

**Električni izolacijski materiali – Ugotavljanje učinkov ionizirnega sevanja - 5.  
del: Postopki za ocenjevanje staranja med uporabo (IEC 60554-5:2003)**

Electrical insulating materials - Determination of the effects of ionizing radiation -  
Part 5: Procedures for assessment of ageing in service (IEC 60554-5:2003)

**iTeh STANDARD PREVIEW  
(standards.iteh.ai)**

[SIST EN 60544-5:2004](https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004)

[https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-  
286b9145b69c/sist-en-60544-5-2004](https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004)

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 60544-5:2004

<https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004>

EUROPEAN STANDARD

**EN 60544-5**

NORME EUROPÉENNE

EUROPÄISCHE NORM

April 2003

ICS 17.240; 29.035.01

English version

**Electrical insulating materials -  
Determination of the effects of ionizing radiation  
Part 5: Procedures for assessment of ageing in service  
(IEC 60544-5:2003)**

Matériaux isolants -  
Détermination des effets  
des rayonnements ionisants  
Partie 5: Procédures pour l'estimation  
du vieillissement en service  
(CEI 60544-5:2003)

Elektroisolierstoffe -  
Bestimmung der Wirkung  
ionisierender Strahlung  
Teil 5 : Bewertungsverfahren für die  
Alterung während des Einsatzes  
(IEC 60544-5:2003)

**iTeh STANDARD PREVIEW  
(standards.iteh.ai)**

SIST EN 60544-5:2004

<https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004>

This European Standard was approved by CENELEC on 2003-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

**CENELEC**

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

The text of document 15E/210/FDIS, future edition 1 of IEC 60544-5, prepared by SC 15E, Methods of test, of IEC TC 15, Insulating materials, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60544-5 on 2003-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2004-01-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2006-04-01

Annexes designated "normative" are part of the body of the standard.  
In this standard, annex ZA is normative.  
Annex ZA has been added by CENELEC.

---

## Endorsement notice

The text of the International Standard IEC 60544-5:2003 was approved by CENELEC as a European Standard without any modification.

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 60544-5:2004

<https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004>

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60544-1	1994	Electrical insulating materials - Determination of the effects of ionizing radiation Part 1: Radiation interaction and dosimetry	EN 60544-1	1994
IEC 60544-2	1991	Guide for determining the effects of ionizing radiation on insulating materials Part 2: Procedures for irradiation and test	-	-
IEC/TR2 61244-1	1993	Determination of long-term radiation ageing in polymers Part 1: Techniques for monitoring diffusion-limited oxidation	-	-
IEC/TR2 61244-2	1996	Part 2: Procedures for predicting ageing at low dose rates	-	-
IEC/TR2 61244-3	1998	Long-term radiation ageing in polymers Part 3: Procedures for in-service monitoring of low-voltage cable materials	-	-

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 60544-5:2004

<https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004>

NORME  
INTERNATIONALE  
INTERNATIONAL  
STANDARD

CEI  
IEC

60544-5

Première édition  
First edition  
2003-02

---

---

**Matériaux isolants –  
Détermination des effets des  
rayonnements ionisants –**

**Partie 5:**

**Procédures pour l'estimation  
du vieillissement en service**

iteh STANDARD PREVIEW  
(standards.iteh.ai)

**Electrical insulating materials –  
Determination of the effects of  
ionizing radiation –**

SIST EN 60544-5:2004  
<https://standards.iteh.ai/catalog/standards/sist/ced07611-5412-434a-bc4b-2003/60544-5-2004>

**Part 5:**

**Procedures for assessment  
of ageing in service**

© IEC 2003 Droits de reproduction réservés — Copyright - all rights reserved

Aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'éditeur.

