guide for the statistical analysis of ageing test data - Part 1: Methods based on mean values of normally distributed test results*

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

Bibliography

[1] IEC 60216 series, *Electrical insulating materials – Thermal endurance properties*

[2] IEC 60493-1:2011, *Guide for the statistical analysis of ageing test data - Part 1: Methods based on mean values of normally distributed test results*

[3] ISO 2578:1993, *Plastics - Determination of time-temperature limits after prolonged exposure to heat*

[4] ISO 11346, *Rubber, vulcanized or thermoplastic - Estimation of life-time and maximum temperature of use*

[5] IEC 60216-8, *Electrical insulating materials - Thermal endurance properties - Part 8: Instructions for calculating thermal endurance characteristics using simplified procedures*

[6] IEC 60216-2, *Electrical insulating materials - Thermal endurance properties - Part 2: Determination of thermal endurance properties of electrical insulating materials - Choice of test criteria*

[7] IEC 60050-212:2010, *International Electrotechnical Vocabulary - Part 212: Electrical insulating solids, liquids and gases*

[8] IEC 60216-3, *Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics*

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

[10] IEC 60216-3:2021, *Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics*

[11] IEC 60216-8:2013, *Electrical insulating materials - Thermal endurance properties - Part 8: Instructions for calculating thermal endurance characteristics using simplified procedures*

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