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Irish Standard
I.S. EN 60544-2:2012

Electrical insulating materials - Determination of the effects of ionizing radiation on insulating materials -- Part 2: Procedures for irradiation and test (IEC 60544-2:2012 (EQV))

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60544-2

October 2012

ICS 17.240; 29.035.01

English version

Electrical insulating materials - Determination of the effects of ionizing radiation on insulating materials - Part 2: Procedures for irradiation and test

(IEC 60544-2:2012)

Matériaux isolants électriques - Détermination des effets des rayonnements ionisants sur les matériaux isolants - Partie 2: Méthodes d'irradiation et d'essai (CEI 60544-2:2012)

Elektroisolierstoffe - Bestimmung der Auswirkungen ionisierender Strahlung auf Isolierstoffe - Teil 2: Verfahren zur Bestrahlung und Prüfung (IEC 60544-2:2012)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Ref. No. EN 60544-2:2012 E

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Foreword

The text of document 112/208/FDIS, future edition 3 of IEC 60544-2, prepared by IEC/TC 112 "Evaluation and qualification of electrical insulating materials and systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60544-2:2012.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-05-13
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-08-13

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60093	-	Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials	HD 429 S1	-
IEC 60167	-	Methods of test for the determination of the insulation resistance of solid insulating materials	HD 568 S1	-
IEC 60212	-	Standard conditions for use prior to and during the testing of solid electrical insulating materials	EN 60212	-
IEC 60243-1	-	Electrical strength of insulating materials - Test methods - Part 1: Tests at power frequencies	EN 60243-1	-
IEC 60544-1	-	Electrical insulating materials - Determination of the effects of ionizing radiation - Part 1: Radiation interaction and dosimetry	EN 60544-1	-
IEC 60544-4	-	Electrical insulating materials - Determination of the effects of ionizing radiation - Part 4: Classification system for service in radiation environments	EN 60544-4	-
ISO 37	-	Rubber, vulcanized or thermoplastic - Determination of tensile stress-strain properties	-	-
ISO 48	-	Rubber, vulcanized or thermoplastic - Determination of hardness (hardness between 10 IRHD and 100 IRHD)	-	-
ISO 178	-	Plastics - Determination of flexural properties	EN ISO 178	-
ISO 179	Series	Plastics - Determination of Charpy impact properties	EN ISO 179	Series
ISO 527	Series	Plastics - Determination of tensile properties	EN ISO 527	Series
ISO 815	Series	Rubber, vulcanized or thermoplastic - Determination of compression set	-	
ISO 868	-	Plastics and ebonite - Determination of indentation hardness by means of a durometer (Shore hardness)	EN ISO 868	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSULATING MATERIALS – DETERMINATION OF THE EFFECTS OF IONIZING RADIATION ON INSULATING MATERIALS –

Part 2: Procedures for irradiation and test

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.
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International Standard IEC 60544-2 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.

This third edition cancels and replaces the second edition, published in 1991, and constitutes a technical revision.

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

– alignment with standards recently developed by SC 45A as well as with other parts in the IEC 60544 series.

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

FDIS	Report on voting
112/208/FDIS	112/216/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.

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

A list of all parts of the IEC 60544 series can be found, under the general title *Electrical insulating materials – Determination of the effects of ionizing radiation on insulating materials*, on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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

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

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INTRODUCTION

When selecting insulating materials for applications in radiation environments, the component designers should have available reliable test data to compare candidate materials. To be meaningful, the performance data should be obtained on each material by standardized procedures, and the procedures should be designed to demonstrate the influence that variations of the service conditions have on the significant properties. This point is of particular concern where in normal service conditions low dose rates exist and where the insulation materials have been selected from radiation endurance data obtained from tests conducted at high dose rates.

Environmental conditions shall be well controlled and documented during the measurement of radiation effects. Important environmental parameters include temperature, reactive medium and mechanical and electrical stresses present during the irradiation. If air is present, radiation-induced species can enter into reactions with oxygen that would not occur in its absence. This is responsible for an observed influence of the absorbed dose rate for certain types of polymers if irradiated in air. As a result, the resistance may be several orders of magnitude lower than when the sample is irradiated under vacuum or in the presence of inert gas. This is generally called the "dose-rate effect", which is described and reviewed in references [1] to [14][1].

