

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Evaluation and qualification of electrical insulation systems

Évaluation et qualification des systèmes d'isolation électrique

IEC 60505:2011

<https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2011 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, 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 either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, 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 la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

[IEC 60505:2011](#)

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00



IEC 60505

Edition 4.0 2011-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Evaluation and qualification of electrical insulation systems

Évaluation et qualification des systèmes d'isolation électrique

ITeH STANDARD PREVIEW
(standards.iteh.ai)
<https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE **XC**
CODE PRIX

ICS 29.080.30

ISBN 978-2-88912-539-5

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	9
3.1 General terms	10
3.2 Terms related to service stresses and ageing.....	10
3.3 Terms related to testing.....	11
4 Ageing.....	12
4.1 Ageing mechanism	12
4.2 Assessment of ageing mechanisms.....	14
4.3 Electrical ageing.....	15
4.4 Thermal ageing	17
4.5 Mechanical ageing	19
4.6 Environmental ageing.....	21
4.7 Accelerated ageing.....	22
4.8 Multifactor ageing.....	23
5 Basic evaluation considerations.....	23
5.1 Elements for preparing an evaluation method.....	23
5.1.1 Object	23
5.1.2 Service conditions	23
5.1.3 Life values.....	24
5.2 Types of evaluation procedures.....	24
5.3 Choice of the test object.....	26
5.4 Experimental test procedures	26
5.5 Conclusions for standardization practices.....	27
6 Functional ageing tests.....	27
6.1 Test objects.....	27
6.1.1 Construction of test objects	27
6.1.2 Number of test objects.....	28
6.1.3 Quality assurance tests	28
6.1.4 Preconditioning subcycle	28
6.1.5 Initial diagnostic tests	28
6.1.6 Reference EIS	28
6.2 Test conditions	28
6.2.1 Continuous and cyclic testing	28
6.2.2 Levels of test stresses, ageing factors and diagnostic factors.....	29
6.3 Determination of EIS service life	29
6.3.1 Extrapolation of life test results	29
6.3.2 Comparison of life test data	29
6.4 Diagnostics	30
6.4.1 Diagnostic tests – End point criteria.....	30
6.4.2 Additional specific tests	31
6.5 Analysing the data.....	31
6.6 Test report	31
Annex A (informative) Glossary.....	32

Bibliography.....	71
Figure 1 – Ageing of an EIS	13
Figure 2 – Intrinsic/extrinsic electrical ageing of practical EIS	15
Figure 3 – Intrinsic/extrinsic thermal ageing of practical EIS	17
Figure 4 – Intrinsic/extrinsic mechanical ageing of practical EIS	20
Figure 5 – Intrinsic/extrinsic environmental ageing of practical EIS	22
Figure 6 – Elements of evaluation methods.....	23
Figure 7 – Type of evaluation procedure	25
Figure 8 – Selection of test object.....	26
Figure 9 – Establishing the test method	27
Figure A.1 – Surface abrasion damage	32
Figure A.2 – Surface enamel peeling like string	32
Figure A.3 – Scheme of the measurement set-up for the charging/discharging current.....	33
Figure A.4 – Example of sample preparation.....	33
Figure A.5 – Charging/discharging current on HDPE film	34
Figure A.6 – Property versus time behaviour, detection of threshold (end point, p_L) and maintenance time.....	35
Figure A.7 – Correspondence between the ageing plots of the property p (in red), obtained at different stress levels, and the resulting life line	35
Figure A.8 – Example of charge injection of positive carriers (holes) from the anode and of negative charge carriers (electrons) from the cathode in a PE flat specimen, detected by space charge measurement performed by PEA method	36
Figure A.9 – Stress-strain curve for a typical material.....	37
Figure A.10 – Scheme of measurement set- up for charging/discharging current	38
Figure A.11 – Example of sample preparation.....	38
Figure A.12 – Charging/discharging current on HDPE film	38
Figure A.13 – Charging current at 135 °C and different values of DC electrical field	39
Figure A.14 – Charging current at 120 °C and different values of DC electrical field	39
Figure A.15 – Corona at post insulator head	40
Figure A.16 – Corona on top and arcing to ground.....	40
Figure A.17 – Stages of mechanical ductile fracture (cracking) (Source unknown).....	41
Figure A.18 – Photo showing orderings in epoxy structure and void.....	42
Figure A.19 – Discharge between conductors through air.....	44
Figure A.20 – Paper insulation degraded by electrical surface discharges	44
Figure A.21 – Example of electric strength test on XLPE sample 0,2 mm thick.....	45
Figure A.22 – Two parameters Weibull plot electric strength results performed on seven XLPE specimens, 0,2 mm thick.....	45
Figure A.23 – Loss angle of a dielectric	47
Figure A.24 – Loss factor for pre-treated and thermally aged (at 110 °C and 130 °C) XLPE cables measured at 90 °C plotted vs. frequency.....	47
Figure A.25 – Field lines from a positive charge above a plane conductor.....	48
Figure A.26 – Electrical tree.....	49
Figure A.27 – EPDM ashing and erosion on fitting	50
Figure A.28 – Failing external insulation	51