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

CODE PRIX  
PRICE CODE

V

Pour prix, voir catalogue en vigueur  
For price, see current catalogue

## CONTENTS

FOREWORD .....	7
INTRODUCTION .....	11
1 Scope and object .....	13
2 Normative references.....	13
3 Abbreviations.....	13
4 Background .....	15
4.1 Diffusion limited oxidation (DLO) .....	15
4.2 Dose rate effects (DRE).....	17
4.3 Accelerated ageing .....	17
4.4 Approaches to ageing assessment.....	19
5 Condition monitoring techniques .....	19
5.1 Introduction .....	19
5.2 Establishment of correlation curves for CM methods.....	21
5.3 Indenter .....	23
5.4 Oxidation induction time (OIT) .....	25
5.5 Oxidation induction temperature (OITP).....	29
5.6 Thermogravimetric analysis (TGA).....	31
5.7 Density measurements .....	35
6 Equipment deposit .....	39
6.1 Requirements of a deposit.....	41
6.2 Installation of an equipment deposit.....	41
6.3 Testing of samples from the deposit.....	43
6.4 Determination of sampling intervals.....	43
6.5 Real-time aged equipment and operating experience.....	45
Bibliography.....	63
Figure 1 – Development of ageing data on changes in tensile elongation and a condition indicator (for example, indenter modulus) – Schematic.....	49
Figure 2 – Correlation curve derived from data in Figure 1 – Schematic.....	51
Figure 3 – Correlation curve for indenter modulus against tensile elongation for a CSPE cable jacket material [7] .....	51
Figure 4 – Typical force – Displacement curve from indenter measurements, showing definition of indenter modulus .....	53
Figure 5 – Typical shape of thermogram from an OIT test, showing baseline and onset determination (method B) – Schematic.....	53
Figure 6 – Shape of thermogram from an OIT test with no well-defined baseline – Schematic .....	55
Figure 7 – Shape of thermogram from an OIT test with multiple onsets – Schematic.....	55
Figure 8 – Shape of thermogram from a typical OITP test on a semi-crystalline material (for example, XLPE) – Schematic.....	57
Figure 9 – Shape of test data plot from a typical TGA test – Schematic.....	57
Figure 10 – Example of correlation curve for TGA data against tensile elongation, for a PVC sheath material [7] .....	59



Figure 11 – Reverse temperature effect during radiation ageing of XLPE cable insulation material during radiation ageing at elevated temperature [20].....59

Figure 12 – Determination of lead times for a cable deposit – Schematic [21] .....61

Table 1 – Recommended test parameter values for indenter measurements .....47

Table 2 – Recommended test temperatures for OIT measurements.....47

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 60544-5:2004

<https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004>

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

**Part 5: Procedures for assessment of ageing in service**

## FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60544-5 has been prepared by subcommittee 15E: Methods of test, of IEC technical committee 15: Insulating materials.

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

FDIS	Report on voting
15E/210/FDIS	15E/214/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.

IEC 60544 consists of the following parts, under the general title *Electrical insulating materials – Determination of the effects of ionizing radiation*:

Part 1: Radiation interaction and dosimetry

Part 2: Procedures for irradiation and test

Part 3: (now incorporated into Part 2)

Part 4: Classification system for service in radiation environments

Part 5: Procedures for assessment of ageing in service

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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

## **iTeh STANDARD PREVIEW (standards.iteh.ai)**

SIST EN 60544-5:2004

<https://standards.iteh.ai/catalog/standards/sist/ced026f1-54f2-434a-bc4b-286b9145b69c/sist-en-60544-5-2004>

## INTRODUCTION

Organic materials provide a significant proportion of insulations used in electrical systems. These materials are sensitive to the effects of irradiation and the response varies widely between different types. It is therefore important to be able to assess the degree of degradation of these insulating materials during their service lifetimes. This part of IEC 60544 provides recommended procedures for monitoring ageing of insulating materials in service.

There are a number of approaches to the assessment of ageing of polymer-based components exposed to radiation environments [1], [2]<sup>1</sup>. These are based on better understanding of the factors affecting ageing degradation which has been developed over the last 15 years. In a nuclear power plant, qualification programmes are normally used for selection of components, including those based on polymeric materials. These initial qualification procedures, such as IEEE-323 [3], were written before ageing was well understood. Most of the methods discussed in this document are therefore used to address the limitations of the initial qualification process.

This part is the fifth in a series dealing with the effect of ionizing radiation on insulating materials.

Part 1 (Radiation interaction) constitutes an introduction dealing very broadly with the problems involved in evaluating radiation effects. It also gives a guide to dosimetry terminology, several methods of determining exposure and absorbed dose, and methods of calculating absorbed dose in any specific material from the dosimetry method applied.

Part 2 (Procedures for irradiation and test) describes procedures for maintaining seven different types of exposure conditions during irradiation. It also specifies the controls that shall be maintained over these conditions so that when test results are reported, reliable comparisons of material performance can be made. It also defines certain important irradiation conditions and test procedures to be used for property change determinations and corresponding end-point criteria.

Part 3 has been incorporated into Part 2.

Part 4 (Classification system for service in radiation environments) provides a recommended classification system for categorizing the radiation endurance of insulation materials.

---

<sup>1</sup> Figures in square brackets refer to the bibliography.