NOTE For the user of this Part of IEC 60544 who wants to go into more detail, the cited references are listed in the Bibliography. Where these are not publications in internationally available journals, addresses where the cited scientific reports can be obtained are given at the end of the references.

The irradiation time can become relevant because of time-dependent complications caused by:

a) physical effects such as diffusion-limited oxidation [8], [10]; and

b) chemical phenomena such as rate-determining hydroperoxide breakdown reactions [10], [14].

Typical diffusion-limited effects are commonly observed in radiation studies of polymers in air. Their importance depends upon the interrelationship of the geometry of the polymer with the oxygen permeation and consumption rates, both of which depend upon temperature [10]. This means that the irradiation of thick samples in air may result in oxidation only near the air-exposed surfaces of the sample, resulting in material property changes similar to those obtained by irradiation in an oxygen-free environment. Therefore, when the material is to be used in air for a long period of time at a low dose rate, depositing the same total dose at a high dose rate in a short exposure period may not determine its durability. Previous experiments or considerations of sample thickness combined with estimates of oxygen permeation and consumption rates [8], [10] may eliminate such concerns. A technique that may be useful for eliminating oxygen diffusion effects by increasing the surrounding oxygen pressure is under investigation [8].

Radiation-induced reactions will be influenced by temperature. An increase in reaction rate with temperature can result in a synergistic effect of radiation and heat. In the case of the more commonly used thermal ageing prediction, the Arrhenius method is employed; this makes use of an equation based on fundamental chemical kinetics. Despite considerable ongoing investigations of radiation ageing methodologies, this field is much less developed [9]. General equations involving dose, time, Arrhenius activation energy, dose rate and temperature are being tested for modelling of ageing experiments [10-12]. It should be noted that sequential application of radiation and heat, as it is frequently practised, can give very different results depending on the order in which they are performed, and that synergistic effects may not be properly simulated [13], [14].

The electrical and mechanical properties required of insulating materials and the acceptable amount of radiation-induced changes are so varied that it is not possible to establish

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1 References in square brackets refer to the bibliography.

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acceptable properties within the framework of a recommendation. The same holds for the irradiation conditions. Therefore, this standard recommends only a few properties and irradiation conditions which previous experience has shown to be appropriate. The properties recommended are those that are especially sensitive to radiation. For a specific application, other properties may have to be selected.

Part 1 of IEC 60544 constitutes an introduction dealing very broadly with the problems involved in evaluating radiation effects. It also provides a guide to dosimetry terminology, several methods of determining the exposure and absorbed dose, and methods of calculating the absorbed dose in any specific material from the dosimetry method applied. The present part describes procedures for irradiation and test. Part 4 of IEC 60544 defines a classification system to categorize the radiation endurance of insulating materials. It provides a set of parameters characterizing the suitability for radiation service. It is a guide for the selection, indexing and specification of insulating materials. The earlier Part 3 of IEC 60544 has been incorporated into the present Part 2.

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ELECTRICAL INSULATING MATERIALS – DETERMINATION OF THE EFFECTS OF IONIZING RADIATION ON INSULATING MATERIALS –

Part 2: Procedures for irradiation and test

1 Scope

This Part of IEC 60544 specifies the controls maintained over the exposure conditions during and after the irradiation of insulating materials with ionizing radiation prior to the determination of radiation-induced changes in physical or chemical properties.

This standard specifies a number of potentially significant irradiation conditions as well as various parameters which can influence the radiation-induced reactions under these conditions.

The objective of this standard is to emphasize the importance of selecting suitable specimens, exposure conditions and test methods for determining the effect of radiation on appropriately chosen properties. Since many materials are used either in air or in inert environments, standard exposure conditions are recommended for both of these situations.

It should be noted that this standard does not consider measurements which are performed during the irradiation.

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 60093, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60167, *Methods of test for the determination of the insulation resistance of solid insulating materials*

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

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

IEC 60544-1, *Electrical insulating materials – Determination of the effects of ionizing radiation – Part 1: Radiation interaction and dosimetry*

IEC 60544-4, *Electrical insulating materials – Determination of the effects of ionizing radiation – Part 4: Classification system for service in radiation environments*

ISO 37, *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

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