IEC 60034-18-32

Edition 1.0 2010-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Machines électriques tournantes – Partie 18-32: Evaluation fonctionnelle des systèmes d'isolation – Procédures d'essai pour enroulements préformés – Evaluation par endurance électrique

IEC 60034-18-32:2010

Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2010 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 Varembé
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 It also gives information on projects, withdrawn and replaced publications.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.
- 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

Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

IEC 60034-18-32

Edition 1.0 2010-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Machines électriques tournantes – Partie 18-32: Evaluation fonctionnelle des systèmes d'isolation – Procédures d'essai pour enroulements préformés – Evaluation par endurance électrique

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

Q

ICS 29.160

ISBN 978-2-88912-225-7

® Registered trademark of the International Electrotechnical Commission
Marque déposée de la Commission Electrotechnique Internationale

Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

CONTENTS

FOREWORD ... 3
INTRODUCTION ... 5
1 Scope ... 6
2 Normative references ... 6
3 Terms and definitions ... 6
4 General considerations ... 7
4.1 Relationship to Part 1 of IEC 60034-18 ... 7
4.2 Selection and designation of test procedures ... 7
4.3 Reference insulation system ... 7
4.4 Test procedures (IEC 61251) ... 8
4.5 Extent of tests ... 8
5 Test objects ... 9
5.1 Construction of test objects ... 9
5.2 Number of turns ... 9
5.3 Number of test specimens ... 9
5.4 Initial quality control tests ... 9
6 Electrical ageing ... 9
6.1 Voltage levels and intended test lives ... 9
6.2 Test temperatures during electrical endurance testing ... 10
6.3 Ageing procedure for the mainwall insulation ... 10
6.4 Ageing procedure for the turn insulation ... 10
6.5 Maintenance of stress grading coatings ... 10
7 Diagnostic sub-cycle ... 11
7.1 General ... 11
7.2 Voltage tests ... 11
7.3 Other diagnostic tests ... 11
8 Failures ... 11
8.1 Failure location and verification ... 11
8.2 Failed specimen observations ... 12
8.3 Dimensional measurements ... 12
9 Functional evaluation of the data ... 12
9.1 General ... 12
9.2 Full evaluation ... 12
9.3 Reduced evaluation ... 14
9.4 Recommended data to be recorded ... 15
Bibliography ... 17

Figure 1 – Comparison of ageing data from candidate (C) and reference (R) insulation systems showing qualification ... 13
Figure 2 – Comparison of ageing data from candidate and reference insulation systems showing failure to qualify ... 14
Figure 3 – Comparison of reduced evaluation test data from four separate candidate systems with that from the reference system ... 15

Table 1 – Test procedure designations ... 7

AVA Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

Part 18-32: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation by electrical endurance

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 60034-18-32 has been prepared by IEC technical committee 2: Rotating machinery.

This first edition cancels and replaces IEC/TS 60034-18-32, published in 1995 and constitutes a technical revision.

The main technical changes with regard to the previous technical specification are as follows.

a) simplification of clauses;
b) reduction in the number of test procedures;
c) inclusion of full bars and coils as test objects;
d) a new clause dealing with failures and failure criteria.

Documents
Document Sharing Hub
Full document details: IEC 60034-18-32 2010

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

CDV	Report on voting
2/1580/CDV	2/1602/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

A list of all parts of the IEC 60034 series, published under the general title *Rotating electrical machines,* can be found on the IEC website.

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

The committee has decided that the contents of this amendment and the base 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.

Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

INTRODUCTION

Part 1 of IEC 60034-18 presents general principles for the evaluation of insulation systems used in rotating electrical machines.

This standard deals exclusively with insulation systems for form-wound windings and concentrates on electrical functional evaluation.

Documents
Document Sharing Hub

Full document details: 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

1 Scope

This part of IEC 60034-18 describes test procedures for the evaluation of electrical endurance of insulation systems for use in a.c. or d.c. rotating electrical machines using form-wound windings. The test procedures are comparative in nature, such that the performance of a candidate insulation system is compared to that of a reference insulation system with proven service experience. The test procedures are principally directed at the insulation systems in air-cooled machines but may also be used for evaluating parts of the insulation systems in hydrogen cooled machines. Note that the qualification procedures of inverter duty insulation systems for form-wound windings can be found in IEC 60034-18-42.

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

IEC 60034-15:2009, *Rotating electrical machines – Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines*

IEC 60034-18-1:2010, *Rotating electrical machines – Part 18-1: Functional evaluation of insulation systems – General guidelines*

3 Terms and definitions

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

3.1
mainwall insulation
main electrical insulation that separates the conductors from the earthed stator/rotor core in motor and generator windings

3.2
turn insulation
electrical insulation that covers each conductor in coils/bars

3.3
interturn insulation
electrical insulation that separates the conductor turns from each other in coils/bars

3.4
corona protection material
material which is used to coat a stator coil/bar within the slot portion of the stator core to avoid slot discharges

AVA Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

3.5
stress grading material
material generally having a non-linear resistivity characteristic, applied to the endwindings of stators to reduce the maximum surface electrical stress

4 General considerations

4.1 Relationship to Part 1 of IEC 60034-18

The principles of Part 1 of IEC 60034-18 should be followed unless the recommendations of this International Standard indicate otherwise.