Figure A.29 – Failing external insulation	51
Figure A.30 – Critical failure of solid cable insulation (XLPE) by electrical breakdown	52
Figure A.31 – Example flashover	53
Figure A.32 – Substation – Outdoor installation	54
Figure A.34 – Internal interfaces in epoxy structure and void	56
Figure A.35 – Example of craze and crack development in an inter-lamellar space under mechanical tension T	57
Figure A.36 – Water treeing	58
Figure A.37 – After 11 years in service UV and moisture impact	59
Figure A.38 – Random (amorphous) structure of a molecular chain	59
Figure A.39 – Oriented structure (semi-crystalline) of a molecular chain	59
Figure A.40 – Typical morphology of melt-grown polyethylene spherulites	60
Figure A.41 – Areas in which PD generally occur	61
Figure A.42 – Classes of defect – Internal, surface and corona PD	61
Figure A.43 – Basic PD measurement circuit	62
Figure A.44 – Examples of PD patterns relevant to internal, surface and corona PD	62
Figure A.45 – GIS research – Metal conductor protrusion	63
Figure A.46 – Internally strained epoxy – Frozen in strains in epoxy resin due to thermal stress, measured by TMA curves	64
Figure A.47 – Externally strained parts in an on-load tap changer (OLTC)	64
Figure A.48 – A material being loaded in a) compression, b) tension, c) shear	65
Figure A.49 – Effect of thermal-mechanical stresses leading to interfacial electrical tracking	66
Figure A.50 – Stress-strain curve for a typical material	66
Figure A.51 – Over crimped rod; breaks during tensile test	67
Figure A.52 – Typical installation fault	68
Figure A.53 – Surface tracking on sheds and fitting end	68
Figure A.54 – Vented trees – Initiate at interface	69
Figure A.55 – Tape wrinkling	70
Table 1 – Ageing temperatures	19
Table 2 – Cyclical and continuous procedures	30

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EVALUATION AND QUALIFICATION OF ELECTRICAL INSULATION SYSTEMS

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.

International Standard IEC 60505 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.

This fourth edition cancels and replaces the third edition, published in 2004, and constitutes a technical revision.

The main change with respect to the previous edition is the addition of a Glossary in the form of Annex A to this standard.

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

FDIS	Report on voting
112/174/FDIS	112/184/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.

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.

The contents of the corrigendum of March 2017 have been included in this copy.

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.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[IEC 60505:2011](#)

<https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011>

INTRODUCTION

The life of an electrical insulation system (EIS) or systems frequently determines the life of electrical equipment which can be affected by electrical, thermal, mechanical or environmental stresses acting either individually or in combination.

Intended, estimated or proven service life times are essential parameters for describing the life of electrical insulation systems. In the early days of electrotechnical engineering, life figures were rather vague. The limitation of the life of the insulation under thermal stress was one of the first indicators of the effect of ageing in some equipment in service. As experience in using EIS increased, it was appreciated that there was a need to select specific materials having satisfactory life time at a given temperature, to enable the required service life to be achieved and to allow for the calculation of the thermal capability of equipment.

