PD IEC/TR 60216-7-2:2016

BSI Standards Publication

Electrical insulating materials — Thermal endurance properties

Part 7-2: Results of the round robin tests to validate procedures of IEC TS 60216-7-1 by non-isothermal kinetic analysis of thermogravimetric data

Documents
Document Sharing Hub

Full document details: PD IEC/TR 60216-7-2:2016

National foreword

This Published Document is the UK implementation of IEC/TR 60216-7-2:2016.

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 2016.
Published by BSI Standards Limited 2016

ISBN 978 0 580 92883 3
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 September 2016.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: PD IEC/TR 60216-7-2:2016

IEC TR 60216-7-2

Edition 1.0 2016-08

TECHNICAL REPORT

colour inside

Electrical insulating materials – Thermal endurance properties – Part 7-2: Results of the round robin tests to validate procedures of IEC TS 60216-7-1 by non-isothermal kinetic analysis of thermogravimetric data

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.020; 29.020; 29.035.01

ISBN 978-2-8322-3606-2

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/TR 60216-7-2:2016

CONTENTS

FOREWORD....4
INTRODUCTION....6
1 Scope....7
2 Normative references....7
3 Terms and definitions....7
4 Test specimens....8
5 Test apparatus....9
5.1 Thermogravimetric analyser (TGA)....9
5.2 Purge gas supplied into the TGA furnace....9
6 Test procedures....9
6.1 General....9
6.2 Preconditioning of test samples....10
6.3 TGA tests with multiple heating rates....10
6.4 Calculation of the activation energy (E_a)....10
6.5 Determination of thermal endurance using TGA....11
6.5.1 General....11
6.5.2 Determination of RTE_A by given degree of conversion from reference material (Method A)....11
6.5.3 Determination of TI_A by fixed degree of conversion at 0,05 (Method B)....12
7 Round robin test results....12
7.1 TGA test results....12
7.2 Degree of conversion correlated to the activation energy from conventional heat ageing data....12
7.3 HIC_A determined by Method A and Method B....13
7.4 RTE_A determined by Method A and TI_A by Method B....14
7.5 Difference between RTE_A and TI determined by the conventional heat ageing tests....16
8 Observations from the round robin test results....17
8.1 General....17
8.2 Sample weight variation....18
8.3 Humidity and hydrolysis of the sample....19
8.4 Consideration on repeatability of TGA curves....20
8.5 Baseline drift and responsiveness to heating rates of TGA....21
9 Conclusion and recommendation....24
Bibliography....26

Figure 1 – Fitting curve of plots between degree of conversion and activation energy determined by ISO 11358-2 (example)....11
Figure 2 – Correlation between the initial sample mass of sample A and the difference of RTE_A (TI_A) from TI....19
Figure 3 – Correlation between the initial sample mass of sample B and the difference of RTE_A (TI_A) from TI....19
Figure 4 – Overlay charts of TGA curves in multiple heating rates in multiple laboratories (enlarged)....22
Figure 5 – Logarithm plots for activation energy calculation....23
Figure 6 – Fitting curves of degree of conversion vs. activation energy by TGA....24

AVA Documents
Document Sharing Hub
Full document details: PD IEC/TR 60216-7-2:2016

Table 1 – Heat ageing properties of the test specimens by the conventional procedure described in IEC 60216-5 9
Table 2 – Degree of conversion identical to the activation energy of the conventional heat ageing 13
Table 3 – HIC_A determined by Method A and Method B for dielectric strength 13
Table 4 – HIC_A determined by Method A and Method B for tensile strength 14
Table 5 – HIC_A determined by Method A and Method B for impact strength 14
Table 6 – RTE_A determined by Method A and TI_A by Method B for dielectric strength 15
Table 7 – RTE_A determined by Method A and TI_A by Method B for tensile strength 15
Table 8 – RTE_A determined by Method A and TI_A by Method B for impact strength 16
Table 9 – Difference between RTE_A or TI_A, and TI for dielectric strength 16
Table 10 – Difference between RTE_A or TI_A, and TI for tensile strength 17
Table 11 – Difference between RTE_A or TI_A, and TI for impact strength 17
Table 12 – Comparison of degree of conversion with original or rerun data at 8 K/min 21

Documents
Document Sharing Hub
Full document details: PD IEC/TR 60216-7-2:2016

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSULATING MATERIALS – THERMAL ENDURANCE PROPERTIES –

Part 7-2: Results of the round robin tests to validate procedures of IEC TS 60216-7-1 by non-isothermal kinetic analysis of thermogravimetric data

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. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 60216-2-7, which is a Technical Report, has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.

Documents
Document Sharing Hub
Full document details: PD IEC/TR 60216-7-2:2016

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
112/354/DTR	112/370/RVC

Full information on the voting for the approval of this Technical Report 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 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.

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

Documents
Document Sharing Hub

Full document details: PD IEC/TR 60216-7-2:2016

INTRODUCTION

IEC technical committee 112, (IEC/TC112) has been working on the development of IEC TS 60216-7-1 that considers the use of activation energy determined through thermal analytical tools plus abbreviated conventional heat ageing to determine a thermal index on a polymeric compound. At the same time, the UL LTTA Forum has been discussing alternative methods that could speed up the determination of a thermal index. Members of the IEC/TC112 and of the UL LTTA Forum have joined efforts to determine whether the Technical Specification developed by IEC/TC112 can be used to offer an alternative method of evaluating polymeric compounds for a thermal index.

Members of IEC/TC112 and the UL LTTA Forum decided to conduct a round robin test (RRT) using thermogravimetric analysis (TGA) according to ISO 11358-2 on a known compound, with a known activation energy determined through conventional ageing with a view to validate the acceptability of IEC TS 60216-7-1, and to determine whether a similar thermal index could be calculated. The round robin testing was conducted with conventional TGA by multiple heating rates. However, running isothermal tests can be a follow up of this RRT.

Documents
Document Sharing Hub
Full document details: PD IEC/TR 60216-7-2:2016

ELECTRICAL INSULATING MATERIALS – THERMAL ENDURANCE PROPERTIES –

Part 7-2: Results of the round robin tests to validate procedures of IEC TS 60216-7-1 by non-isothermal kinetic analysis of thermogravimetric data

1 Scope

The purpose of this part of IEC 60216, which is a Technical Report, is to validate the procedures of IEC TS 60216-7-1 in providing a similar temperature index to conventional methods used in other parts of the IEC 60216 series.

These round robin test results do not provide statistical analysis for precisions. The round robin test focuses on preliminary studies to understand the evaluation and calculation procedures, influence on apparatus, and data variance among laboratories before determination of precisions.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

3.1
activation energy
Arrhenius activation energy
E_a
empirical parameter characterizing the exponential temperature dependence of the reaction rate constant

[SOURCE: IUPAC “Goldbook”]

3.2
end-point
limit for a diagnostic property value based on which the thermal endurance is evaluated

3.3
time to end-point
failure time
time to reach the end point or conventional failure

3.4
relative temperature endurance index
RTE
numerical value of the temperature in degrees Celsius at which the estimated time to end-point of the candidate material is the same as the estimated time to end-point of the reference material at a temperature equal to its assessed temperature index

Note 1 to entry: RTE_A is the relative temperature endurance index calculated through the analytical procedure.

AVA Documents
Document Sharing Hub
Full document details: PD IEC/TR 60216-7-2:2016