Edition 1.0 2012-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Rotating electrical machines –
Part 18-34: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation of thermomechanical endurance of insulation systems

Machines électriques tournantes –
Partie 18-34: Evaluation fonctionnelle des systèmes d'isolation – Procédures d'essai pour enroulements préformés – Evaluation de l'endurance thermomécanique des systèmes d'isolation

IEC 60034-18-34:2012

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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.

Useful links:

IEC publications search - www.iec.ch/searchpub

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It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

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

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

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.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).
Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

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

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 60034-18-34

Edition 1.0 2012-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Rotating electrical machines –
Part 18-34: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation of thermomechanical endurance of insulation systems**

**Machines électriques tournantes –
Partie 18-34: Evaluation fonctionnelle des systèmes d'isolation – Procédures d'essai pour enroulements préformés – Evaluation de l'endurance thermomécanique des systèmes d'isolation**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX P

ICS 29.160

ISBN 978-2-83220-116-9

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

Part 18-34: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation of thermomechanical endurance of 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 60034-18-34 has been prepared by IEC technical committee 2: Rotating machinery.

This standard cancels and replaces IEC/TS 60034-18-34 (2000).

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

FDIS	Report on voting
2/1660/FDIS	2/1669/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.

NOTE A table of cross-references of all IEC TC 2 publications can be found on the IEC TC 2 dashboard 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

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

INTRODUCTION

IEC 60034-18-1 presents general guidelines for the evaluation and classification of insulation systems used in rotating electrical machines.

This part deals with the evaluation of insulation systems for form-wound windings under thermal cycling operation. This kind of endurance is of special importance for long rotating machines (especially indirectly cooled) and machines that are exposed to a very large number of considerable load changes during normal operation.

The main ageing factor expected in this test procedure is a mechanical stress due to the thermal expansion difference between the conductor and the insulation, which is defined as a thermomechanical stress. In this test, a transient temperature gradient from the conductor to the outer surface of the bar or coil is generated with similar time constant as those found in real generators. This thermal cycle is repeated to induce fatigue in the insulation system.

In this test, the thermal ageing is negligible. For thermal functional test, see IEC 60034-18-31.

ROTATING ELECTRICAL MACHINES –

**Part 18-34: Functional evaluation of insulation systems –
Test procedures for form-wound windings –
Evaluation of thermomechanical endurance of insulation systems**

1 Scope

This part of IEC 60034 gives test procedures for the evaluation of thermomechanical endurance of insulation systems of form-wound windings.

In this evaluation, the performance of a candidate system is compared to that of a reference insulation system with proven service experience.

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 60028:1925, *International standard of resistance for copper*

IEC 60034-1:2010, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-15, *Rotating electrical machines – Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines*

IEC 60034-18-1, *Rotating electrical machines – Part 18-1: Functional evaluation of insulation systems – General guidelines*

IEC 60034-18-32:2010, *Rotating electrical machines – Part 18-32: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation by electrical endurance*

IEC/TS 60034-27:2006, *Rotating electrical machines – Part 27: Off-line partial discharge measurements on the stator winding insulation of rotating electrical machines*

IEC 60093:1980, *Method of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC/TR 60894:1987, *Guide for a test procedure for the measurement of loss tangent of coils and bars for machine windings*

3 General considerations

3.1 Relationship to IEC 60034-18-1

The principles of IEC 60034-18-1 should be followed, unless the recommendations of this part indicate otherwise.

3.2 Thermomechanical ageing process

As a result of thermomechanical cycling, the following mechanical degradations can occur in the insulation system of the windings:

a) delamination between layers of the insulation;
b) delamination between a layer of the insulation and the conductor;
c) abrasion at the outer surface of the insulation;
d) circumferential cracking of the insulation (tape separation/girth cracking), most likely in the extension of the straight part;
e) mechanical damage to the insulation caused by distortion of the end turns of the winding.