The user of this standard may evaluate existing test methods and provide correlation with his equipment. Therefore, the user of this standard is responsible for demonstrating the validity of the existing test method in accordance with the principles of this standard.

The determination of the prospective life is a fundamental task when developing and designing an EIS. Estimated service life of an EIS needs to be established for several reasons:

- for type testing when introducing a new EIS into production;
- for quality assurance of production;
- for estimating the life expectancy of new equipment;
- for estimating the remaining life for maintenance purposes.

“Ageing” focuses on the mechanisms affecting the EIS performance. “Evaluation” links these potential mechanisms by “Analysis” and “Diagnostics” to the design of a specific kind of evaluation test procedure.

The keyword structure below meets such requirements and allows an easier choice of the parts of interest.

```
graph TD; Root[Evaluation of EIS] --> 4[4. Ageing]; Root --> 5[5. Basic Consideration of Evaluation]; Root --> 6[6. Functional Ageing Tests]; 4 --> 4.1[4.1 Ageing]; 4 --> 4.2[4.2 Assessment of Ageing Mechanisms]; 4 --> 4.3[4.3 Electrical Ageing]; 4 --> 4.4[4.4 Thermal Ageing]; 4 --> 4.5[4.5 Mechanical Ageing]; 4 --> 4.6[4.6 Environmental Ageing]; 4 --> 4.7[4.7 Accelerated Ageing]; 4 --> 4.8[4.8 Multifactor Ageing]; 5 --> 5.1[5.1 Element for preparing Evaluation]; 5 --> 5.2[5.2 Type of Evaluation]; 5 --> 5.3[5.3 Choice of Test Object]; 5 --> 5.4[5.4 Experimental Data Procedure]; 6 --> 6.1[6.1 Test Objects]; 6 --> 6.2[6.2 Test Conditions]; 6 --> 6.3[6.3 Determination of EIS Service Life]; 6 --> 6.4[6.4 Diagnostic]; 6 --> 6.5[6.5 Analyzing the Data]; 6 --> 6.6[6.6 Test Report];
```

CONTENTS

1. Keywords

2. References

3. Definitions
IEC 60505:2011
<https://standards.iteh.ai/catalog/standards/sisr/60505/iec-60505-2011>

Evaluation of EIS

4. Ageing

- 4.1 Ageing
- 4.2 Assessment of Ageing Mechanisms
- 4.3 Electrical Ageing
- 4.4 Thermal Ageing
- 4.5 Mechanical Ageing
- 4.6 Environmental Ageing
- 4.7 Accelerated Ageing
- 4.8 Multifactor Ageing

5. Basic Consideration of Evaluation

- 5.1 Element for preparing Evaluation
- 5.2 Type of Evaluation
- 5.3 Choice of Test Object
- 5.4 Experimental Data Procedure

6. Functional Ageing Tests

- 6.1 Test Objects
- 6.2 Test Conditions
- 6.3 Determination of EIS Service Life
- 6.4 Diagnostic
- 6.5 Analyzing the Data
- 6.6 Test Report

iteh STANDARDS PREVIEW
(standards.iteh.ai)

EVALUATION AND QUALIFICATION OF ELECTRICAL INSULATION SYSTEMS

1 Scope

This International Standard establishes the basis for estimating the ageing of electrical insulation systems (EIS) under conditions of either electrical, thermal, mechanical, environmental stresses or combinations of these (multifactor stresses).

It specifies the principles and procedures that shall be followed, during the development of EIS functional test and evaluation procedures, to establish the estimated service life for a specific EIS.

This standard should be used by all IEC technical committees responsible for equipment having an EIS.

