PD IEC/TS 60216-7-1:2015

BSI Standards Publication

Electrical insulation materials — Thermal endurance properties

Part 7–1: Accelerated determination of relative thermal endurance using analytical test methods (RTE_A) — Instructions for calculations based on activation energy

bsi.

...making excellence a habit.™

Document Sharing Hub

National foreword

This Published Document is the UK implementation of IEC/TS 60216-7-1:2015.

The UK participation in its preparation was entrusted to Technical Committee GEL/112, Evaluation and qualification of electrical insulating materials and systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2015.

Published by BSI Standards Limited 2015

ISBN 978 0 580 84730 1

ICS 19.020; 29.020; 29.035.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2015.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: PD IEC/TS 60216-7-1:2015

IEC TS 60216-7-1

Edition 1.0 2015-03

TECHNICAL SPECIFICATION

Electrical insulation materials – Thermal endurance properties – Part 7-1: Accelerated determination of relative thermal endurance using analytical test methods (RTE_A) – Instructions for calculations based on activation energy

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.020; 29.020; 29.035.01

ISBN 978-2-8322-2430-4

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: PD IEC/TS 60216-7-1:2015

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms, definitions and abbreviations 7
3.1 Terms and definitions 7
3.2 Abbreviations 9
4 General considerations 9
4.1 Thermal degradation kinetics 9
4.2 Thermal analysis 10
4.3 Thermal endurance 10
5 General basics 11
5.1 Reaction rate, r 11
5.2 Extent of reaction ξ 12
5.3 Rate of conversion $\dot{\xi}$ 12
5.4 Order of reaction, n 12
5.5 Rate law 13
6 Thermokinetic parameter estimation 13
7 Analytical test methods 16
7.1 General 16
7.2 Isothermal methods 16
7.3 Model-free methods 16
7.4 Model-fitting methods 17
7.5 Conventional reference point 17
8 Calculation procedures 17
8.1 Determination of the kinetic parameters 17
8.2 Determination of analytical temperature endurance index, RTE_A, and halving interval, HIC_A 17
8.3 Determination of RTE_A 17
8.3.1 General 17
8.3.2 Calculation 18
9 Test report 19
Bibliography 21

Figure 1 – Thermal endurance graph for the determination of the relative temperature endurance (RTE) 18

Documents
Document Sharing Hub
Full document details: PD IEC/TS 60216-7-1:2015

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSULATION MATERIALS – THERMAL ENDURANCE PROPERTIES –

Part 7-1: Accelerated determination of relative thermal endurance using analytical test methods (RTE_A) – Instructions for calculations based on activation energy

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 60216-7-1, which is a technical specification, has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulation materials and systems.

AVA Documents
Document Sharing Hub
Full document details: PD IEC/TS 60216-7-1:2015

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
112/298/DTS	112/314/RVC

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

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

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

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

Documents
Document Sharing Hub

Full document details: PD IEC/TS 60216-7-1:2015

INTRODUCTION

The existing procedures of the IEC 60216 series for the evaluation of thermal endurance of an electrical insulation material can be time consuming. These methods are therefore of limited use during development of new materials or screening of existing products for use as a material in an electrical insulation. There is an important demand from industry for a rapid test method of relative thermal endurance (RTE) / temperature index (TI) and halving interval (HIC) to reduce project times and cost. A short-term test procedure for conventional thermal endurance characterization is proposed in IEC 60216-5 and a simplified approach to data processing is described in IEC 60216-8. Non-conventional methodology for thermal endurance characterization which can reduce further test times is considered in this technical specification.

The basic procedure is based on thermal analysis methods (DSC and TGA in particular, but not restricted to them) to evaluate the activation energy of the thermal degradation of the material. The activation energy is directly correlated with the HIC of the thermal endurance.

With this information, a single-point thermal endurance test, according to IEC 60216-1 and IEC 60216-5, at the highest temperature of those selected for the conventional thermal ageing procedure, is sufficient to calculate the temperature corresponding to a selected life, typically 20 000 h, i.e. an estimate of TI. However, due to the inherent uncertainty associated with this analytical approach, only RTE can be provided for material characterization. This is obtained performing the single-point thermal endurance test in the same conditions of temperature and environment as a reference material of known thermal endurance characteristics, i.e. TI and HIC.

The analytical test methods described in this technical specification may satisfy the demand of shortening the insulating material characterization procedure, if used with care and considering the restrictions these methods imply. At present, the universal applicability and the accuracy of these methods is not validated, thus a round robin test is required to provide an IEC standard based on these procedures. This part of IEC 60216 is therefore published as a technical specification.

A general assessment process of the procedures will be developed in other sub-parts of IEC 60216-7.

Documents
Document Sharing Hub
Full document details: PD IEC/TS 60216-7-1:2015

ELECTRICAL INSULATION MATERIALS – THERMAL ENDURANCE PROPERTIES –

Part 7-1: Accelerated determination of relative thermal endurance using analytical test methods (RTE_A) – Instructions for calculations based on activation energy

1 Scope

This technical specification describes the procedure for the evaluation of the thermal endurance of electrical insulating materials, based on thermal analysis methods for the evaluation of the activation energy of the thermal degradation reaction and a conventional life test providing a life point in the thermal endurance graph. The purpose of the test procedure is to estimate the relative temperature index (RTE).

Predictions of thermal endurance based on this procedure are limited to ageing reactions where one single reaction is predominant and directly correlated to the end-point criteria for a specific application.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

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

IEC 60216-5, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material.*

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

ISO 11357-6, *Plastics – Differential scanning calorimetry (DSC) – Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)*

ISO 11358-2, *Plastics – Thermogravimetry (TG) of polymers – Part 2: Determination of activation energy*

ISO 11358-3, *Plastics – Thermogravimetry (TG) of polymers – Part 3: Determination of the activation energy using the Ozawa-Friedman plot and analysis of the reaction kinetics*

Documents
Document Sharing Hub
Full document details: PD IEC/TS 60216-7-1:2015