3.3 Designation of test procedure

Depending upon which ageing processes are to be simulated, two test procedures will be described.

Test procedure 1, in which the test bars/coils of the winding are assembled in model slots simulating the conditions in an actual machine, including the supports at both ends of the bars/coils.

Test procedure 2, in which the bars/coils are free to move, without the restraints caused by the presence of model slots and end supports.

Test procedure 1 can be used to simulate all the ageing processes listed in 3.2. This is the most informative method for assessing thermomechanical endurance performance because it simulates more precisely the conditions occurring in the windings of machines in service.

Test procedure 2 can be used to simulate ageing process 3.2 a) and 3.2 b), namely when the winding design allows for free axial movement of the bars/coils in the slots.

In both test procedures, the test objects are initially exposed to quality control tests and optional diagnostic tests. At certain prescribed times during and at the end of the thermal cycling, the diagnostic tests may be repeated. The ultimate final functional test is a destructive test.

3.4 Reference insulation system

A reference insulation system shall be tested using the same test procedure as for the candidate system. An insulation system qualifies to be used as a reference insulation system, if it has shown successful operation over suitably long periods of time at typical operating conditions for that insulation system. The class temperature of the reference insulation system shall not differ from that of the candidate insulation system by more than one thermal class. If experience with a suitable reference system is not available, maximum permissible changes of the properties of the insulation system caused by the thermomechanical endurance test shall be specified, in some cases after an agreement between manufacturer and user.

4 Test specimens and test objects

4.1 Construction

The test specimen shall be an actual bar or coil (see Figure 1) for a rotating machine. The test specimen shall have the same shape and the same length as the bar/coil that could be used in an actual machine. It shall be manufactured by applying the insulation system to a conductor with the same design and materials and using the same procedure as an actual bar/coil. The conductor cross-section, insulation thickness, creeping distances and corona suppression shall be similar to those of an actual bar/coil of the maximum rated voltage to be tested.

In test procedure 1, the test object comprises a number of test specimens (see 4.2) assembled in model slots and supported as in a real machine.

The bars or coils shall be fully cured as in the functional machine.