2 Normative references

The following referenced documents are indispensable for the application 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 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*
<https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011>

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

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

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

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

IEC/TS 61251, *Electrical insulating materials – AC voltage endurance evaluation – Introduction*

IEC 62539, *Guide for the statistical analysis of electrical insulation breakdown data*

3 Terms and definitions

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

3.1 General terms

3.1.1

electrical insulation system

EIS

insulating structure containing one or more electrical insulating materials (EIM) together with associated conducting parts employed in an electrotechnical device

3.1.2

electrical insulating material

EIM

material with negligibly low electric conductivity, used to separate conducting parts at different electrical potentials

[IEC 60050-212:2010, 212-11-01, modified]

3.1.3

reference EIS

established EIS evaluated on the basis of either a known service experience record or a known comparative functional evaluation

3.1.4

candidate EIS

EIS under evaluation to determine its service capability (with regard to electrical, thermal, mechanical, environmental or multifactor stresses)

3.1.5

intended life

design life of an EIS under service conditions

[IEC 60505:2011](https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011)

3.1.6

estimated life

expected service life derived from either service experience or the results of tests performed in accordance with appropriate evaluation procedures, or both, as established by the responsible organization or technical committee

3.1.7

evaluation

establishment of relationships between service requirements and life data obtained from service experience analysis or from the results of functional tests

3.2 Terms related to service stresses and ageing

3.2.1

ageing stress

electrical, thermal, mechanical or environmental stress whose action on an EIS causes irreversible property changes

3.2.2

potentially destructive stress

stress in service which can cause the failure of the aged EIS, alone or in combination with other stresses

3.2.3

service conditions

combination of stresses and duty that are to be expected in a specific application of an electrical device

3.2.4**reference operating conditions**

service conditions of the equipment to which the test conditions of the functional test procedure are related

3.2.5**service requirements**

specified stresses, intended performance and duty of an electrical device

3.2.6**service experience**

the quantitative and/or qualitative record during service, with or without failure of an EIS

3.2.7**ageing**

irreversible changes of the properties of an EIS due to action by one or more stresses

NOTE 1 Some changes (e.g. hydrolytic changes) can be partly reversible if the ambient conditions change.

NOTE 2 Ageing leads to degradation of the EIS.

3.2.8**intrinsic ageing**

irreversible changes of fundamental properties of an EIS caused by the action of ageing factors on the EIS

3.2.9**extrinsic ageing**

irreversible changes of properties of an EIS caused by action of ageing factors on unintentionally introduced imperfections in the EIS

3.2.10**interaction**

modifications of the type or degree of ageing produced by the combination of two or more stresses relative to their ageing effect if acting individually on separate objects

3.2.11**direct interaction**

interaction between simultaneously applied stresses that differs from that occurring with sequentially applied stresses

3.2.12**indirect interaction**

interaction which occurs between simultaneously applied stresses, which remains unchanged when the factors are applied sequentially

3.3 Terms related to testing**3.3.1****functional test**

procedure to obtain information about the suitability of an EIS under specified conditions

3.3.2**test object**

sample of original equipment or part thereof, or model representing the equipment completely or partially, including the EIS, to be used in a functional test

iTeh STANDARD PREVIEW
(standards.iteh.ai)

IEC 60505-2011
<https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011>

3.3.3

accelerated ageing

ageing resulting of an increase in the level and/or frequency of application of the stress beyond normal service conditions

3.3.4

accelerated test

functional test applying accelerated ageing to shorten testing time

3.3.5

conditioning

subjecting a specimen to an atmosphere of a specified relative humidity or complete immersion in water or other liquid, at a specified temperature for a specified period of time

3.3.6

prediagnostic conditioning

variable or fixed stresses, which can be applied continuously or periodically to an EIS to enhance the ability of a functional test to detect the degree of ageing

NOTE Prediagnostic conditioning may cause additional ageing.