4.2 Selection and designation of test procedures

One or more of the procedures in this International Standard should be suitable for the majority of evaluations. Evaluation is usually performed by the manufacturer of the machine/coils or by a third party laboratory. It is the manufacturer's responsibility to justify the most suitable procedure in Table 1 on the basis of past experience and knowledge of the insulation systems to be compared.

The test procedure should be selected from Table 1 and designated by IEC 60034-18-32 procedure N, where N is the designation given in the Table 1. Subclauses 4.3, 4.4 and 4.5 give guidance on how to select the test procedure.

Table 1 – Test procedure designations

Designation of test procedure N	Applied ageing voltage		Diagnostic tests		
	Mainwall insulation (6.3)	Interturn insulation (6.4)	Mainwall insulation (7.2.1)	Interturn insulation (7.2.2 or 7.2.3)	Stress grading (7.3)
AA	Constant	None	Not required (A)	No test (A)	Optional (D)
CA	Constant	None	Other test (C)	No test (A)	Optional (D)
AB	Constant	Yes	Not required (A)	Impulse test (B)	Optional (D)

NOTE 1 The meaning of the letters of the diagnostic test are as follows: A – No test; B – Impulse test; C – Other test (such as dissipation factor and partial discharge tests); D – Visual observation.

NOTE 2 Where a diagnostic test is not required on the mainwall insulation, the ageing voltage acts simultaneously as the diagnostic factor.

All the above tests are carried out at room temperature. However, if they are to be performed at any other temperature (see 6.2.2), the designation of the test procedure shall include the Celsius temperature in brackets, e.g. AA(190). Each of the procedures may be used for the full evaluation according to 4.5.1 or for the reduced evaluation according to 4.5.2.

Procedure AA is the preferred choice if the manufacturer has no past experience or knowledge of the candidate system and the behaviour of the mainwall insulation is defined.

4.3 Reference insulation system

A reference insulation system should be tested using a test procedure equivalent to that used for the candidate system (see IEC 60034-18-1). The reference insulation system should have service experience at not less than 75 % of the intended maximum rated voltage of the candidate system. When extrapolation of the insulation thickness is used, some information should be provided showing the correlation between electrical lifetime and electrical stress for the different insulation thicknesses.

Documents
Document Sharing Hub
Full document details: IEC 60034-18-32 2010

4.4 Test procedures (IEC 61251)

4.4.1 General

Electrical ageing tests are usually performed at fixed voltage levels until failure. From such tests, characteristic times to failure at each voltage level are obtained. The results for both the candidate system and the reference system should be reported on a graph, as shown by the example in Figure 1, and compared. There is no proven physical basis for extrapolation of this characteristic to the service voltage level $U_N/\sqrt{3}$, where U_N is the r.m.s. rated phase to phase voltage. Statistical evaluation of the results of testing should be performed according to IEC 62539.

4.4.2 Electrical ageing of the mainwall insulation

In service, electrical ageing of the mainwall insulation is primarily caused by continuous electrical stress at power frequency. In addition, the insulation is required to withstand transient over-voltages arising from switching surges or inverter supply. The ability of the mainwall insulation to withstand transient over-voltages from converter supplies may be demonstrated by the system's performance using IEC 60034-18-42. This standard describes voltage ageing of the mainwall insulation, carried out at power frequency or at a frequency up to 10 times greater.

4.4.3 Electrical ageing of the turn insulation

Electrical ageing of the turn insulation can arise due to the steady-state stress applied across the mainwall insulation. This could be particularly significant at the edges of the conductors where the electrical stress reaches a maximum.

Where multiturn coils or bars are used, the power frequency voltage between turns is sufficiently low that ageing due to this electric stress is not of major significance. However, steep-fronted surges on the winding caused by switching and other disturbances can generate sufficient stress between turns for ageing to take place. Since the waveforms and frequency of occurrence are variable and dependent upon circuit parameters, this International Standard recommends that, for comparison purposes, electrical ageing of the turn insulation be performed using IEC 60034-18-42.

4.5 Extent of tests

4.5.1 Full evaluation

The extent of the electrical functional tests will depend upon the purpose of the evaluation. A full evaluation will be needed where there are substantial differences in the compositions of the reference and candidate systems.

4.5.2 Reduced evaluation

There are situations when it will be sufficient to carry out reduced evaluation using the minimum number of test specimens and the middle voltage level from the range of reference tests.

Comparison of a candidate insulation system to a reference system, where there are no intended or only minor differences in composition or manufacturing procedures (so-called minor changes, see IEC 60034-18-1), may be carried out using only one voltage level but with the recommended minimum number of test specimens (see 5.3). Reduced evaluation is allowed only if the rated voltages are the same for both systems.