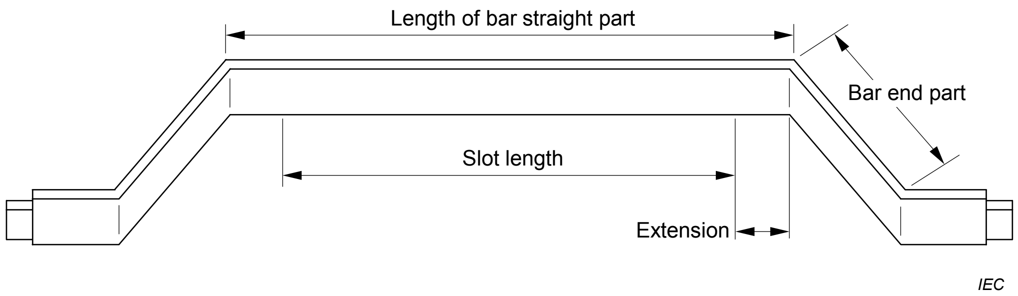

Figure 1a – Stator bar

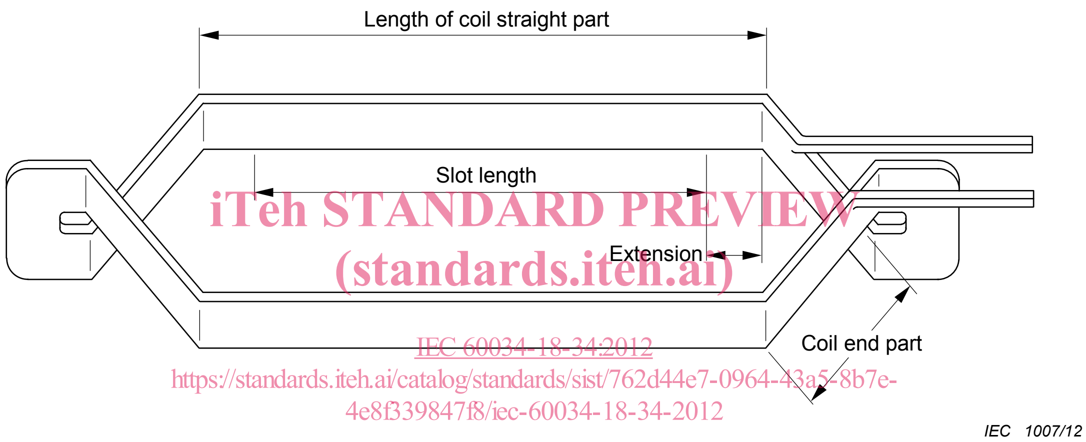

Figure 1b – Stator coil

Figure 1 – Details of stator bar and coil definitions

4.2 Number of test specimens

At least five bars or three coils shall be tested in each thermomechanical test. Additional coils/bars should be necessary to monitor the conductor temperature and to perform destructive tests on reference (non-cycled) set of bars/coils (see 5.1, 6.3 and 7.2). If the temperature is determined from the copper resistance variation, these additional coils/bars may not be needed.

5 Heating and cooling cycles

5.1 Temperature and length of heating and cooling cycles

The thermomechanical cycling of the insulation system under test is accomplished by alternately heating and cooling the test objects between fixed upper and lower temperature limits, measured at the surface of the conductors of the test objects in the straight part and also in the end parts so as to minimize any heat-sink effect (see 6.3 a) and 7.2).

The preferred measurement method of the conductor temperature is accomplished using thermocouples, thermistors or fibre-optic sensors in direct contact to the conductor. In order to obtain good contact to the surface of the conductors, the temperature sensor shall be built into the bare-bar before being insulated or inserted into a hole drilled through the insulation on a separate control bar.

An alternative method to avoid the insertion of a probe directly on the copper conductor is to measure the resistance of the bar/coil. The copper resistivity depends of its temperature according to a relationship given in IEC 60028. From the resistance measured when the bar/coil is at ambient temperature, the average temperature of the copper can be determined from the relationship given in IEC 60028. The reference measurement of copper resistance is essential and shall be made when the whole bar/coil is at the same, exactly known ambient temperature between 10 °C and 30 °C. During the heating, the copper resistance can be measured by the voltage drop along the bar/coil if a direct current source is used to heat the bar/coil. The position of the voltage measurement point shall be as close as possible to the edge of the insulation, without including the connections, and shall always be at the same location. The temperature along the surface of the bars/coils shall be uniform within ± 10 K as measured using a non-contact technique such as a thermographic camera or a infra-red pyrometer. Terminals should normally be thermally insulated to prevent a heat sink effect.

NOTE 1 The harmonic content of the d.c. source should be low to minimize the effect of inductance.

If the resistance method is used during heating, it may also be used during cooling. A suitably small direct current measurement should then be applied to get a lower temperature limit with sufficient accuracy. To restart the cycle when the lower temperature limit is reached, a surface temperature measurement may also be performed. It is necessary to determine beforehand the surface temperature which corresponds to the lower temperature limit at the conductor by performing a test using the resistance variation measured by direct current injection. This method is the same as the “resistance method” in IEC 60034-1. An increase of the thermal conductivity of the insulation wall is expected during the ageing process, but its change should have limited influence on the lower temperature limit.

The upper temperature limit shall normally be the class temperature (T_c) of the insulation system. It shall be controlled within ± 3 K. If the copper resistance method is used to control the temperature, the upper limit shall be set at (T_c – 5) °C. With this method, the upper temperature limit shall be controlled within ± 5 K. Since the thermal conductivity often changes with ageing, it is necessary to monitor the upper temperature limit of copper temperature during the test, at least on one bar/coil. The lower temperature limit shall be in the interval between 30 °C and 50 °C.