3.3.7

diagnostic factor

variable or fixed stress which is applied to an EIS to establish the degree of ageing

3.3.8

diagnostic test

periodic or continuous application of a specified level of a diagnostic factor to a test object to determine whether or when the end-point criterion has been reached

<https://standards.iteh.ai/catalog/standards/sist/86979cec-0f84-4ca1-9e83-c839e0b660b7/iec-60505-2011>

3.3.9

end-point criterion

moment when a system is no longer able to fulfil its service purposes

3.3.10

life

time for a property to reach the end-point criterion for objects in functional tests

3.3.11

test cycle

in a test, repetitive period of application of one or more stresses, either sequentially or simultaneously, and of diagnostic factors

3.3.12

subcycle

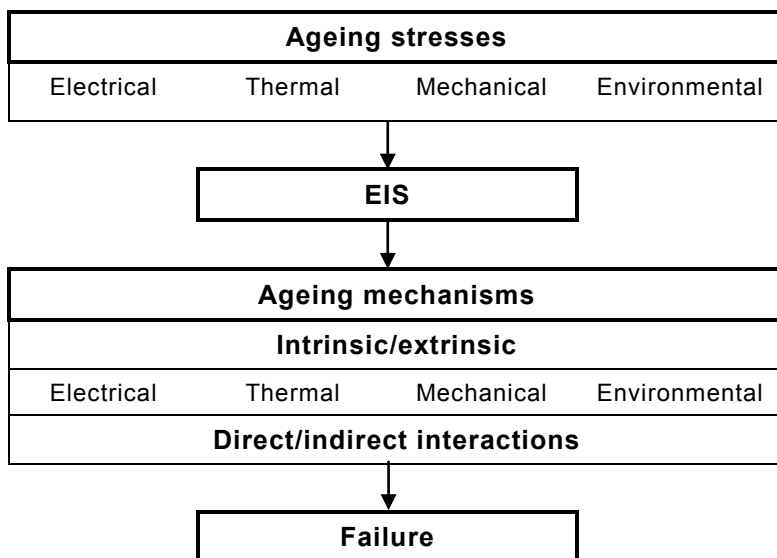
defined period within test cycle

NOTE The subcycle may be, for instance, a period of application of high temperature and humidity for influencing the system properties, or application of high voltage for diagnostic purposes

4 Ageing

4.1 Ageing mechanism

Ageing is defined as the irreversible changes of the properties of an EIS due to action by one or more stresses. Ageing stresses may cause either intrinsic or extrinsic ageing. A schematic representation of the basic process is shown in Figure 1.



IEC 1231/11

Figure 1 – Ageing of an EIS

The type and level of contamination and/or the extent of imperfections in an EIS will, in many types of electrical apparatus, significantly affect the service performance. In general, the fewer and less severe the contaminant and/or defects in the EIS, the better is its performance. To avoid obtaining misleading results from functional tests, a candidate EIS should contain, as far as practicable, the full range of contaminants and/or defects expected when the actual system is used in service.

The ageing stresses produce electrical, thermal, mechanical or environmental ageing mechanisms that eventually lead to failure. During ageing, applied stresses, which initially do not affect the EIS, can cause additional ageing and, as a result, modify the rate of degradation.

When ageing is dominated by one ageing factor, this is referred to as single-factor ageing. Multifactor ageing occurs when more than one ageing factor substantially affects the ageing of the EIS. Ageing factors can act synergistically, i.e. there can be direct interactions between the stresses. Interactions may be either positive or negative.

The ageing of a practical EIS may be complex and failure is usually caused by a combination of ageing mechanisms, even if there is only one dominant ageing factor as, for example, in single-factor ageing.

Where experience or existing knowledge of how a specific EIS will perform in service is limited, the user of this standard shall decide whether single or multifactor test procedures are appropriate for his specific equipment or apparatus.

NOTE The classification of the operational environments of electrical equipment is dealt with in IEC publications prepared by IEC technical committee 75, and methods for environmental endurance testing of electrical equipment are described in IEC publications prepared by IEC technical committee 50 (notably IEC sub-committee 50B), see bibliography.

When speaking of environmental effects, this is understood to comprise environments other than the normal standard laboratory atmospheres specified in IEC 60212.

A number of other standards that provide methods of exposure or characterization of insulation are listed in the bibliography.