An example of a minor change might be the sourcing of the same material from a different supplier or a change of pulping process. An example of a minor processing change might be the installation of a new controller or new pipework in a vacuum pressure impregnation (VPI) process. It should be emphasized that a minor change is one which is not expected to have a

Documents
Document Sharing Hub
Full document details: IEC 60034-18-32 2010

significant effect on the insulation system. It is the responsibility of the manufacturer to justify the use of the reduced qualification procedure

5 Test objects

5.1 Construction of test objects

Test objects should preferably be complete bars or coils made to normal manufacturing standards. Alternatively, they may be constructed to represent the configuration of the finished winding component to be evaluated and be subjected to the full normal or intended manufacturing processes. When using separate coils or bars as models, creepage distances and any necessary voltage grading are to be appropriate to the stresses applied during testing. An electrode should extend the full slot length of the model and encircle the entire circumference of the coil cross-section.

The sample preparation and test procedures described in IEC 60034-18-42 may be used for qualifying stress grading systems applied to endwinding insulation.

5.2 Number of turns

For the turn insulation, it is generally necessary to use complete coils in order to include the effects of shaping and conductor reinforcement. The number of turns and the thickness of the turn insulation should be such that when the test voltage chosen in accordance with 6.1 is applied, the turn dielectric stress is not less than the highest that would be imposed by applying the appropriate test voltage to any design of coil for which the insulation system can be used.

Where a power frequency voltage is to be applied between the turns, the coil should be wound with two parallel conductors, each insulated with turn insulation, or the coil has to be cut in the end windings. When using VPI coils, the cut-through and separation of the conductors in this area have to be done before impregnation. If the test procedure chosen (see 4.2) does not apply a power frequency voltage between the turns, the test object can be a multiturn coil wound in the normal manner with a single (or stranded) conductor.

5.3 Number of test specimens

An adequate number of test specimens shall be aged at each test voltage level in order to obtain statistical confidence. This number should not be less than five.

5.4 Initial quality control tests

Before starting the first ageing sub-cycle, the following quality control tests shall be performed:

– visual inspection of the test specimens;
– high-voltage tests according to IEC 60034-1;
– dissipation factor test or/and partial discharge test.

6 Electrical ageing

6.1 Voltage levels and intended test lives

For full evaluation as described in 4.5.1, at least three power frequency voltages should be selected so that the intended mean time to failure at the highest voltage is about 100 h, and at the lowest voltage above 5 000 h. For reduced evaluation where only one voltage level is required (see 4.5.2), it should be chosen so that the intended mean time to failure is about 1 000 h. The alternating voltage applied to the test objects should be maintained within ± 3 %.

AVA Documents
Document Sharing Hub

Full document details: IEC 60034-18-32 2010

6.2 Test temperatures during electrical endurance testing

6.2.1 Electrical ageing at room temperature

Electrical ageing is preferably carried out in air at room temperature at voltages and/or frequencies higher than those in the steady-state operating conditions in order to accelerate the effects of electrical stress.

6.2.2 Electrical ageing at elevated temperature

Any appropriate means of heating may be used when the electrical ageing tests are performed at elevated temperatures. The temperature rise due to the applied electrical stress can affect the results, especially when using increased frequency, and shall be recorded. If thermal ageing does occur, the testing should follow the procedures in IEC 60034-18-33 for multifactor testing.

6.3 Ageing procedure for the mainwall insulation

The electrical stress is applied between the stator core or the outer conductive layer on the surface of the test specimen and the conductors. If the test object is a multiturn coil, both the mainwall insulation and the turn insulation are aged by the electrical stress during this period. For test procedures with sub-cycles (Clause 7), the duration of these sub-cycles should be such that approximately ten sub-cycles are performed on a test specimen having a median life. Higher than power frequency is allowed to shorten the test times but experience has shown that the maximum acceptable acceleration factor is 10 times the power frequency. Care should be taken that the dielectric losses do not increase the temperature of the insulation so much that the results are affected. This is especially important at elevated temperatures. The same frequency should be used for the candidate and reference insulation system. Increased frequency test results may only be used for direct comparison if the lives of the systems are affected similarly by the increase of frequency.

6.4 Ageing procedure for the turn insulation

Ageing of the turn insulation due to repetitive transient over-voltages is evaluated according to procedure AB in Table 1. The mainwall insulation ageing sub-cycle is followed by a turn insulation ageing sub-cycle consisting of the application of a power frequency voltage between turns for 10 min. This voltage shall be

$$\frac{1{,}5 \times U_N}{n}$$

where where U_N is the rated voltage of the insulation in kV and n is the number of turns, but not less than $0{,}3 \times U_N$.

The temperature rise due to the applied electrical stress can affect the results, especially when using increased frequency and should be recorded. Increased frequency test results may only be used for direct comparison if the lives of the systems are affected similarly by the increase in frequency.

6.5 Maintenance of stress grading coatings

A stress grading coating is usually applied to the outer surface of the coil or bar beyond the earthed semi-conductive slot coating. The stress grading coating may take the form of paints or tapes or a combination of the two. During the electrical endurance test, deterioration may occur which does not result in insulation failure. Remedial action to the stress grading material and forced air cooling are permitted during the progress of the voltage endurance test on the basis that it is the mainwall insulation that is being tested rather than the stress grading system.

Documents
Document Sharing Hub
Full document details: IEC 60034-18-32 2010