The time for heating as well as for the cooling shall be between 30 min and 60 min as shown in Figure 2. The insulation system under test and the reference insulation system shall be tested with the same cycle except that the upper test temperature limits will be different if the temperature classes of these insulation systems differ.

NOTE 2 Some insulation systems have a softening temperature above the upper temperature limit. This may influence the test results, especially when comparing results with an insulation system that has a low glass transition temperature.

NOTE 3 For machines with particular thermal operating conditions, shorter times may be used.

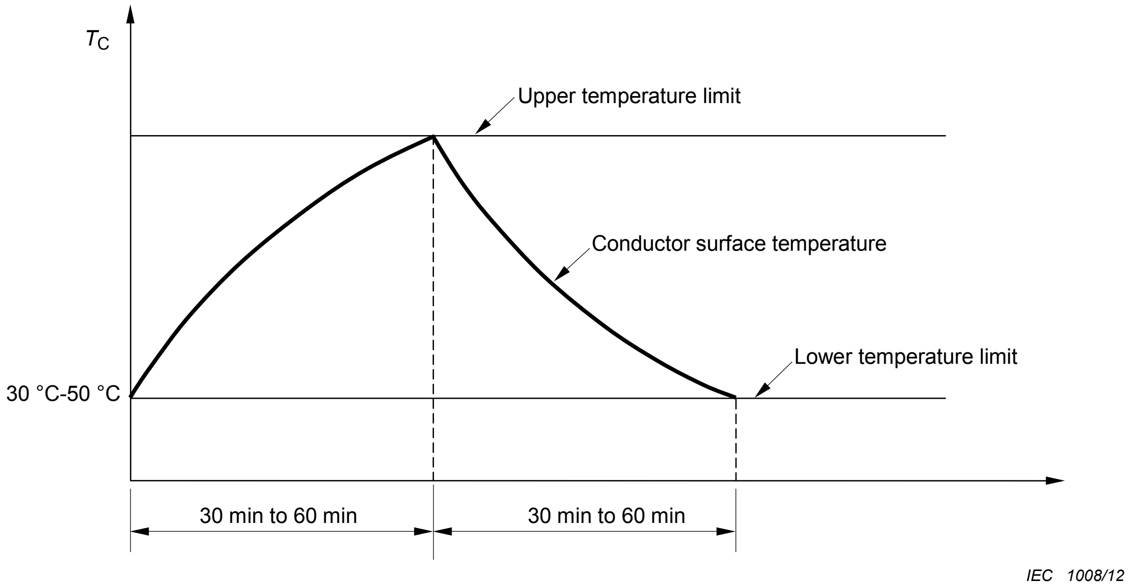

Figure 2 – Heating and cooling cycle schedule

5.2 Number of cycles

The test objects shall be exposed to a minimum of 500 thermal cycles.

6 Test procedure 1 for bars/coils in model slots

6.1 Model slot

The thermomechanical test according to this test procedure shall be carried out on bars/coils placed in model slots. These slots shall satisfy the following requirements.

a) The length of the model slots and the extension of the bars/coils outside the slot shall be the same as those in an actual machine. See Figure 1.

b) Laminated model slots are preferred, but alternative models which adequately represent the slot surfaces and the mechanical characteristics of laminated cores may be used. Dimensional deformations of the slot structure should be avoided as much as possible. Ventilation ducts should preferably be included. They should be similar in width and give similar sliding wear to the insulation surface as those in an actual machine.

c) The bars/coils shall be installed in the model slots as in the slots of an actual machine, using normal manufacturing procedures and components. The tightness of the wedges and any possible slot packing system shall be uniform axially. It is preferred that the model should be oriented horizontally or vertically according to design. If this is not followed, it is possible that the ageing process given in 3.2 e) will not be simulated properly.

For additional model details, see the note to Figure 3.